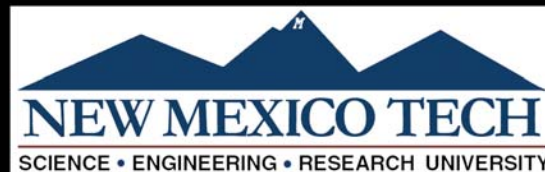




# NEW MEXICO TECH COURSE CATALOG 2012-2013



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**For information on undergraduate admission, please contact:**

Director of Admission  
New Mexico Tech  
801 Leroy Place  
Socorro, NM 87801  
575.835.5424  
1.800.428.TECH  
admission@admin.nmt.edu  
www.nmt.edu/future-students

**International students who wish to apply for undergraduate admission, please contact:**

International & Exchange Programs  
575.835.5022  
International\_undergrad@admin.nmt.edu

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**For information on graduate admission, contact:**

Dean of Graduate Studies  
New Mexico Tech  
801 Leroy Place  
Socorro, NM 87801  
575.835.5513  
1.800.428.TECH  
graduate@nmt.edu

Prospective graduate students,  
both domestic and international,  
should use the address above.

# Academic Calendar

## 2011 Fall Semester

Deadline for Intent to Graduate	July 1
Orientation for New incoming students	August 20
Registration and Validation	August 22
Classes Begin	August 23
Late Registration Fees Begin (\$30/day)	August 25
Last day to Add a class	August 30
Academic Holiday	September 5
Non-Validated Student Disenroll	September 7
Last day to drop a class	September 9
Registration Closes	September 9
Midsemester	October 12
Academic Holiday	October 21
Grade Option Deadline (pass/fail or Audit)	November 9
Last Day to Withdraw from a class	November 9
Thanksgiving Vacation	November 24, 25
Pre-Registration for Spring 2012	Nov 28-Dec 2
Deadline for Completion Papers (Masters, PhD)	December 2
Last Day of Classes	December 9
Finals Begin	December 10
End of Finals	December 15
End of Semester	December 16

## 2012 Spring Semester

Deadline for Intent to Graduate	December 1
Registration and Validation	January 16
Classes Begin	January 17
Late Registration Fees Begin (\$30/day)	January 19
Last day to Add a Class	January 24
Non-validated Student Disenroll	February 1
Last day to Drop a class	February 3
Registration Closes	February 3
Midsemester	March 7
Spring Vacation	March 12-16
Grade Option Deadline (pass/fail or Audit)	April 4
Last day to Withdraw from a class	April 4
Academic Holiday	April 6
Pre-Registration for Summer 2012	April 9-13
Pre-Registration for Fall 2012	April 16-20
Deadline for Completion Papers (Masters, PhD)	April 27
Last Day of Classes	May 4
Finals Begin	May 5
End of Finals	May 10
End of Semester	May 11
Commencement	May 12

## 2012 Field Camp

Geology Field Camp	May 19-July 1
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## 2012 Summer Session

Deadline for Intent to Graduate	June 1
Registration and Validation	June 11
Classes Begin	June 12
Non-validated Student Disenroll	June 13
Late Registration Fees Begin (\$30/day)	June 14
Last day to add/drop a class	June 19
Registration Closes	June 19
Academic Holiday	July 4
Grade Option Deadline (pass/fail or Audit)	July 17
Last day to Withdraw from a class	July 17
Deadline for Completion Papers (Masters, PhD)	July 20
End of Semester	August 3

## 2012 Fall Semester

Deadline for Intent to Graduate	July 1
Orientation	August 18
Registration and Validation	August 20
Classes Begin	August 21
Late registration Fees Begin	August 23
Last day to Add a class	August 28
Academic Holiday	September 3
Non-validated Student Disenroll	September 5
Last day to drop a class	September 7
Registration Closes	September 7
Midsemester	October 10
Academic Holiday	October 19
Grade Option Deadline (pass/fail or Audit)	November 7
Last day to Withdraw from a class	November 7
Thanksgiving Vacation	November 22, 23
Pre-Registration for Spring 2013	November 26-30
Deadline for Completion Papers (Masters, PhD)	November 30
Last Day of Classes	December 7
Finals Begin	December 8
End of Finals	December 14
End of Semester	December 14

# Degrees Offered at Tech

## Associate Degrees

Associate of General Studies  
Associate of Science in Business

## Bachelor of Science

Basic Sciences  
Biology  
Chemical Engineering  
Chemistry  
Civil Engineering  
Computer Science  
Earth Science  
Electrical Engineering  
Environmental Engineering  
Environmental Science  
Information Technology  
Management  
Management of Technology  
Materials Engineering  
Mathematics  
Mechanical Engineering  
Mineral Engineering  
Petroleum and Natural  
Gas Engineering  
Physics  
Psychology  
Technical Communication

## Bachelor of General Studies

## Minors

Aerospace Engineering  
Biology  
Biomedical Engineering  
Chemistry  
Civil Engineering  
Earth Science  
Education  
Electrical Engineering  
Environmental Engineering  
Explosives Engineering  
Hispanic Studies  
History  
Literature  
Management  
Materials Engineering  
Mathematics  
Mechanical Engineering  
Mineral Engineering  
Optical Science and Engineering  
Petroleum Engineering  
Philosophy  
Physics  
Polymer Science  
Psychology  
Technical Communication

## Other Principal Areas of Instruction

(no degree offered)  
Aerospace Studies (AFROTC)  
Art History  
Education  
English  
Fine Arts  
History  
Languages  
Music

## Master of Engineering Management

## Master of Science for Teachers

## Master of Science

Biology  
Chemistry  
Computer Science  
Electrical Engineering  
Environmental Engineering  
Geochemistry  
Geology  
Geophysics  
Hydrology  
Materials Engineering  
Mathematics  
Mechanical Engineering  
Mineral Engineering  
Petroleum Engineering  
Physics

## Doctor of Philosophy

Chemistry  
Computer Science  
Earth and Environmental Science  
Geochemistry  
Geology  
Geophysics  
Hydrology  
Materials Engineering  
Mathematics  
Applied and  
Industrial Mathematics  
Petroleum Engineering  
Physics  
Astrophysics  
Atmospheric Physics  
Instrumentation  
Mathematical Physics

# Equal Opportunity Policy

The New Mexico Institute of Mining and Technology is committed to the policy that all persons shall have access to its programs, facilities, and employment without regard to race, age, religion, color, national origin, ancestry, sex, sexual orientation, physical or mental handicap or serious medical condition, spousal affiliation, or gender identity, as required by the New Mexico Human Rights Act, Title VI and Title VII of the 1964 Civil Rights Act as amended, Civil Rights Act of 1866, Executive Order 11246, Section 503 and 504 of the Rehabilitation Act of 1973, The Americans with Disabilities Act, The Age in Employment Discrimination Act of 1990, Vietnam Era Veterans Readjustment Assistance

## Other Formats

The New Mexico Tech 2011-2012 catalog is available online at: [www.nmt.edu](http://www.nmt.edu)

The catalog is also available in other formats upon request. Contact:

The Office of Admission  
New Mexico Tech  
801 Leroy Place  
Socorro, NM 87801  
575.835.5424 or 1.800.428.TECH.

## Proviso

The provisions of this catalog are not to be regarded as an irrevocable contract between the student and New Mexico Institute of Mining and Technology. New Mexico Tech reserves the right to change any provisions or requirements at any time within the student's term of residence.

# Terms and Abbreviations You Should Know

## Academic Terms

### Academic Load

The academic year at Tech consists of two semesters. A class hour is 50 minutes in length; ordinarily, a laboratory period is about three times as long. One class hour or laboratory period a week through a semester gives one credit hour.

A full-time undergraduate should carry an academic load of approximately 16 credit hours per semester for the fall and spring semesters. During the summer session, 6 credit hours is a full-time academic load; 3 credit hours is half-time.

Graduate students: see page 52 for information about academic load.

The Veterans Administration requires students on the GI Bill to carry a minimum of 12 credit hours (6 credit hours in summer) to qualify for full benefits. Physical Recreation (PR), Fine Arts (FA), and Community Education courses (designated by the letter "C" in the course number) do not count toward the minimum credit hours for veterans. Complete information can be obtained in the Center for Student Success.

### Auditing a Class

If you wish to participate in a course to learn about the subject but not be required to earn a letter grade, you can audit the course. You will receive a grade of satisfactory audit (SA) or unsatisfactory audit (UA) as determined by the instructor, but no credit. Payment is the same as for a credit class. Professors will expect you to attend class and to be prepared.

### Challenge Exams

If you think you already know the material in a course you are required to take, ask the department chair for a challenge exam. For a small fee, you will be tested on the course material. Depending on the department, you may receive a letter grade or an "S" (for Satisfactory), or they may simply waive the course. Or, of course, you may be told you have to take the course anyway.

## Course Numbers

Courses numbered from 100 to 199 are intended primarily for first-year students (freshmen); 200 to 299 for second-year students (sophomores); 300 to 399 for third-year students (juniors); 400 to 499 for fourth-year students (seniors); and 500 to 599 for graduate students. Exceptions may be made with the approval of the major advisor and instructor. Graduate students may be allowed credit for courses numbered 300 and above.

## Credit Hours

Credit hours are measured in class hours (cl hrs), lab hours (lab hrs), and recitation/discussion hours (recitation hrs).

"1 cl hr" and "1 recitation hr" correspond roughly to one hour spent in class each week and is equivalent to one (1) credit hour. "3 lab hrs" equals about three hours per week in the laboratory and is also equivalent to one (1) credit hour.

In addition to class and lab time, you can expect to spend about two to three hours of study and preparation for each credit hour of class. Most one-semester classes average three credit hours. To graduate with a bachelor's degree, you will need a minimum of 130 credit hours, depending on your chosen major.

## Directed Study

Directed study courses are usually self-paced 300- to 500-level classes. Typically, a directed study is research-oriented and allows you to work and progress in a relatively unstructured situation. To sign up, you will need the instructor's permission, the approval of the department chair, and a special form from the Office of the Registrar.

## Electives

Electives are courses taken in addition to the specific courses required by your major. Electives bring your credit hours up to the required number for graduation. Some majors allow students to choose many electives; others, few. Please refer to the specific degree requirements for your major.

New Mexico Tech's Community College classes (designated by the letter "C" in the course number) may not be used to fulfill the General Education Core Curriculum Requirements for a Bachelor of Science degree (page 100). However, some majors allow students to use these classes to fulfill elective credit.



## General Education Core Curriculum Requirements

These are courses in humanities, mathematics, and basic science which all bachelor of science students must complete in order to graduate. The general degree requirements should be met by the end of your sophomore year. See page 100-101 for both undergraduate and graduate general degree requirements.

## Good Academic Standing (Undergraduate)

*Graduate students: For information on satisfactory progress, see page 54.*

A regular undergraduate student will be considered to be in good standing if the student maintains the minimum semester grade-point average (GPA) listed below:

<i>Total semester hours attempted (cumulative)</i>	<i>Minimum semester GPA needed to maintain good standing</i>
0-29	1.60
30-59	1.80
60 or more	2.00

For determination of academic standing, "semester hours attempted" means courses in which a student earns grades of A, A-, B+, B, B-, C+, C, C-, D+, D, F, S, U, and all transfer credits. "Semester hours attempted" does not include courses in which a student earns grades of IN, SA, UA, W, or WO. Transfer credits are not used in computing the GPA.

A student whose semester GPA falls below the minimum requirements needed for good standing will be placed on academic probation (see page 70).

## Academic Warning

Any undergraduate student whose GPA for the preceding semester is less than 2.00 or whose cumulative GPA is less than 2.00 will be placed on academic warning, regardless of their total semester hours attempted or academic standing.

When a student is placed on academic warning, he or she must:

- visit the Center for Student Success (CSS) and complete all of the self-assessment activities indicated by the CSS
- meet with their academic advisor or their major

Department Chair and develop an academic action plan for the next three semesters

- submit the academic action plan to the CSS no later than 10 days prior to the close of registration during the Fall and Spring semesters or 2 days prior to the close of registration during the Summer semester.

The Academic Standards and Admissions Committee will review the academic action plan and determine if the above conditions have been successfully met. Failure to comply with these requirements will result in a hold placed on the student's account until these conditions are satisfied.

## Grade Point Average (GPA)

Your semester GPA is found by multiplying the number of credit hours for each course with a number corresponding to your grade in the course and then dividing by the total number of credit hours in the semester. A=4, B=3, C=2, D=1, F=0. For example, a student taking two three-hour courses who received an A and a B would have a GPA for that semester of 3.5.

$$((3 \times 4.0) + (3 \times 3.0)) / [3 + 3] = 21.0 / 6 = 3.5$$

See page 69 for a complete list of possible grades and their grade points.

Courses taken for grades of S, U, SA, and UA are not calculated in your GPA.

Your cumulative GPA is an average over your entire Tech career. Transfer credits are not included in your cumulative GPA.

## Major

Your major is your primary field of study. The number of credit hours required in your major varies by program. Since your choice of major determines which courses you are required to take, it is advisable to declare your major as soon as possible. You may change majors at any time, but the earlier the better.

You must declare a major and be assigned a major advisor prior to completing the coursework for the major. You may declare or change your major at the Center for Student Success.

## Minor

New Mexico Tech awards minors for your secondary field of study. (See page 6 for a list of minors.) The number of credits required for a minor vary from department to department, a minimum of 18

credit hours is required. Students cannot earn a minor with either the Associate of General Studies or Bachelor of General Studies.

You must declare a minor and be assigned a minor advisor prior to completing the coursework for the minor. You may declare or change your minor at the Center for Student Success.

### Prerequisites and Corequisites

Some courses have prerequisites, courses you must successfully complete before enrolling in that course. Exceptions may be made with the instructor's approval. If you enroll in a course in which you do not have the prerequisites without the instructor's permission, you may be disenrolled.

Corequisites are courses taken during the same semester.

Prerequisites and corequisites are not determined by the student's individual catalog, but rather by the catalog in effect at the time that the course is offered.

### Satisfactory Academic Progress for Financial Aid

To be in good standing for financial aid purposes, a student must earn at least 67 percent of the hours attempted with a cumulative G.P.A. of:

1.6 if you have attempted 0 to 29 credit hours

1.8 if you have attempted 30 to 59 credit hours

2.0 if you have attempted 60 or more credit hours

See page 43 for further information about satisfactory academic progress for financial aid purposes.

### Validation

Validation is acceptance of your financial responsibilities to New Mexico Tech for all courses you are registered for. You must validate with the New Mexico Tech Business Office before your registration process can be considered complete. Students who are not validated by the Wednesday before the drop deadline will be disenrolled from classes.

## Course Abbreviations

AE	Aerospace Engineering
ACCT	Accounting
ANTH	Anthropology
ART	Art History
AFAS	Air Force ROTC
BA	Business Administration
BCS Business	Computer Systems
BIOL	Biology
CE	Civil Engineering
CED	Community Education
CERT	CED Certificate Program
CH E	Chemical Engineering
CHEM	Chemistry
CSE	Computer Science Engineering
ECON	Economics
EDUC	Education
EE	Electrical Engineering
EMGT	Engineering Management
ENGL	English
ENVE	Environmental Engineering
ENVS	Environmental Science
ERTH	Earth Science
ES	Engineering Science
FA	Fine Arts
FIN	Finance
FREN	French
GEOC	Geochemistry
GEOL	Geology
GEOP	Geophysics
GERM	German
HIST	History
HW	Health & Wellness
HYD	Hydrology
IT	Information Technology
LIFE	Lifestyle
MATE	Materials Engineering
MENG	Mechanical Engineering
MATH	Mathematics
ME	Mineral Engineering
METE	Metallurgical Engineering
MGT	Management
MKT	Marketing
MUS	Music
OPT	Optics
PETR	Petroleum Engineering
PHIL	Philosophy
PHYS	Physics
PR	Physical Recreation
PS	Political Science
PSY	Psychology
SPAN	Spanish
ST	Science Teaching
TC	Technical Communication
WGS	Women's and Gender Studies

## Other Abbreviations, Acronyms, and Terms Used at Tech

AOC	Array Operations Center	NRAO	National Radio Astronomy Observatory
CC	Community College/Continuing Education	OCLC	Library Database
CEMED	Center for Energetic Materials and Devices	OIEP	Office of International and Exchange Programs
CSS	Center for Student Success	OST	Optical Surfacing Technology
DE	Distance Education	PAS	Performing Arts Series
E&ES	Department of Earth and Environmental Science	PASSCAL	IRIS's Program for Array Seismic Studies of the Continental Lithosphere
EEG	Environmental Evaluation Group	PRRC	Petroleum Recovery Research Center
ECO	Etscorn Campus Observatory	R&ED	Research and Economic Development Office
EMRTC	Energetic Materials Research and Testing Center	RA	Resident Assistant
EODI	Educational Outreach and Distance Instruction	RCN	Residential Computing Network
FacMgmt	Facilities Management	ROTC	Reserve Officer Training Corps
FE exam	Fundamentals of Engineering exam	SA	Student Association
GOLD	Group Opportunities for Learning and Development	SAC	Student Activities Center
GPA	Grade Point Average	SAIC	Science Application International Corporation
ICASA	Institute for Complex Additive Systems Analysis	SUR	Student and University Relations Office
IERA	Institute for Engineering Research and Applications	TA	Teaching Assistant
ILEA	International Law Enforcement Academy	TAC	Tech Authorization Code (for long-distance telephone access)
IRIS	Incorporated Research Institutions for Seismology	TCC	Tech Computer Center
ISD	Information Services Department	UC	User Consultant (at the TCC)
ITV	Instructional Television	VLA	Very Large Array radio telescope
LIBROS	Tech Library's On-Line Catalog	VLBA	Very Long Baseline Array radio telescope
MEVO	Mount Erebus Volcano Observatory	VSQ	Visiting Scientists' Quarters
MRO	Magdalena Ridge Observatory	WIPP	Waste Isolation Pilot Project
MROI	Magdalena Ridge Observatory Interferometer		
MSEC	Mineral Science and Engineering Complex		
NCKRI	National Cave and Karst Research Institute		
NMBGMR	New Mexico Bureau of Geology and Mineral Resources (often referred to as "the Bureau")		
NMCCNS	New Mexico Common Course Numbering System		

# The University

## An Overview of New Mexico Tech

New Mexico Institute of Mining and Technology, commonly known as New Mexico Tech, is devoted to excellence in education and research. The atmosphere is casual, and each student can expect to be recognized as a distinct individual.

New Mexico Tech students may choose from programs in the earth sciences, physical and biological sciences, engineering disciplines, technical communication, mathematics, management, computer science, and information technology. In addition, breadth and enrichment are provided by supporting programs in the arts, humanities, and social sciences. The New Mexico Tech student gains a liberal education, as well as a thorough science, mathematics, and engineering education.

At New Mexico Tech there is no artificial distinction between pure and applied research and no sharp dividing line between teaching and research. The New Mexico Tech student is challenged to learn, to think in the abstract, and to bring abstractions to bear on practical situations. Employment of students in the many research facilities and in departmental research is central to New Mexico Tech's programs.

Undergraduate students can choose from among 21 bachelor of science programs or pursue a degree in general studies (Associate of General Studies and Bachelor of General Studies), an interdisciplinary degree that allows students to create a unique educational portfolio structured to specific interests and career goals. Graduate programs extend through the doctoral level and contribute to the research atmosphere that also benefits undergraduate instruction. Many graduating seniors continue their studies in graduate or professional schools.

With an enrollment of approximately 1,900 students, New Mexico Tech offers the advantages of small classes—the average class size is 14 students for lectures and only 12 students in lab sessions. (Introductory classes are usually larger.)

Although New Mexico Tech does not offer athletic scholarships or participate in major spectator sports, students participate in a rich variety of intramural, club, and individual sports activities. Student organizations cater to professional, hobby, religious, and social interests.

## The Campus

New Mexico Tech's beautifully landscaped campus

is an oasis of green in the desert, with tall trees, grassy lawns, and flowerbeds. The central section of 320 acres contains academic buildings, laboratories, residence halls, family housing, and recreational areas. An additional 40 square-mile area adjoining the main campus is used for research and testing activities. Socorro Peak, with an elevation of 2,208 m (7,243 ft) above sea level, is immediately west of the campus quadrangle and contains a mine now used for seismic studies. Recreational areas on campus include the Joseph A. Fidel Student Services Center, Student Activities Center (SAC), Swim Center, tennis courts, Macey Theater/Conference Center, the Etscorn Campus Observatory, the Gymnasium, and an 18-hole Golf Course.

## A Brief History of New Mexico Tech

What began over a century ago as a mining school has evolved into an important research and educational institution. New Mexico Tech was founded as the New Mexico School of Mines in 1889, when it was established by an act of the Territorial Legislature. Over the years, Tech's emphasis has expanded, first into the area of petroleum engineering, and then, in the 1940s, into physics research. Today, New Mexico Tech is known for its expertise in highly specialized areas such as earth and atmospheric sciences, astrophysics, testing of energetic materials, and such engineering fields as chemical, civil, electrical, materials, mechanical, environmental, petroleum, and mineral engineering.

In addition to the educational arm of the Institute, New Mexico Tech has numerous research and service entities, including the New Mexico Bureau of Geology and Mineral Resources, the Research and Economic Development Division, the Petroleum Recovery Research Center, the Energetic Materials Research and Testing Center, Optical Surfacing Technologies, Langmuir Laboratory for Atmospheric Research, the Institute for Complex Additive Systems Analysis, and Incorporated Research Institutions for Seismology.

In recognition of the growing role of the Institute, the State Legislature changed the name in 1951 from "New Mexico School of Mines" to "New Mexico Institute of Mining and Technology," which is still the official name. The name "New Mexico Tech" came into common use in the 1960s.

The graduate program was begun in 1946 and involves staff and facilities of the entire Institute.

## Our Mission

New Mexico Tech is an institute of higher learning that serves the diverse population of New Mexico by integrating education, research, public service, and economic development through emphasis on science, technology, engineering, mathematics, natural resources, communication, and cultural awareness. Our mission is to:

1. help students learn creative approaches to addressing complex issues;
2. acknowledge state, national, and global diversity by developing an inclusive learning environment;
3. create and communicate knowledge;
4. solve technical and scientific problems.

### Institute-Wide Student Learning Outcomes:

New Mexico Tech bases its curricula and its co-curricular activities on the following student learning outcomes; we continuously assess the level of achievement our students demonstrate in these outcomes. NMT students will:

1. learn to reason well and to evaluate and apply information;
2. develop analytical and quantitative skills for competence in science and math;
3. communicate to different audiences in multiple forms;
4. exercise their role as members of diverse societies and cultures;
5. learn responsible values and ethics for their professional lives;
6. gain expertise in their chosen field of study.

## Institutional Values

New Mexico Tech is a community of people who are guided by certain values as they perform their professional tasks and develop initiatives. More than operating procedures as they are fundamental to our endeavors, our institutional values are:

Creativity, excellence, integrity, collegiality and citizenship, service, leadership, and commitment to economic prosperity and technological development.

### • Creativity

Creativity is integral in virtually all endeavors. It calls for curiosity, adaptability, resourcefulness, and requires imagination, vision, and diligence. Whether the task being performed is by a NMT carpenter, secretary, graduate student, or regent, our institution encourages, and expects, creativity. Creativity is

demonstrated by faculty, staff, and administrators in our various student learning initiatives.

### • Excellence

Excellence speaks for itself. New Mexico Tech is known for the high quality of its education and research but we aspire to an apex of excellence in which the whole is greater than the sum of its parts. At this level, excellence is rewarded at New Mexico Tech.

### • Integrity

Integrity is honored as a fundamental value at New Mexico Tech. Dishonesty cheating, and plagiarism have no place in a respected institution of higher education. But real integrity goes further than these negatives; integrity means having the courage to defend the truth, to act fairly and honestly in all our endeavors, and to be responsible members of the community.

### • Collegiality and Citizenship

New Mexico Tech is a place where people care about each other and demonstrate social responsibility. That sense of caring and responsibility we call collegiality and citizenship. Demonstrating collegiality and citizenship means being open with others, sharing with them, and collaborating with them for the good of the Institution. Practicing collegiality and citizenship also means mentoring: acting as a guide and advisor to a colleague, a student, an associate, a coworker.

Collegiality and citizenship includes caring about and contributing to the community—the campus community, the community of Socorro, the larger community of the State of New Mexico, and the global community. Collegiality and citizenship means valuing the diversity of race, gender, ethnicity, and nationality that creates our community.

### • Service

As a community of learners, New Mexico Tech also acknowledges a responsibility to serving society, especially since learning helps meet not only individual needs, but also those of the larger community. Service is a source of motivation and inspiration to those who practice it, reflecting both a capacity for relating to others, as well as deep-level concern for the quality of human life. The social benefits of service are further fulfilled through the expansion of knowledge by teaching, scientific investigation, technology transfer, economic development, and outreach programs.

## • Leadership

New Mexico Tech has been, is, and will continue to be at the forefront of science, technology, engineering, mathematics, and communication research, design, and education. Creating an open environment that also develops and fosters tomorrow's leaders is of paramount importance. Leadership involves motivational methods that influences others to share a vision of our university's mission and outcomes – toward a common understanding of where New Mexico Tech is now and where it is heading and toward an increased commitment to a continuous achievement of those visionary ends. By inspiring, engaging, enabling, and empowering others throughout the university, members at all levels and in the variety of disciplines, areas, and programs can take on leadership roles. Strong, effective leadership is best exemplified not through methods of control, but through positive influence.

## • Commitment to Economic Prosperity and Technological Development

New Mexico Tech promotes regional and state economic prosperity and technology development through its academic and resources. In addition to preparing the workforce of tomorrow through academic rigor and practical research experience, the university provides strategic support, technical assistance, technology transfer, And development and implementation of bold new research initiatives, enabling technologies and training programs to bolster both public and private sector success and competitiveness. Furthermore, New Mexico Tech is committed to integrating diversity into all facets of its work since the intrinsic value of understanding and respecting similarities and differences among all groups is central to fully achieving the university's comprehensive academic, research, and outreach goals and objectives.

## Accreditation

New Mexico Tech is accredited by the North Central Association of Colleges and Secondary Schools as a doctoral degree-granting university. Its credits are accepted by leading colleges and universities throughout the United States. It is approved by the Attorney General of the United States for the attendance of non-immigrant students, by the United States Department for Exchange Visitor Program P-I-1282, and by the Veteran's Approval Division of the Office of Military Affairs for attendance by students entitled to veteran's benefits.



### HLC Contact Information:

New Mexico Tech is accredited by [The Higher Learning Commission](http://www.ncacihe.org/), which is part of the North Central Association of Colleges and Schools. <http://www.ncacihe.org/> (312) 263-0456.

### NMT Contact Information:

New Mexico Tech 801 Leroy Place Socorro NM 87801  
575-835-5434

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The chemistry curriculum is approved by the Committee on Professional Training of the American Chemical Society.

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The bachelor's programs in chemical engineering, civil engineering, electrical engineering, mechanical engineering, environmental engineering, materials engineering, mineral engineering and petroleum engineering are accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

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The Computer Science and Engineering undergraduate program is accredited by the Computing Accreditation Commission (CAC) of ABET, <http://www.abet.org>.

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New Mexico Tech is also a member of the American Society for Engineering Education.

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The Graduate School is a member of the Council for Graduate Schools in the United States.

# Research and Service Organizations at New Mexico Tech

New Mexico Tech has a number of organizations whose missions involve research and/or public service. Many of these organizations employ students at the graduate and undergraduate levels, providing students not only with employment but also with educational work experiences that enhance their value to future employers.

## Center for Energetic Materials and Devices (CEMED)

The Center for Energetic Materials and Devices (CEMED) is a research organization that develops applications for energetic materials and energetic devices. It consists of New Mexico Tech, Sandia National Laboratories, and Los Alamos National Laboratory in a consortium that is administered by New Mexico Tech. The facilities of the CEMED partners are world-class and CEMED's development capabilities include more than 200 professional staff, state-of-the-art laboratories, thousands of acres of field test ranges and access to the most advanced computational equipment available.

The prime advantage to CEMED's customers is the single entity working on the customer's research problem with the facilities and skills of three research organizations. CEMED provides cost effective design, development, and testing of energetic devices for commercial, civilian and military applications. CEMED also provides educational opportunities for undergraduate students, graduate students and post doctoral researchers. These students are the future workforce for research and development of energetic materials and devices both in New Mexico and around the country.

## Energetic Materials Research and Testing Center (EMRTC)

([www.emrtc.nmt.edu](http://www.emrtc.nmt.edu))

In existence for more than 50 years, the Energetic Materials Research and Testing Center (EMRTC) is the largest of the research divisions at New Mexico Tech.

EMRTC conducts research on the performance and safety of energetic materials and explosives for the U.S. Government, friendly foreign governments,

and academic and commercial entities at its 40-square mile field test laboratory. This complex includes more than 30 separate test sites, gun ranges, and state-of-the-art research laboratories. EMRTC also develops tools to analyze material interactions by using computer codes designed to simulate detonation, fragmentation, and impact.

To support the educational and research processes of New Mexico Tech, EMRTC provides joint appointments for faculty and staff and opportunities for graduate and undergraduate student employment.

EMRTC hires up to 30 undergraduate and graduate students each semester and through the summer months. The opportunities provided include construction, design, analysis, test setup, instrumentation and data collection, film analysis, report preparation, and other valuable work experiences for the real world. Many of EMRTC's student workers have been able to get jobs (some at EMRTC) based on the experience they gained while working at EMRTC.

EMRTC also develops and conducts a program of training courses for federal, state, tribal, and allied government agencies; academic institutions; and commercial entities in the following areas:

- **National Domestic Preparedness** — EMRTC is a member of the National Domestic Preparedness Consortium (NDPC), a partnership of public and private organizations whose goal is to provide a focused, threat-responsive, long-term national capability to execute and sustain a comprehensive and coordinated domestic emergency responder education, training, testing and exercise program.

EMRTC conducts this training for state, county, and city officials who are responsible for responding to terrorist incidents. Trainees actively engage in scenario-based activities designed to provide practice in the skills they will use on the job. First responders and other participants from every state in the nation have been trained at EMRTC.

- **Anti-Terrorist Research and Training** — EMRTC's anti-terrorist activities include research and test programs conducted to develop means for reducing injury and for mitigating damage caused by terrorist bombings and other incidents.

In addition, EMRTC conducts several anti-terrorist training programs under a grant from the Department of State for students from allied foreign governments. New Mexico law enforcement personnel have also attended these courses.

- **Explosives Safety** — EMRTC conducts research and training programs in explosives and energetic materials safety. Research includes investigations of materials handling, storage, and transportation. Training includes acquainting personnel who operate government and commercial firing sites and laboratories involved in the research, development, testing, and evaluation of energetic materials with safety requirements and techniques.

As a result of its diversified business areas, wide-ranging research and test activities, and ever expanding training programs, EMRTC synergistically complements New Mexico Tech's educational and research responsibilities, enhances employment opportunities, and significantly contributes to the economic development of New Mexico.

## **Institute for Complex Additive Systems Analysis (ICASA)**

*(www.icasa.nmt.edu)*

The Institute for Complex Additive Systems Analysis (ICASA) is a cooperative alliance among academia, industry, and government that New Mexico Tech administers under contract with the Department of Defense along with the support of the state of New Mexico. This alliance is dedicated to studying the behavior, vulnerabilities, and predictability of complex systems through ICASA's unique approach, known as the Complex Additive Systems Analysis (CASA) process. This process gathers information-age research and applies this research to real-world problems.

ICASA's basic research focus is to understand the additive effects—or unintended consequences—of efficient design in interdependent systems of systems. Research is pursued through four strategic thrusts: carrying out basic research on complex additive systems; applying research to real-world problems in the private and public sectors; developing key enabling technologies to assist in applying research results; and establishing training and education programs to meet customer's unique needs. ICASA's research is characterized by the study of dynamical systems, control theory, mathematical physics, and economics using the tools of theoretical analysis, modeling, and simulation.

ICASA's Electrical Power (EP) team works to understand and model cascading power failures. The EP team uses the CASA process, mathematical

modeling, computer simulation and visualization, hardware implementation, and control of dynamical systems to analyze power grids. Currently, they are working on a multimillion dollar training and decision support system that will allow power operators to react more effectively to power grid failures.

The primary function and goal of ICASA is to assist and encourage the implementation of formal degree programs at New Mexico Tech. These programs integrate components of the computer science, engineering, and management departments. The first integrated program was Information Technology (IT), which is jointly managed by the computer science and management departments. The IT program has since flourished from a small venture into a full-fledged accomplished program by being the only IT program offered in the state of New Mexico. It was also named as a Center of Excellence in Information Assurance by the National Security Agency (NSA) in 2002. Only 50 universities in the nation have been awarded this designation. ICASA will continue to assist and support more degree programs, which may include the combining of computer science and engineering as well as other disciplines.

ICASA offers New Mexico Tech undergraduate and graduate students, and on occasion, commendable high school seniors throughout the state, opportunities to research real-world problems. Students in their freshman or sophomore years may apply for a Student Research Initiative (SRI), a program that introduces the basic principle of complex additive systems and the CASA process. Project topics include electrical power, financial networks, research organizations, and epidemics. Students also learn about the development and presentation of scientific research while working with a mentor.

SRI is part of ICASA's career path program designed to take a student from basic research projects during their freshman and sophomore years to student internships for their junior and senior years. Eventually, opportunities may be offered for graduate assistantships and a professional appointment with ICASA or their partner organizations. As ICASA continues to grow and embrace new disciplines, New Mexico Tech students are offered additional educational and research opportunities through the institute.



## **Institute for Engineering Research and Applications (IERA)**

*(iera.nmt.edu)*

The Institute for Engineering Research and Application is a contract research, development and technical assistance organization working in a variety of areas that are related to energy, space, and the environment. IERA includes an administrative office and three technical divisions, all located in Albuquerque: the Environmental Finance Center, the Engineering and Information Sciences Division, and the Strategic Programs Office.

The Environmental Finance Center (EFC) was established in 1992 by the Environmental Protection Agency to provide assistance to state, local, and tribal governments and the private sector with the financial and managerial side of environmental compliance and infrastructure. The EFC provides technical assistance to tribal water systems to improve compliance with the Safe Drinking Water Act and to build and enhance the capabilities of tribal water system operators and managers. The EFC is also involved in Source Water Protection, alternative wastewater treatment methods, Clean Air Investment Fund, utility rate setting, tribal water system operator certification, and many other activities associated with environmental and security issues surrounding drinking water and waste water systems.

The Engineering and Information Sciences (E&IS) division is involved in endeavors ranging from educational and technical assistance to innovative research, engineering and prototype development. Since 1996 IERA has offered training in geographic information systems (GIS) and global positioning systems (GPS), provided in the form of ESRI GIS and Trimble GPS short courses taught by certified instructors. The Energy Conversion Research Laboratory (ECRL) is the center of all direct energy conversion, power, propulsion and other laboratory based R&D activities in the E&IS division. The resources of the ECRL are focused on conducting advanced R&D and T&E in each of these areas, with major resources focused on conducting highly realistic testing of space components and systems. Personnel expertise includes non-nuclear testing of space nuclear power systems, liquid metal systems (NaK, sodium, potassium, lithium, cesium and mercury), thermionic direct energy conversion technology, pulse power systems, electronic systems, laser propulsion

technology, high vacuum systems, concept/prototype system design, modeling and simulation, and materials development and characterization.

The Strategic Programs Office fosters growth of new areas and incubates a wide variety of research and applications. Currently, there are two efforts in international programs. First is the development and implementation of chemical/biological sensors and the establishment of the International Sensor Technology program within New Mexico Tech. Second is participation in a program to mentor and train engineers from foreign countries with regard to radioactive waste disposal issues (sponsored by the International Atomic Energy Agency and USAID). Additionally, investigators are working on energy conservation/energy efficiency studies for various agencies and are participating in the development of a hydrogen economy in the state of New Mexico.

## **International Law Enforcement Academy (ILEA)**

*(www.ilearoswell.org/mission.html)*

The mission of the International Law Enforcement Academy—Roswell (ILEA-R) is to provide advanced criminal justice management instruction to mid- to senior law enforcement officials from around the world and expose them to American society and institutions. ILEA's goals are to enhance the ability of experienced law enforcement officials to combat crime in their respective countries and encourage bilateral and regional cooperation in combating transnational crime.

ILEA-R is a program of the U.S. Department of State, Bureau for International Narcotics and Law Enforcement Affairs.

ILEA-R is administered through a cooperative agreement with the New Mexico Tech. Tech has partnered with Science Applications International Corporation, Sam Houston State University and Eastern New Mexico University - Roswell to operate the Academy.

## **IRIS PASSCAL Instrument Center and EarthScope USArray Array Operations Facility**

*(www.passcal.nmt.edu)*

The Incorporated Research Institutions for Seismology (IRIS; *www.iris.edu*) Consortium's Program for Array Seismic Studies of the Continental Lithosphere

(PASSCAL) Instrument Center is located in New Mexico Tech's Research Park. The Center is primarily supported by the National Science Foundation (NSF) and U.S. Department of Energy, and is operated by Tech professional staff in coordination with the Department of Earth & Environmental Science Geophysics Program and the Geophysical Research Center. In association with researchers and students from around the world, Instrument Center staff engage in hardware/software development and training associated with earthquake, volcano, glaciological, and other seismological research, handle logistical support and fieldwork for Earth science experiments, and maintain the world's largest academic pool of research seismological instrumentation. PASSCAL instruments are routinely employed in teaching and research projects with investigators from Tech's Geophysics Program, as well as many other U.S. and international research institutions. A key component of the Instrument Center's operations is to provide unique opportunities for New Mexico Tech and other students to learn about and contribute to the international seismological research community through employment, internships, and other opportunities.

The Instrument Center also hosts the Array Operations Facility for the seismological USArray component of EarthScope ([www.earthscope.org](http://www.earthscope.org)), an NSF Earth Science research project of unprecedented scope studying the geology and geophysics of the North American continent and the deep Earth.

## Langmuir Laboratory for Atmospheric Research

([www.ee.nmt.edu/~langmuir](http://www.ee.nmt.edu/~langmuir))

Langmuir Laboratory, built by New Mexico Tech in 1963, is located at an elevation of 3,240 m (10,630 ft) in the Magdalena Mountains, 27 km (17 air miles) southwest of the main campus. The laboratory was named in honor of Dr. Irving Langmuir, Nobel Prize winner, who participated in numerous experiments at Tech related to cloud physics after the discovery of cloud seeding in 1946. Because of its location and unusual climatic situation, the site provides unique opportunities for studies of thundercloud mechanisms, lightning, and precipitation. Overnight living accommodations are available for faculty and students working at the laboratory.

The Langmuir Research Site consists of 33,000 acres of Cibola National Forest which surrounds

Langmuir Laboratory. Public Law 96-550, passed by Congress in 1980, preserves the land in its undeveloped state and encourages scientific research as a prime land use in this national forest. Restricted Airspace R-5113 supports flights of instrumented airplanes, rockets, and balloons. The laboratory is operated under a special use permit issued by the U.S. Forest Service.

## Magdalena Ridge Observatory (MRO)

([www.mro.nmt.edu](http://www.mro.nmt.edu))

The Magdalena Ridge Observatory's 2.4-meter telescope is now operational. It is optimized for observations of Solar System objects.

The Magdalena Ridge Observatory Interferometer (MROI) is currently in construction and development stages, and will be a world-class, state-of-the-art astronomical research facility. At an elevation of almost 10,400 feet in the Magdalena Mountains of the Cibola National Forest, and just a one-hour drive from campus, the MRO will be the fourth highest observatory in the world.

Using interferometry, the same technique used at the Very Large Array (VLA) radio telescope to link 27 separate radio receivers to form one gigantic instrument, the MRO interferometer will link ten large optical and infrared telescopes to provide the resolving power of a single 400-meter telescope. This instrument will have better optical resolution than the Hubble Space Telescope by a factor of 300.

## Mount Erebus Volcano Observatory (MEVO), Antarctica

([erebus.nmt.edu](http://erebus.nmt.edu))

The Department of Earth and Environmental Science operates a year-round network of scientific instrumentation (seismic, infrasonic, geodetic, and environmental) on the active Mount Erebus volcano in Antarctica for fundamental research in volcanology under support from the National Science Foundation, Office of Polar Programs. Each year, Austral summer observations and surveillance are made by New Mexico Tech students and faculty from a field camp situated 3400 meters high on the volcano. Mt. Erebus, the world's southernmost active volcano, features a unique lava lake in its summit crater and has frequent eruptions. Data is telemetered to the Crary Science Lab at McMurdo Station, Antarctica, and then transferred via the Internet to Tech for year-round analysis and archiving in near real time.

## **National Cave and Karst Research Institute (NCKRI)**

(<http://www.nature.nps.gov/nckri/index.htm>)

In Public Law 101-578, of November 15, 1990. Congress directed that the Secretary of the Interior, acting through the Director of the National Park Service, establish and administer a National Cave and Karst Research Institute (NCKRI). This center is located in Carlsbad, New Mexico and New Mexico Tech is responsible for the planning, coordination, and administration of the Institute and its programs.

Cave and karst systems are vital to humankind in myriad ways. The protection and management of water resources have been identified as major issues facing the planet as we enter the 21st century. As much as 35% percent of America's freshwater resources are tied up in groundwater in cave and karst regions including evaporite sequences. Caves also serve as rich storehouses of information about natural resources, human history, evolution, and global climate change—not to mention such current concerns as waste disposal, petroleum recovery, and biomedical investigations.

The goals of the Institute are the furtherance of the science of speleology; centralization and standardization of speleological information; interdisciplinary cooperation in cave and karst research programs to foster research, education, promotion of national, and international cooperation in environmental considerations for the protection of cave and karst landforms, and promotion of environmentally sound, sustainable resource management practices.

Program areas considered essential to such an Institute's mission include information management, research, and education.

## **National Radio Astronomy Observatory (NRAO)**

([www.nrao.edu](http://www.nrao.edu))

NRAO is not a division of New Mexico Tech (it is funded by the National Science Foundation), but its office on the New Mexico Tech campus operates two major radio telescopes: the Very Large Array (VLA) and Very Long Baseline Array (VLBA).

## **New Mexico Bureau of Geology and Mineral Resources (NMBGMR)** ([www.geoinfo.nmt.edu](http://www.geoinfo.nmt.edu))

The New Mexico Bureau of Geology and Mineral Resources is the official state agency responsible by law for original investigations of geology and mineral and water resources in New Mexico. The Bureau investigates, evaluates, and disseminates information on geology, mineral, water, and energy resources, and extractive metallurgy—with emphasis on aiding the discovery and responsible development of nonrenewable resources for the benefit and well-being of the citizens of this state. The director of the Bureau also serves as State Geologist.

Although primarily a technical organization providing counsel to state and federal agencies, as well as extractive industries, the Bureau also serves all interested citizens by advancing the understanding of the state's geology and natural resources. Environmental geology and geohydrology are increasingly important parts of the Bureau's service and applied research.

The Bureau's Mineral Museum represents one of the most outstanding mineral collections in the United States. The collections contain more than 16,000 mineral, rock, mineral product, mining artifact, and fossil specimens. Specific displays highlight minerals from the New Mexican mining districts and the southwestern United States, as well as fluorescent minerals. Other significant specimens from around the world are also displayed. In addition to display specimens, a reference collection of New Mexico rocks, ores, and minerals is available for research. A museum demonstration facility allows for hands-on explorations into earth science phenomena as well as illustrating the importance of mineral products in modern society.

The New Mexico Library of Subsurface Data contains more than 6.5 million individual cuttings samples from 16,300 different oil, gas, and water wells drilled in the state. The samples, taken from different levels to show various strata, are valued at more than \$1 million. Collected for more than 50 years, the cuttings samples also represent tests for uranium, coal, and other minerals. The library also contains well logs from approximately 49,000 wells and driller's logs from more than 15,000 wells. A core library contains selected cores from petroleum and mining

drill holes throughout New Mexico. All are available for study. Basic information on 100,000 wells in the state is also available.

The information assembled by the Bureau staff of scientists is provided to the public through maps, publications, and direct response to individual inquiries. Publications are distributed throughout the world on an exchange agreement with other geological surveys. Exchange publications are kept for reference in the Tech library. By furnishing vital scientific information and advice, the Bureau aids in the establishment of new mining and petroleum operations and new energy and mineral industries in the state, as well as in the expansion and diversification of existing resource industries and the state's water supplies.

The extensive laboratories of the Bureau are designed and equipped for analysis and experimentation in a wide variety of areas useful to the geosciences. These facilities are used not only in the Bureau programs, but also are available for use in instructional programs by students majoring in geology and metallurgy, and in materials, mineral, and petroleum and natural gas engineering. A substantial number of graduate and undergraduate students are employed by the Bureau. Students work on research projects and in laboratories and offices. In addition, many of the staff also teach classes and advise on student projects.

## **New Mexico Bureau of Mine Safety**

The Bureau of Mine Safety (BMS) exists to actively promote the safety of the miners of New Mexico. BMS trains thousands of miners each year, including miners trained in Spanish language classes. BMS training and initiatives have contributed to a superb safety record in New Mexico.

Directed by the State Mine Inspector, the department is a state and federally funded organization providing services to New Mexico and its miners in the following areas:

### **Mine Rescue and Emergency Response -**

Coordination of incident response, equipment and human resources

### **Legislative Issues Relative to Miner Safety -**

Includes being the point of contact for the Governor's office on mine related issues and legislation

**Mine Compliance Assessment and Courtesy Inspections** – Communicating the legislated mining safety standards and ensuring adherence

**Safety and Health Training** - Providing safety and health training to mine workers, contractors, as well as federal and state organizations involved in special mine-related activities

**Certification of Coal Mine Officials** - Developing and providing an examination process designed to certify qualified coal mine officials

**Safety Award, Other Education & Communication Programs** – Safe Operator of the Year, Zero [accident] Frequency Awards, Small Mine Mentoring Program, BMS website and Informational Meetings are all BMS programs designed to further awareness and actively promote the safety of New Mexico's miners

**Coordination of New Mexico Mine Safety Board (MSB)** – This board promulgates the rules that affect the mining industry in the State of New Mexico

## **New Mexico Petroleum Recovery Research Center (PRRC)** ([baervan.nmt.edu](http://baervan.nmt.edu))

The Petroleum Recovery Research Center (PRRC), the only research center of its kind in New Mexico, is a world-class scientific research organization dedicated to solving problems related to the oil and gas industry. The PRRC's mission is to develop, through theoretical and practical research, improved oil recovery methods to increase oil and natural gas recovery from New Mexico's and the nation's oil and gas reservoirs and to transfer new technology to the industry and to local independents.

Interaction between the educational institution and the PRRC's research staff is extensive. New Mexico Tech offers the only petroleum and natural gas engineering degree program in the state, and students have ample opportunity to participate in ongoing front-line research at the PRRC while pursuing their academic training. The center's current research program includes studies involving the use of gels to reduce water production and increase

reservoir sweep efficiency; improved carbon dioxide (CO<sub>2</sub>) flooding with emphasis on mechanisms that control injectivity; fundamental research on rock/fluid interactions and their influence on oil recovery, with emphasis on studies of wettability alteration and asphaltenes; reservoir characterization using artificial intelligence; CO<sub>2</sub> sequestration studies; and the development of membrane and sensor technologies for use in cleanup of produced water from oil and gas recovery, for high-temperature CO<sub>2</sub> capture, and for the efficient conversion of natural gas into more valuable higher hydrocarbons and hydrogen. Current New Mexico oil and gas production data and related information is disseminated to the public via the center's GO-TECH web site, developed in-house, which is continually expanding as a result of ongoing collaborations with various state and federal agencies and with local independents.

The PRRC employs 20 full-time research and professional personnel, provides research assistantship support to an average of 25 graduate students year round, and employs an average of 22 undergraduate students throughout the academic year. The center's daily operations are conducted at the John M. and Esther L. Kelly Petroleum Building which features general office space, 20 laboratories (approximately 20,000 square feet), specially designed storage areas, a core-cutting and welding facility, machine and woodworking shops, a reports and publications office, and a large seminar room.

## **New Mexico Tech Research and Economic Development Division** ([www.nmt.edu/~red](http://www.nmt.edu/~red))

Faculty and student involvement in research is a distinguishing characteristic of New Mexico Tech. The Research and Economic Development Division (R&ED) encourages research throughout Tech in many ways. R&ED places a special emphasis on encouraging interdisciplinary and collaborative work and not only provides financial support, but also promotes research through professional and technical expertise, services, and facilities.

The main state-supported research component of R&ED is the Geophysical Research Center (GRC). The GRC supports research in atmospheric physics and chemistry, air quality, seismology, and groundwater hydrology. The Langmuir Laboratory for Atmospheric Research (part of the GRC), located in the nearby Magdalena Mountains, is an

internationally recognized facility for research in lightning, cloud physics, and water chemistry. The Incorporated Research Institutions for Seismology (IRIS) is operated in coordination with the GRC and the Tech Geophysics program. The GRC also supports specialized computer facilities for data analysis, the New Mexico Tech Seismologic Observatory, numerous cloud physics radar facilities, and a Schweizer aircraft for in-situ measurements of thunderstorms. Through the GRC, a number of faculty, graduate students, and undergraduate students are supported in their research.

Additional research activities and facilities directly sponsored and supported by R&ED include an astronomical observatory in the Magdalena Mountains and astronomical research on campus in cooperation with the National Radio Astronomy Observatory.

R&ED is Tech's central link for information about potential funding sources and program guidelines for sponsoring agencies. Other R&ED services include a machine shop equipped for specialized research projects, an instrument and supply room that focuses on the distinct needs of researchers, a corporation equipment and maintenance yard, and Tech's hazardous waste and safety office. These groups and the administrative office staff, are available to assist researchers, as well as the entire Tech community. R&ED further serves as a point of contact for economic development. R&ED contributes to New Mexico's growth in the area of technology by cooperating with industry and governmental agencies to move new ideas and discoveries from the academic laboratory into the marketplace.

## **New Mexico Tech Research/Industrial Park**

New Mexico Tech's Research/Industrial Park, 600 acres located west of the main campus, is ideally suited to house industrial firms interested in the development of chemical/explosives technologies; companies seeking a site for testing and experimental procedures more appropriate to a field laboratory setting than a conventional lab; and centers for environmentally sensitive research and development. Tenants of the Research/Industrial Park can benefit from the expertise of Tech faculty and researchers as well as the various research laboratories and support services on campus.

## **New Mexico Tech Seismological Observatory**

(<http://www.ees.nmt.edu/outside/Geop/NMTSO>)

The Earth and Environmental Science Department Geophysics program operates a state-wide network of seismographs dedicated to recording and study of earthquakes and other seismological phenomena throughout New Mexico and the southwestern United States. The program also coordinates earthquake educational outreach activities in association with the Bureau of Geology through support from the New Mexico State Department of Public Safety, the United States Geological Survey, the Incorporated Research Institutions for Seismology (IRIS), the National Science Foundation, and other agencies.

## **Optical Surface Technologies (OST)**

Optical Surface Technologies, LLC is a small high-tech business based in Albuquerque, New Mexico. OST was founded through a joint venture between New Mexico Tech and a private sector firm with high value equipment provided by the Air Force via an educational partnership. OST was spun out of a New Mexico Tech research center with the New Mexico Tech University Research Corporation retaining a minority ownership in the company.

OST provides high-value optical manufacturing products and technical services to government and commercial customers. OST is a full service optical manufacturing company that provides its customers with custom solutions to meet challenging optical requirements. It can fabricate, polish and perform final testing on optics up to two meters in diameter, and can coat optics up to one meter. The company can also provide design, testing, polishing, and measurement services for advanced materials, space and astronomical telescopes, high energy laser optics and specialized custom large optics.

The company's complete "start-to-finish" capability includes optical system design and optimization, fabrication and metrology, full range coating, and complete spectral performance testing. The focus of OST's business is to provide optical hardware that is very specific in application and that meets the most demanding requirements. Some examples of OST products are utilized in space debris tracking, near-Earth observation, laser fusion programs and space cryogenic systems.

## **Playas Research, Development, Test and Evaluation (RDT&E) and Training Complex**

The Playas Research, Development, Test and Evaluation (RDT&E) and Training Complex, located in the "bootheel" of New Mexico, is a "real-world" training center for programs in prevention and response to suicide bombings, terrorist activities, and other related programs. Operated by New Mexico Tech's EMRTC, Playas is used for simulations of urban warfare, emergency preparedness drills, anti-terrorism training, military operations training in urban terrain, hostage negotiation training, and other activities.

The U.S Department of Homeland Security (DHS) has formally committed to using Playas for training purposes during the next five years. Other federal, state, local, and tribal government departments, agencies and organizations have also expressed strong interest in the complex and its capabilities.

## Joseph R. Skeen Library

(<http://infohost.nmt.edu/~nmtlib/>)

The Joseph R. Skeen Library's collection and services support the educational, research, public service, and economic development mission of New Mexico Tech. Although the library maintains a collection of over 600,000 printed books, maps, government documents, and periodicals, the vast majority of the items in the library's collection are digital and are accessible 24/7 through the library's website. The library also works to protect its users' right to privacy, supports intellectual freedom, and upholds intellectual property rights.

Housed in an attractive, three-story building with a prominent clock tower, the Skeen Library actively works to provide a safe, welcoming, and friendly environment. Food, drink, and talking are all allowed in the library, which is open 91 hours a week during the semester. The library houses a coffee shop, 6 study rooms, a presentation seminar room, a variety of flexible technology-equipped group study areas, a computer lab, a popular DVD collection, and a popular reading collection. The library provides the general public with free access to Internet connected computers and wireless Internet connections, as well as having a large number of computers dedicated only for student use.

The library also provides inter-library loan services to students and faculty members thus allowing access to the collections of 70,000 libraries worldwide. Students and faculty who wish to visit other libraries may also request Passports to attain borrowing privileges at other university libraries in New Mexico.

The library also has a collection of archival materials relating to the history of New Mexico Tech (previously known as The New Mexico School of Mines), a map collection, a historical microform collection of Socorro newspapers, an extensive collection of historical geologic and mining materials, and the personal library of the late U.S. Representative Joseph R. Skeen.

To learn more about the library and its staff and services, please visit our website at <http://infohost.nmt.edu/~nmtlib/>

## Tech Computer Center (TCC)

([www.nmt.edu/~tcc/](http://www.nmt.edu/~tcc/))

The TCC is open to students, faculty, and staff while classes are in session. Students in all disciplines

are encouraged to use the facility as a normal part of their course work. The center provides computer access to any regularly New Mexico Tech matriculated student who requests it, subject to TCC regulations and the New Mexico Tech Computer Usage Policy.

Each TCC user is given an e-mail address and access to the Internet, as well as an initial storage space. The TCC has a wide range of scientific software available.

TCC operates a network of Linux, Macintosh, and Windows workstations. At the time of publication, there are more than 300 workstations, all equipped with color screens, on the academic network.

In addition, there are PC labs connected to a Samba server on the campus network. There are also several computer classrooms with computers and integrated projection systems. Several labs have scanners, and all are connected to the network printing system.

The campus network is connected to the National Science Foundation Internet II nationwide computer network. The network connection gives Tech access to other New Mexico colleges, Sandia and Los Alamos national laboratories, and thousands of other sites worldwide.

In addition to the facilities found in the TCC there are many other computer systems on campus used in conjunction with departmental programs and funded research.

The TCC is an integral part of major research projects at Tech. Students and faculty who desire to use of the facilities are encouraged to contact the director of the center at 575.835.5735 or via e-mail at [tcc@nmt.edu](mailto:tcc@nmt.edu).

The TCC also offers free classes each semester to acquaint students with how to use the TCC and the World Wide Web.

## Distance Education

(<http://distance.nmt.edu>)

New Mexico Tech's Distance Education Program uses the latest in Internet-based course delivery technology to offer primarily graduate-level courses in mechanical engineering, materials engineering, engineering management, environmental engineering, petroleum engineering, science teaching, and other disciplines. Distance courses are designated with a "D" following the course number in the New Mexico Tech schedule of classes. Distance education classes usually meet in one of the distance education classrooms in Cramer Hall and often include non-

distance education sections. Students who are not taking a course via distance education but wish to access distance education resources, such as lecture recordings, can sign up for a “V” section, which requires a \$50 Media Resources Fee.

The Distance Education Department also maintains multimedia classrooms on campus that are set up for lecture capture. Students in these courses may, if the instructor wishes, view recordings of lectures accessible from a Web page.

The Distance Education Department also maintains multimedia classrooms on campus that are set up for lecture-capture. Students in these courses may, if the instructor wishes, view recordings of lectures accessible from a Web page.

Admission and course registration can be completed online. The Distance Education staff can assist in handling other program paperwork for students not able to come to Tech’s campus.

For information on distance education courses, contact the department at 575.835.5511, toll-free at 1.866.644.4887, or <http://distance.nmt.edu>. Current course listings of Distance Education courses can be found at <http://distance.nmt.edu/courses>.

## New Mexico Tech Community Education

([www.distance.nmt.edu/cc](http://www.distance.nmt.edu/cc))

The New Mexico Tech Community Education Department provides credit courses in physical recreation, fine arts, as well as non-credit courses for New Mexico Tech students, faculty, and staff and the surrounding community. No degrees are offered through the Community Education Department.

Community Education classes, which are signified by a “C” following the course number, are graded on an S/U basis and can be used as elective credit in most majors. Full-time undergraduate students do not pay extra tuition when these courses are part of their 12-18 hour course load. Graduate students may enroll in a limited number of Community Education classes to supplement their full-time course load on approval from the Graduate Office. Full-time graduate students may enroll for 1 credit of Community Education coursework beyond their 12 hour credit limit, at no extra charge (see page 52 for restrictions).

Students who are not pursuing a degree program are classified as special students. They are limited to a maximum of six credit hours per semester. Special students who have never taken a class at Tech need to complete an Application for Admission Form from the Admission Office. After being admitted, students need to register for the class at the Office of the Registrar.

The Community Education Coordinator may be

reached at 575.835.6581, or at the office in Cramer 201. Further information on the Community Education Department may be found at [www.distance.nmt.edu/cc](http://www.distance.nmt.edu/cc).

## Center for Student Success (CSS)

The Center for Student Success, located in the Joseph A. Fidel Center, serves both faculty advisors and students. We work towards the development of quality advising relationships between faculty and students, as well as provide a wide spectrum of academic support services to help students explore their life goals, interests, and abilities.

Academic advisors are assigned to undergraduate students from among the faculty in their major department. Undecided majors receive counseling and are provided with suitable interim advisors from the faculty.

## Freshman First-Year Experience Program

The Freshman First-Year Experience program (FYE) is designed to help first year students smoothly transition from high school to New Mexico Tech. The program is an advocate for student success and fulfillment both inside and outside the classroom. The major component of the FYE program is the Freshman Seminar, EDUC 101. Freshman Seminar is a one credit hour course which covers the “how to’s” of becoming successful Tech student. Topics covered in the course include: college study skills, learning style, test-taking skills, time and stress management, goal setting, personal responsibility and money management.

## Academic Counseling

Individual and group counseling is offered to help students identify their learning style and develop academic success skills such as time and stress management, study skills, and adaptive choice-making.

## Group Opportunities for Learning and Development (GOLD Tutoring Services)

GOLD is an academic assistance program based upon the idea that successful students can help other students. The GOLD tutoring services offer help in biology, computer science, chemistry, physics, math, and other courses. It is administered through the CSS, and services are free.



## Writing Center

The Writing Center assists both graduate and undergraduate students with many forms of writing from essays, technical papers, to resumes and everything in between. Hours are drop-in. Services are free and are offered each regular semester.

## Academic Referral

The Academic referral program is designed to identify and aid students who are having academic problems and to help them deal with those problems early in a given semester. The program serves students who are referred by faculty members, students on probation, and students who are academically under prepared for the rigorous and demanding curricula at New Mexico Tech.

## Student Affairs

The goal of the Student Affairs office is to help Tech students succeed in college. Offices include Career Services, Counseling Services, Multicultural Programs, and International and Exchange Programs. Staff are available to provide students with information and advice on subjects including learning about a chosen profession, applying to study abroad, developing a time management plan, helping to find a scholarship, and dealing with a personal problem. Located in the Joseph A. Fidel Center, offices are open 8 a.m. to 5 p.m. daily.

## Career Services

Career Services provides career counseling; resume, cover letter, and interviewing skills assistance; and listings of permanent, temporary, on-campus, internship, fellowship, and research positions. Career Services is responsible for Career Fairs, the Cooperative Education program, maintaining placement records, sponsoring workshops on aspects of graduate school and job search processes, and providing assistance to employers, including scheduling information session and on-campus interviews. Although Tech assumes no responsibility for obtaining employment for its students, every effort is made to assist those who take advantage of Career Services. Information is available at [www.nmt.edu/career-services](http://www.nmt.edu/career-services).

## Counseling Services

Counseling Services provides students with individual, couples/family, and group counseling, outreach programs, and consultation. We adhere to the Code of Ethics of the New Mexico Board of Social Work Examiners. All services are strictly confidential and are

free to students enrolled for six or more credits hours. The office is located in the Joseph A. Fidel Center and is open from 8 a.m. to 5 p.m. weekdays. Crisis intervention is available; counseling is provided by New Mexico independently licensed clinical social worker and substance addiction therapist.

## Disability Services

Disability Services arranges academic accommodations for students who have documented disabilities that affect their ability to participate on an equal basis with students who do not have disabilities. Students with sensory, mobility, learning, psychological, or other recognized disabilities are encouraged to contact this office to assist with accommodations. The office is located in the Joseph A. Fidel Center and is open from 8 a.m. to 5 p.m. weekdays. Students are encouraged to request services well in advance of the start of the semester to allow adequate time to make needed arrangements. Students must provide current documentation to be eligible for accommodations. New Mexico Tech is committed to ensuring that the campus is accessible to all individuals.

## Multicultural Programs

Multicultural Programs helps recruit and retain U.S. ethnic minority students. New Mexico Tech supports student chapters of the American Indian Science and Engineering Society (AISES), the Society of Hispanic Professional Engineers (SHPE), and the Society of the Advancement of Chicanos and Native Americans in Science (SACNAS). Multicultural Programs works to provide academic and financial support as well as providing information about opportunities within and outside the institution. Multicultural Programs is in the Admission Office on the second floor of the Joseph A. Fidel Center. The phone number is 575.835.5424.

## International and Exchange Programs

Student Affairs is responsible for International and Exchange Programs. The office provides advice and counsel to international students, especially with regard to visa-related matters. It also coordinates activities, both on- and off-campus, designed to help students from other countries make the transition to living in the United States and Socorro. These activities include orientations, international receptions, International Education Week, and Global Village Day.

In addition, the office maintains information about study abroad opportunities in other countries, coordinates Tech's student exchange program with a number of foreign universities (page 30), and participates in the New Mexico International Education Consortium.

# Student and Campus Life Residential Life

<http://externalweb.nmt.edu/reslife>

New Mexico Tech housing consists of nine student residence halls and 26 family housing units located on campus, as well as one apartment complex off campus. All are within walking distance to classrooms, labs, the computer center, child care, research facilities, food service, and the bookstore. If you are a regular, full-time student, you are eligible to live on-campus.

Four of the halls (Driscoll, Presidents', West, and South) sit on Tech's tree-lined Campus Drive, close to the gym, Joseph A. Fidel Student Center, athletic field, Student Activity Center, swimming pool, and tennis courts. The Altamirano Apartments and Baca Hall are just a block farther away. Desert Willow Apartments and the Guest House are southwest of these halls. Mountain Springs Apartments are on the corner of Bullock Boulevard and El Camino Real (two blocks from campus).

Rooms typically come with a twin bed, desk, chair, closet, and dresser. Apartments typically have a couch, chairs, coffee table and end tables. Family units and Mountain Springs single bedroom units are not furnished. All rooms come with ethernet ports. Free laundry machines are located in each building (except Mountain Springs).

**Driscoll Hall** was designed with friendliness in mind. Both floors have large, open lounge areas, which are pleasant for group study and socializing. There is also a community kitchen. Rooms open into an interior hallway. Each wing shares a large, communal bathroom, and each room has its own sink. The average room size is 14' X 14'.

**Presidents' Hall** is one of New Mexico Tech's most historic buildings. It features large, comfortable rooms with a community bathroom. Presidents Hall is a non-coed hall that houses both males and females. The building is split into two sections that are completely separate from one another. Female residents are located on the first and second floors while male residents reside in the lower level. Access keys will not allow entrance into opposite sex floors.

**West Hall**, an all male residence hall, is adjacent to the Joseph A. Fidel Center dining room. This two-story, closed hall has four wings, each of which shares a common bath. Hallways run on the interior of the building with room windows surrounding the exterior. Average room size is 20' X 11'.

**South Hall** has each room opening directly to the outside. This co-ed community features rooms arranged in suites, each consisting of two bedrooms and one bathroom. Each room has its own sink and vanity area, and each suite is shared by four students of the same sex. The average room size is 11' 6" X 19' 10".

**Baca Hall** is a co-ed building arranged in suites, sharing a bathroom among four people of the same sex. Each room also has its own sink and vanity area and the room opens directly to the outdoors. The average room size is 11' 8" X 23' 2". Baca Hall is a part of our specialty housing. Alcohol and tobacco are prohibited regardless of age, and quiet hours are enforced 24 hours a day.

**Altamirano Apartments** this apartment complex offers both four private bedroom, two-bath, and two private bedroom, one-bath apartments. Each apartment is furnished and has a fully functional kitchen and ample closet space. The complex also offers study rooms and open courtyards.

**Desert Willow Apartments** Desert Willow is located in a private cul-de-sac. The two-bedroom (1 private and 1 double), 1 1/2 bath townhouse apartments offer a secure, community-like atmosphere for single students and families. Each building is made up of six apartments, and there are laundry facilities on-site. In addition to the playground out the back door, Tech's Children's Center is just down the street.

**Mountain Springs Apartments** this complex offers off-campus living with on-campus amenities for single students, families, and graduate students. Mountain Springs is located within walking distance, at the corner of Bullock and El Camino Real, with two different two-bedroom layouts and a one-bedroom layout. All apartments include wireless and high-speed internet connections.

**Guest House** this house overlooks the 16th fairway of the Tech Golf Course and is reserved for graduate students and non-traditional undergraduate students. To live in this fully furnished, four-bedroom house, the resident must be over 25 or be enrolled in a graduate program.

If you live on campus, you are expected to abide by Residential Life rules and procedures, which are found in the *New Mexico Tech Student Handbook*, the Room and Board Agreement, and the *Community Standards for Residence Halls* webpage <https://www.nmt.edu/current-student-info/144-residence-halls-standards>.

## Food Court and Meal Plans

<http://externalweb.nmt.edu/reslife>

The New Mexico Tech food service is operated by Chartwells, located in the Joseph A. Fidel Center, and is designed to meet the needs and lifestyles of students. The

dining program offers an array of multicultural cuisine in addition to high-quality home cooking. Chartwells offers meal plans that are flexible, convenient, and excellent in value. Dining options range from fresh foods with unlimited seconds for those students on the meal plan, to an assortment of comfort foods, gourmet coffees, sandwiches, salads, and a la carte selections. Special events and theme dinners are offered each month. Steak and shrimp night is offered every two weeks.

Students living in the traditional halls are required to choose one of the following flex meal plans: 150 +75 Tech dollars, 175 + 50 Tech dollars, 200 + 25 Tech dollars, or 225 + 25 Tech dollars per semester. Students living in the campus apartments are required to purchase one of the following three meal plans; 30 meals + 125 Tech dollars, 50 meals + 50 Tech dollars or 60 meals. Block plans of 25, 60 and 80 meals are available for commuters. Meals and Tech dollars do not carry forward from semester to semester. However, if a student runs low on meals there is a variety of smaller plans that can be purchased at any time.

The food court is open from 7:00 a.m. to 7:00 p.m. weekdays and from 11:30 a.m. to 7:00 p.m. on weekends. Meal plans may be used at any time during these open hours. Tech Dollars may be used in the food court or the Fire and Ice Coffee Shop. Fire and Ice, located adjacent to the food court, is open from 7:00 a.m. to 11:00 pm weekdays and from 2:00 p.m. to 9:00 p.m. on weekends.

## Children's Center

The New Mexico Tech Children's Center offers full-time and part-time quality and developmentally appropriate education and care for children of New Mexico Tech students and employees, as well as community members. Our staff has an uncompromising commitment to excellence. The Children's Center equally places a high priority on responsiveness and close working relationships with each child and family. We offer a relaxed and casual setting for children ages two through six that uses the Creative Curriculum and developmentally appropriate practices of the National Association for the Education of Young Children (NAEYC). Our Center is open year-round, from 7:30 a.m. to 5:30 p.m., Monday through Friday. Please contact the Children's Center at 505.835.5240 or [asullivan@admin.nmt.edu](mailto:asullivan@admin.nmt.edu), or visit the Center located on Olive Lane next to Macey Conference Center for more information.

## Student Health Center

The Health Center is a convenient and confidential way to meet the health needs of Tech students. The

medical staff provides primary medical care, which includes history taking, physical examination, and lab testing as needed for both acute and chronic health problems. The nurse practitioner can diagnose, prescribe and provide treatment. Medical care outside the center's scope of practice will be referred to a physician.

## Extracurricular Activities SCOPE and Master Calendar

The Public Information Office and Information Systems Division (ISD) provide services to help you find out what is happening on campus. Events for the next few days are listed in the left-hand column of the Tech homepage, [www.nmt.edu](http://www.nmt.edu). SCOPE is emailed twice a week, on Mondays and Thursdays. There is also a Tech calendar on the web, covering events for the next few years.

The Public Information Office also provides news releases telling about the latest research and activities on campus. Be sure to check the Tech homepage for the most recent information.

## Student Government

Students at New Mexico Tech assume important responsibilities for the regulation of their affairs. The Undergraduate Student Association is comprised of all enrolled undergraduate students who have paid the Student Activity Fee. Its governing body is the Student Senate, whose members are elected twice a year for one-year terms. With the approval of the Tech administration, the Student Senate regulates extracurricular activities, organizations, and events. The Senate carries out its functions through the creation of its own committees, and its deliberations are open to all students and other interested persons. Any enrolled student may serve in the Senate if properly elected.

The Graduate Student Association (GSA) is comprised of all enrolled graduate students who have paid the Student Activity Fee. The GSA represents graduate students on policy-making committees, including Graduate Council, Faculty Senate, and the Student Association. The association works with the administration to address issues relating to graduate student life at Tech. They award travel grants for graduate students to present research at professional meetings and provide for extracurricular activities for graduate students and their families. The governing body for the GSA consists of officers and representatives from each department.

## Physical Recreation

The Physical Recreation Department enhances campus life by promoting wellness activities and offering instruction, wellness counseling, Intramural sports, and club sports to the Tech community.

A number of Physical Recreation courses are offered for credit, such as yoga, basketball, volleyball, aerobics, golf, zumba, belly dancing, and many more. In addition, Physical Recreation maintains a fully-equipped health club/weight room and offers training in the use of equipment. The Tech community may use this facility at no charge.

Physical Recreation also oversees a number of club sports, including air rifle shooting, caving, climbing, golf, Frisbee, martial arts, soccer (men's and women's), paintball, rugby, and volleyball (men's and women's). Rugby, soccer, and volleyball belong to regional leagues and compete against off-campus teams.

Equipment for backpacking, rock climbing, canoeing, camping, volleyball, and other recreational activities can be borrowed from the gym.

Other recreational facilities on the Tech campus include an outstanding 18-hole golf course and a year-round swim center.

There are groups in the Socorro area that hold regular events in running and mountain-biking. Many members of the Tech community participate in these.

## Social and Cultural Activities

The New Mexico Tech Performing Arts Series (PAS) brings a wide variety of entertainment to campus. Shows are generally free to students. In any given season, shows may include Celtic, classical, Cajun, Latin, world beat, swing, jazz, blues, folk and bluegrass music; theatre; circus arts (juggling, acrobatics, magic), comedy, dance, and more! PAS shows are a great way to spend an evening with friends or family, to see professors in a social setting, and to experience an amazing array of national touring performers.

The Student Activities Board (SAB) also brings entertainment to campus. The SAB sponsors events such as Comedy Night, Movie Night, poetry slams, dances with live salsa or swing bands, barbecues with DJ's, dances, open-mic nights, and mid-night breakfast held on Sunday before finals week each semester. The SAB and PAS work together to find entertainment that will interest Tech students.

The Student Association funds various Tech clubs. The SAB organizes two big celebrations each year. In the fall, 49'ers is a celebration of Tech's mining heritage. Spring Fling gives students a fun break in the spring. Both feature games, contests, music, dances, barbecue dinners, and other events.

## Socorro and New Mexico

Socorro is a friendly community of over 9000 people, located in the sunny Rio Grande valley 75 miles south of Albuquerque. The main industries in Socorro are education, research, and tourism, with the largest employers being New Mexico Tech and the National Radio Astronomy Observatory. Socorro's population has one of the highest percentages of Ph.D.s per capita in the state of New Mexico.

Outdoor activities abound in the area. The nearby Magdalena Mountains and the slightly farther Gila Wilderness Area offer hiking, camping, rock climbing, fishing, hunting, and many other activities. Developed downhill ski areas are as close as Albuquerque and include Ruidoso, Cloudcroft, Santa Fe, and Taos (New Mexico), or Aspen and Durango (Colorado). Socorro's year-round mild climate is ideal for bicycling, running, golfing, horseback riding, river rafting, and many other pursuits.

In addition to outdoor activities, cultural amenities are also available nearby. Albuquerque offers restaurants, museums, music, theater, and many other cultural activities. Farther north, Santa Fe is a major art center. The entire state, with its long, colorful history is an enchanting place to live and to explore.

Socorro has a pleasant, sunny climate year-round. Average rainfall is less than 10 inches per year, and there are occasional brief winter snows.

## Student Clubs and Activities

A host of student clubs, organizations, and activities flourish at Tech. These are as broad as student interests themselves, including:

### Performance Groups

- Chorus
- Drama Club
- Jazz Band
- Orchestra
- Spring Musical

### Club Sports

Baseball	
Caving	Rugby, Men's and Women's
Climbing	Shooting
Cricket	Soccer, Men's & Women's
Golf	Ultimate Frisbee
Martial Arts	Volleyball, Men's & Women's
Paintball	

## Games

Adventurers' Guild  
Billiards Club  
Chess Club

## Just for Fun

Anime Addicts  
Aquatic Recreation  
KTEK (student radio station)  
Miner's Ink (creative writing journal)  
Paydirt (student newspaper)  
Society for Creative Anachronism  
Tech Amateur Radio Association

## Professional Associations

American Indian Science and Engineering Society (AISES)  
American Society of Mechanical Engineers (ASME)  
Association for Computing Machinery (ACM)  
Institute of Electrical and Electronics Engineers (IEEE)  
International Society of Explosives Engineers (ISEE)  
Society of Economic Geologists, student chapter (SEG)  
Society of Hispanic Professional Engineers (SHPE)  
Society of Mexican American Engineers and Scientists  
Society of Women Engineers  
SACNAS - the Society for the Advancement of Chicanos and Native Americans in Science.  
Tau Beta Pi, Engineering Honor Society

# The Undergraduate Program

At New Mexico Tech, the undergraduate program has two principal objectives:

- 1) to provide a strong general education in:
  - a) the humanities and social sciences, and
  - b) the basic sciences and mathematics; and
- 2) to offer specialization appropriate to a chosen major field of interest.

The General Education Core Curriculum, the requirements common to all bachelor of science degrees, is listed on page 100. Specific requirements for each major are listed under the academic department concerned. It is your responsibility to work out with your advisor a program that meets both the general and specific requirements. In some instances, wide flexibility is allowed in choosing electives; in others, the choice of electives is somewhat restricted.

## Preprofessional Programs

Preprofessional programs are available in the sciences allied with biology, chemistry, and medicine. Among the careers for which preprofessional courses are available at Tech are medicine, dentistry, physical therapy, optometry, pharmacy, and veterinary science. A Bachelor of Science degree in Biology, Chemistry, and Basic Sciences with suitable elective courses will qualify a student for admission to most professional schools related to medicine. Be sure to check the specific requirements of the professional school you are interested in attending. The Bachelor of Science degree in Biology with Medical Technology Option is granted at Tech in cooperation with accredited schools of medical technology.

The undergraduate requirements for admission to a school of law may also be fulfilled. See page 208 for more information about preprofessional programs.

## Teacher Certification

Students enrolled at New Mexico Tech may work toward becoming licensed teachers in secondary public schools (e.g., middle and high schools) in New Mexico through the alternative licensing program. The Bachelor of Science in Basic Sciences is appropriate for these students. Potential students should select a major in math or science (any discipline) in order to meet the

required 24 credit hours in math or science for initial licensure. Eighteen credit hours in education courses are required for the alternative licensing program's teacher certification, and can be used for electives in the student's major course of study. The Socorro Public School System cooperates by providing opportunities for observation and student teaching. Prospective teachers should consult the Alternative Licensing Program Coordinator in the Department of Education as well as their regular academic advisor in planning their programs. See page 168.

## Combined Five-Year Bachelor of Science/Master of Science Programs

New Mexico Tech offers four programs that allow students capable of above-average academic achievement to earn both a bachelor's and master's degree in five years. Through the Department of Earth and Environmental Science, students can earn a bachelor's degree in Earth science with an environmental geology option and a master's degree in geology (page 149) or a bachelor's in a science or engineering field and a master's degree in hydrology (page 149). Similar opportunities are available for students majoring in Biology (page 109), Electrical Engineering (page 243), Environmental Engineering (page 252), Materials Engineering (page 260), and Mathematics (page 184), through their major department.

## Research Opportunities

Tech has a wealth of research projects on campus, many of which employ students for pay or class credit. Since over 99 percent of our faculty have Ph.D.s and conduct research, many professors hire undergraduate students to assist them. In addition, Tech has several divisions dedicated to research (pages 15-22).

## Study Abroad Opportunities

Arrangements for all types of study abroad are made through the Student Affairs. To be eligible to apply for participation, students must, at a minimum:

- have been a full-time, degree-seeking student at Tech for at least one year,
- have completed at least 30 credit hours at Tech,
- have a cumulative G.P.A. of at least 2.5,
- be in good academic standing,
- have a clean disciplinary record, and
- be in good financial standing.

## International Student Exchange

New Mexico Tech has exchange agreements in place with multiple universities, allowing students to study in various countries around the world. Information about these opportunities is available in Student Affairs. Additionally, the office coordinates a Study Abroad Fair each semester.

## International Exchange through NMIEC

Through the New Mexico International Education Consortium, students at any of the State's public universities may gain access to study-abroad programs available at other State universities. Students who participate in study abroad through NMIEC will pay tuition and fees to the New Mexico host university, not to New Mexico Tech.

# Applying for Undergraduate Admission

New Mexico Tech seeks to admit students who have demonstrated, through previous education, aptitude tests, and interests, that they are qualified to complete a degree. Tech subscribes to the National Association for College Admission Counseling's *Statement of Principles of Good Practice*. All official documents sent to New Mexico Tech become the property of the college and will not be returned, nor can copies be provided to entities other than the student. Application forms are also available on the Web at <http://www.nmt.edu/admissions/office>.

## Regular Admission

### Entering Freshmen

#### Admission Requirements

First-time, entering students must meet the following minimum admission requirements:

- 1) The student must be a graduate of an accredited high school with a minimum grade-point average (GPA) of 2.5 (on a 4.0 scale) in high school course work or have passed the general equivalency diploma (GED) examination with an average score of 500 or greater. If your GPA is less than 2.5 but you believe you can succeed at Tech, see the section on Appeal of Admission Decisions, page 36.
- 2) The student must have successfully completed the following high school courses (one unit equals one year of high school study):
  - English—a minimum of four units with at least one unit earned in composition at the junior or senior level.
  - Science—a minimum of two units of sciences, with laboratories, chosen from among biology, physics, chemistry, and earth science.
  - Mathematics—a minimum of three units chosen from among Algebra I, Algebra II, Geometry, Trigonometry, or higher mathematics. Pre-calculus and calculus are recommended.
  - Social Science—A minimum of three units, one of which must be history.

A student who does not meet all of these

requirements may apply, but must justify any deficiencies through correspondence to the Office of Admissions.

- 3) The student must submit official ACT, Inc. (formerly American College Test) or SAT (Scholastic Aptitude Test) score reports. Normally, an ACT composite score of 21 or higher or a combined SAT Critical Reading and Math score of 970 or higher is required. (New Mexico Tech does not use the Written Essay portion of the SAT.) Experience has shown that a student whose scores are below these levels will encounter difficulty with the rigorous academic curriculum at Tech. (Recent ACT scores for entering freshmen averaged 26; SAT, 1080.) ACT and SAT scores are used for course placement and advising purposes.

### Procedure

To be considered for admission, an entering freshmen applicant must:

- 1) complete an *Application for Undergraduate Admission and Scholarship*.
- 2) provide an official high school transcript.
- 3) provide official college transcripts, if the student has taken college classes. (Students who have 30 or more college credits will be considered transfer students. See below.)
- 4) provide either an official ACT Student Profile Report or an SAT College Report.
- 5) pay a \$15 application fee.
- 6) Students who do not meet Tech's minimum ACT or SAT requirement but who have taken college-preparatory classes in math and science must submit letters of recommendation from at least two of their high school math and science teachers sent directly to the Office of Admission.

If you are deemed academically qualified, then you will receive a letter of admission and the *Acceptance of Admission* form. You must complete this form and return it with the non-refundable admission fee of \$50 to the Office of Admission before you are allowed to register for classes.

### Appeal

Students who are denied admission may appeal the decision (see page 36).

## Application Deadlines

August 1 for fall semester

December 15 for spring semester

June 1 for summer session.

## Home-Schooled Students

In order to qualify for admission to New Mexico Tech, the home-schooled student:

- 1) must supply documentation of courses completed. A minimum grade-point average (GPA) of 2.5 (on a 4.0 scale) in coursework is required. If your GPA is less than 2.5 but you believe you can succeed at Tech, see the section on Appeal of Admission Decisions, page 36.
- 2) must have successfully completed the following courses (one unit equals one year of study):
  - English—a minimum of four units with at least one unit earned in composition at the junior or senior level
  - Science—a minimum of two units of sciences, with laboratories, chosen from among biology, physics, chemistry, and earth science
  - Mathematics—a minimum of three units chosen from among Algebra I, Algebra II, Geometry, Trigonometry, or higher mathematics. Pre-calculus and calculus are recommended.
  - Social Science—A minimum of three units, one of which must be history.

A student who does not meet all of these requirements may apply, but must justify any deficiencies through correspondence to the Office of Admission.

- 3) The student must submit official ACT, Inc. (formerly American College Test) or SAT (Scholastic Aptitude Test) score reports. Normally, an ACT composite score of 21 or higher or a combined SAT Critical Reading and Math score of 970 or higher is required. (New Mexico Tech does not use the Written Essay portion of the SAT.) Experience has shown that a student whose scores are below these levels will encounter difficulty with the rigorous academic curriculum at Tech. (Recent ACT scores for entering freshmen averaged 26; SAT, 1080.) ACT and SAT scores are used for course placement and advising purposes.

## Procedure

Home-schooled students must follow the same procedure as entering freshmen (above), in addition, must submit all official academic transcripts and/or documentation of courses completed as well as grades posted in those courses.

## Transfer Students

You will be considered a transfer student if you have a minimum of 30 credit hours transfer from an accredited college or university. (If you have fewer than 30 credit hours of transfer credit, follow the Entering Freshman section above.) Students in good academic standing at other colleges and universities are eligible to apply for transfer admission to New Mexico Tech.

(See page 38 for transferability of credits).

## Admission Requirements

The minimum admission requirements for a student who is classified as a transfer student are as follows:

- 1) The student transferring from another college or university must have completed the same high school course work requirements as entering freshmen (either from high school or from equivalent courses taken since high school).
- 2) The applicant must present college transcripts showing a cumulative GPA of 2.0 or better.
- 3) The student must be in good academic standing at the last institution attended.
- 4) The student must be eligible to re-enroll at the institutions from which he or she wishes to transfer. An applicant who cannot re-enroll at that institution is not eligible to enter New Mexico Tech.

## Procedure

To be considered for admission, a transfer applicant must:

- 1) complete an *Application for Undergraduate Admission and Scholarship*;
- 2) may be asked to provide an official high school transcript at the discretion of the Admission Office;
- 3) provide official college transcripts from all colleges attended, reflecting all courses completed and in progress;
- 4) may be asked to provide an official ACT or SAT Student Profile Report if the student has fewer than 30 hours of transfer credit; and
- 5) pay a \$15 application fee.

If you are deemed academically qualified, then you will receive a letter of admission and the *Acceptance of Admission* form. You must complete this form and return it with the non-refundable admission fee of \$50 to the Office of Admission before you are allowed to register for classes.



## Appeal

Students who are denied admission may appeal the decision (see page 36).

## Application Deadlines

August 1 for fall semester  
December 15 for spring semester  
June 1 for summer session.

## Transfer Credit

New Mexico Tech accepts academic credits from regionally accredited institutions of higher education. All credits will be evaluated and transferred on a course-by-course basis. Credit earned at any institution while a student is on academic or disciplinary suspension will not be accepted at New Mexico Tech. Grades earned at other universities are not transferred to Tech.

See page 38 for a guide for students transferring from another New Mexico college or university. A more complete list of courses offered at other New Mexico colleges and universities and their Tech equivalents is online at <http://hed.state.nm.us/colleges/trnsfercredits.asp>

## International Students

New Mexico Tech is authorized under federal law to enroll nonimmigrant alien students.

## International Undergraduate Admission Requirements

- (1) International students must meet the basic secondary-education requirements for entering freshmen:
  - Science: at least two years of science (biology, physics, chemistry, earth science), with laboratory work
  - Mathematics: at least three years, including algebra, geometry, trigonometry, or calculus
  - Social Science: at least three years, one of which must be history
  - Language: at least four years of language instruction in the native or national language
- (2) The student's grade average must equal at least a GPA of 2.5 on a 4.0 scale.
- (3) A student whose native language is not English must submit a TOEFL score of at least 540 (paper-based) or 207 (computer-based) or 76 (iBT next generation). Information and application forms for this test may be obtained from:

The College Board  
P.O. Box 592  
Princeton, NJ 08541

- (4) An international student transferring from another post-secondary college or university must have completed the same secondary coursework as required of incoming freshmen. If all application materials are submitted before the deadline, transcripts from previous institutions will be evaluated for possible credit transfer before enrollment. Evidence of coursework completed at a foreign institution must be accompanied by course descriptions from that institution, in English.

## International Undergraduate Application Procedures

All documents should be sent to International Undergraduate Admission, Student Affairs. You must:

- Complete an *International Undergraduate Application*, available online at [www.nmt.edu/international-undergraduate-bs-degree-admission-requirements](http://www.nmt.edu/international-undergraduate-bs-degree-admission-requirements)
- Provide a credentials evaluation of all required academic documents compiled by an independent academic credential evaluation provider. New Mexico Tech International Undergraduate Admissions requires that all applicants use [World Education Services](#) for this service and we recommend that you review the [Frequently Asked Questions](#) listed on the WES website. You may apply for this evaluation online at [www.wes.org](http://www.wes.org). WES requires a fee from the applicant for processing applications. You do not need to have any documents sent from your international institution to New Mexico Tech. Your documents will go to WES, and New Mexico Tech will receive a copy of the original documents along with the evaluation. High school/Secondary school applicants should request a Document-by-Document report; college transfer applicants must request a must request a [Comprehensive Course-by-Course Report](#).
- If you are applying to New Mexico Tech from a U.S. institution, make sure official academic records (transcripts, mark sheets, exam results) are sent by the school you attended directly to International Undergraduate Admission, Student Affairs.
- If English is not your native language, submit an official TOEFL score.

- Send a \$15 application fee.
- Complete *the Certificate of Financial Responsibility* (available at [www.nmt.edu/international-undergraduate-bs-degree-admission-requirements](http://www.nmt.edu/international-undergraduate-bs-degree-admission-requirements) showing adequate funds for at least the first year of study plus evidence of continuing ability to fund the remainder of your program.
- Supply proof of all funding listed on the *Certificate*.

### Appeal

Applicants denied admission may appeal the decision to the Academic Standards and Admission Committee.

### Application Deadlines

Application files must be complete (all required documentation received) by:

May 1 for fall semester

October 1 for spring semester

If academically qualified, you will receive a letter of admission and the *Acceptance of Admission* form. You must complete this form and return it with the non-refundable admission fee of \$50 in order to complete the admission process.

### Medical Insurance

International students are required to show proof of medical insurance coverage before registration each semester. Specific requirements for students entering on J1 visas are explained at the time of admission.

### Special Students (Undergraduate)

New Mexico Tech accepts, on a special basis, part-time undergraduate students (for a maximum of six credit hours per semester) who are not pursuing a degree program. International students in F or J status must be regular and full-time (not special or part-time) students.

Applicants for special undergraduate admission who wish to take courses for college credit and who have previously attended an institution of higher education must have a transcript or letter sent from the registrar of their most recently attended institution. This letter, addressed to the New Mexico Tech Admission Office, should attest that they are in good standing at that institution. Students under probation or suspension at New Mexico Tech or any other institution of higher education will not be admitted as special students except by appeal to the Academic Standards and Admission Committee.

Appeals should be addressed to the committee in care of the Office of the Registrar.

Special students and others not seeking a bachelor's degree from New Mexico Tech are expected to meet the prerequisite or corequisite requirements but are otherwise free to choose a program best suited to meet their individual needs.

Non-degree-seeking students who have a bachelor's degree are regarded by New Mexico Tech as Special Graduate Students. Special Graduate Students will be charged tuition at undergraduate rates for courses numbered less than 300 and graduate tuition for all courses numbered 300 and above.

Special students who wish to begin a degree-seeking program must apply for regular admission (page 31).

### Dual Credit Program for High School Students

The primary purpose of the Dual Credit Program at New Mexico Tech is to increase the educational opportunities and options for high school students and increase the overall quality of instruction and learning available through secondary schools.

The Dual Credit Program allows students to earn credit at the secondary and postsecondary levels simultaneously and provides students an early glimpse of college life and college-level studies. Enrolling in college course work is a commitment of your time and energy. Please consider whether enrolling in the Dual Credit Program is a realistic option based on your extracurricular activities and family schedules.

Students interested in participating in the Dual Credit Program at New Mexico Tech must be prepared for the following:

- Students are responsible for their own transportation to and from New Mexico Tech's campus
- Students are expected to adhere to New Mexico Tech's student handbook while on New Mexico Tech's campus and attend the class or classes in which they are registered even if the high school is not in session that day
- New Mexico Tech's academic calendar starts and ends differently than most high school calendars
- Students who take courses that are not part of the approved course list agreed upon between the District and New Mexico Tech will be responsible

for the cost of tuition, fees and textbooks

- Students must follow New Mexico Tech's Registration/Orientation schedule each semester
- Grades earned through the Dual Credit Program at New Mexico Tech are part of your permanent academic record

### Eligibility

Students must be either a junior or senior in high school and enrolled in a public school district during the fall and spring in one-half or more of the minimum course requirements approved by PED for public school students in order to participate in the Dual Credit Program at New Mexico Tech. Students must also have a minimum 3.0 GPA (on a 4.0 scale) and an ACT composite score of 21 or an equivalent SAT critical reading and math score. Students who have not taken the ACT or SAT may submit PSAT scores for review of eligibility. All students must have approval from the school district and the high school counselor prior to registration.

### Financial Aid

Dual Credit students are not eligible for financial aid or scholarships.

### Applying for the Dual Credit Program

Students interested in enrolling in the Dual Credit Program at New Mexico Tech should submit the following each semester:

- Completed Dual Credit Request Form (signed by your high school counselor)
- Current official high school transcript
- Family Educational Right to Privacy Act Release Form (signed by the student and the student's parent/guardian)

Copies of the forms are available at the high school counseling office.

### Course Selection

Course selection will vary based on the Master Agreement with each high school district and New Mexico Tech. Students interested in enrolling in a math class are required to take the Math Placement Exam to determine course placement prior to registering for the class. Students are also required to meet with the Center for Student Success at New Mexico Tech prior to enrolling in any course and must satisfy prerequisites/co-requisites for the class.

### Readmission

A student who has not been continuously enrolled (excluding summer session) must submit an application for readmission to the Office of the Registrar. In addition to the application, a student who left while on academic probation or suspension must submit the following documents:

- A one-page appeal letter that persuasively makes a case for readmission;
- A supporting letter from the student's advisor;
- An Academic Warning Plan completed with input from the student's advisor;
- Such other documents as the student thinks are relevant, such as medical documents or letters of support from faculty, counselors, or the Dean of Students.

A student in good standing will be readmitted by the Registrar. Application and material submitted by a student who left while on academic probation or suspension will be reviewed by the Academic Standards and Admission Committee and written notice of the decision will be given to petitioner.

The deadline for all readmission materials is the day before classes start for that semester.

A student on academic suspension applying for readmission for the summer session must also submit an application for readmission for the fall session.

### Conditions of Readmission

A readmitted student must choose degree requirements to be satisfied from the catalog in effect when the student was readmitted or any subsequent catalog, provided the student be continuously enrolled after readmission.

A student readmitted by the Academic Standards and Admission Committee must follow the guidelines set by the committee. If accepted for readmission, a student on academic probation or suspension will be automatically placed on academic probation and subject to all the rules and regulations of a student on probation.

For students readmitted on probation, failure to meet the minimum GPA for academic good standing (page 9) in the semester following readmission will result in academic suspension (page 70-71) from New Mexico Tech.

Credits earned at another institution during the period of suspension at New Mexico Tech will not be accepted for transfer without prior approval.

If you have attended another college institution of higher education since your last enrollment at New Mexico Tech, you must submit a transcript or letter from the registrar of that institution attesting that you are in good standing at the institution.

### Appeal of Admission Decisions

Experience has shown that most students who earn less than a 2.5 GPA in high school or have an ACT score of less than 21 or combined SAT Critical Reading and Math score of less than 970 do poorly at New Mexico Tech. If you do not meet the requirements for admission, but believe that you have the skills to succeed at New Mexico Tech, complete an *Application for Admission and Scholarship* and send it with supporting documents to the Academic Standards and Admission Committee in care of the Director of Admission. These supporting documents must include:

- A statement from you indicating why you believe that you should be considered for admission and why you can succeed at Tech;
- A minimum of two letters from people (e.g., high school science and math teachers) who are very familiar with your potential for study at a technical university; and
- Other documentation (e.g., participation in science fairs, Science Olympiad, and other relevant technical activities) that you believe bears on the matter of your preparation for bachelor's-level study.

### Appeal Deadlines

Deadlines for appealing admission decisions are:

July 1 for fall semester

December 1 for spring semester

June 1 for summer session.

### Placement

#### ACT/SAT English Waiver

Students who score 27 or higher on the ACT English test or 610 or higher on the SAT Critical Reading test will have English 111 waived as a requirement. Students who score 19 or lower on the ACT English test or 470 or lower on the SAT Critical Reading test are advised to begin with ENGL 103.

#### College Level Examination Program

No credit is given for the College Level Examination Program (CLEP). However, challenge exams are available in various courses (page 72).

### Math Placement

Mathematics is the backbone of all coursework at New Mexico Tech, and the selection of your initial math courses is critical to your success at Tech. Placement is determined by your ACT/SAT math score or the optional math placement test, described below.

ACT Math Score	SAT Math Score	Initial Math Course
20 or lower	490 or below	MATH 101
21 to 25	500 to 580	MATH 103
26 to 29	590 to 660	MATH 104
30 or higher	670 or higher	MATH 131

You may also enroll in MATH 131 (Calculus and Analytic Geometry I) if:

- 1) You are transferring college credit in precalculus and trigonometry.
- 2) You have earned a 3 or higher on the Advanced Placement (AP) Calculus AB exam or a 3 or higher on the AB subscore of the Calculus BC exam.

An optional math placement test, which covers algebra and trigonometry, is available to students who score below 30 on the ACT math test or received below 670 on the SAT mathematics test. Please contact the Registrar's Office at registrar@admin.nmt.edu for information about the math placement test. **Waivers into 100-level math classes are not granted. You must take the math placement exam if you want to enroll in any math class other than those listed above for your ACT or SAT math score.**

# Advanced Placement Program

New Mexico Tech participates in the Advanced Placement Program of the College Entrance Examination Board. Credit and/or advanced placement are granted according to the departmental policies listed below. Advanced Placement credit is not awarded for grades of 1 or 2.

Subject	AP Score	Credits Earned
<b>Biology</b>	3, 4, and 5	Receive credit for BIOL 111 for a total of three (3) credits. Students must take BIOL 111L for laboratory credit.
<b>Calculus AB</b>	3	Receive two (2) elective credits in mathematics. Students proceed directly into MATH 131, Calculus and Analytic Geometry I.
	4 and 5	Receive credit for MATH 131 for a total of four (4) credits. Students proceed directly into MATH 132, Calculus and Analytic Geometry II.
<b>Calculus BC</b>		Use Calculus AB subscore. Credit awarded as above.
<b>Chemistry</b>	3 and 4	Receive credit for CHEM 121(3) for a total of three (3) credits. The student should consult the department chair concerning laboratory credits.
	5	Receive credit for CHEM 121 (3) and 122 (3) for a total of six (6) credits. The student should consult the department chair concerning laboratory credits.
<b>Computer Science A</b>	3, 4, and 5	Receive credit for CSE 213 for a total of three (3) credits.
<b>Computer Science AB</b>	3, 4, and 5	Receive credit for CSE 122 and 213 for a total of six (6) credits.
<b>Economics</b>		
<b>Macroeconomics</b>	4 and 5	Receive credit for ECON 251 for a total of three (3) credits.
<b>Microeconomics</b>	4 and 5	Receive credit for ECON 252 for a total of three (3) credits.
<b>English</b>	4 and 5	English/Composition <b>or</b> English/Literature/Composition: Receive credit for ENGL 111 for a total of three (3) credits and proceed directly into ENGL 112. English/Composition <b>and</b> English/Literature/Composition: Receive credit for ENGL 111 (3) and literature (3) for a total of six (6) credits and proceed directly into ENGL 112.
<b>Foreign Languages</b>	3, 4, and 5	May take a challenge exam to waive the first semester course of that language and receive three (3) credits. The exam is graded S/U only.
<b>Government</b>	3, 4, and 5	Receive credit for PS 171 for a total of three (3) credits.
<b>History</b>		
<b>U.S. History</b>	3, 4, and 5	Receive credit for HIST 141 and 142 for a total of six (6) credits.
<b>European or World History</b>	3, 4, and 5	Receive credit for HIST 151 and 152 for a total of six (6) credits.
<b>Music Listening and Literature</b>	3, 4, and 5	Receive credit for MUS 101 (3) and 102 (3) for a total of six (6) credits.
<b>Music Theory</b>	3, 4, and 5	Receive credit for MUS 201 for a total of three (3) credits.
<b>Physics C Mechanics</b>	3, 4, and 5	Receive credit for PHYS 121 for a total of four (4) credits. The student should consult the department concerning laboratory credit.
<b>Physics C E &amp; M</b>	3, 4, and 5	Receive credit for PHYS 122 for a total of four (4) credits. The student should consult the department concerning laboratory credit.
<b>Psychology</b>	5	Receive credit for PSY 121 for a total of three (3) credits.

## Transfer among New Mexico Higher Education Institutions

During the 2005 New Mexico Legislative session, Senate Bill 161, consistent with requirements of state law (Chapter 224 of the Laws of New Mexico, 1995 as amended) was signed into law to further enhance and facilitate the articulation of general education courses among New Mexico's colleges and universities. In accordance with policies established by the New Mexico Higher Education Department, designated general education core courses successfully completed at any regionally accredited public institution of higher education in New Mexico are guaranteed to transfer to any New Mexico public institution if the student passed the class with a grade of C or higher. Students who have decided on a major and/or an institution at which to complete their studies should consult with an academic advisor at that particular institution to determine the most appropriate course selections. Students enrolling for the first-year of study at a New Mexico college or university and considering possible transfer into a certificate and/or degree program at another institution are encouraged to take the courses approved for transfer during their freshman and sophomore year of study.

### Student Responsibility

New Mexico's colleges and universities have collaborated to produce guides to assist students who plan to transfer before completing a program of study. Course modules are designed to help students select courses carefully so that they may transfer with little or no loss of credit. However, planning for effective transfer with maximum efficiency is ultimately the **student's responsibility**. Responsible transfer planning includes early and regular consultation with the intended degree-granting institution to assure that all pre-transfer coursework will meet the requirements of the desired degree.

### Transferable Lower-Division General Education Common Core

*Students enrolling for first-year study who have not yet selected either an academic focus or the institution where they wish to graduate are advised to take courses during their freshman year outlined in the Lower Division General Education Common Core.* For students enrolled at any public institution in New Mexico, the following courses are guaranteed to transfer to any other New Mexico public college or university, and apply toward

associate and baccalaureate degree program requirements if the student passes the classes with a grade of C or higher. Students should consult advisors at their current institutions regarding which specific courses fit these categories. Students preparing for careers in engineering, health sciences, or other profession-related fields are advised that some of this coursework may not transfer toward general education requirements but in most cases will apply toward elective requirements.

<b>Area I: Communications</b>	<b>select 9 cr hrs</b>
a) College-level English Composition	3-4 cr hrs
b) College-level Writing (a second course building on the above)	3 cr hrs
c) Oral Communication *	3 cr hrs
<b>Area II: Mathematics</b>	<b>select 3 cr hrs</b>
a) College Algebra *	3 cr hrs
b) Calculus	3 cr hrs
c) Other College-level Math+	3 cr hrs
<b>Area III: Laboratory Science</b>	<b>select 8 cr hrs</b>
a) General Biology with Lab	4-8 cr hrs
b) General Chemistry with Lab	4-8 cr hrs
c) General Physics with Lab#	4-8 cr hrs
d) Geology/Earth Science with Lab	4-8 cr hrs
e) Astronomy with Lab	4-8 cr hrs
<b>Area IV: Social/Behavioral Sciences</b>	<b>select 6-9 cr hrs</b>
a) Economics (macro or micro)	3 cr hrs
b) Introductory Political Science	3 cr hrs
c) Introductory Psychology	3 cr hrs
d) Introductory Sociology	3 cr hrs
e) Introductory Anthropology	3 cr hrs
<b>Area V: Humanities and Fine Arts</b>	<b>select 6-9 cr hrs</b>
a) Introductory History Survey	3 cr hrs
b) Introductory Philosophy	3 cr hrs
c) Introductory Course in History, Theory or Aesthetics of the Arts or Literature	3 cr hrs
<b>Total to be selected</b>	<b>35 cr hrs</b>
* Will not meet Core Education Curriculum (page 100)	
+ Should be Calculus II	
# Must be calculus-based physics	

The core matrix of approved courses guaranteed to transfer and meet general education requirements at any New Mexico college or university can be found on the New Mexico Higher Education Department website at <http://hed.state.nm.us>. Follow the "Colleges and Universities" link to the drop down menu and

select "Transferring Credits", then select "Core Matrix". Courses are listed by institution, whether university or community college, under each of the five general education areas. Students may also be able to access this list by going directly to <http://hed.state.nm.us/colleges/matrix.asp>.

### Inter-institutional Transfer Guides and Catalogs

Students who have selected a field of study and/or the institution where they wish to graduate are advised to consult the transfer guide or catalog for that institution for more current and detailed advice to guide their course selection.

### Complaint Procedure for Transfer Students

All New Mexico public post-secondary institutions are required to establish policies and practices for receiving and resolving complaints from students or from other complainants regarding the transfer of course work from other public institutions in the state. A copy of New Mexico Tech's complaint policy may be obtained from the New Mexico Higher Education Department, 1068 Cerrillos Road, Santa Fe, NM 87505, 505.476.6500, <http://hed.state.nm.us/>

### Lower-Division 64-hour Transfer Modules

Students who *have* selected a field of study but have not yet selected the college or university where they wish to earn their baccalaureate degree are advised to take courses during their freshman and sophomore years outlined in one of the Lower-Division 64-hour Transfer Modules. For students enrolled at any public institution in New Mexico, these courses are guaranteed to transfer to any New Mexico university and apply toward bachelor's degree program

requirements. Students should consult advisors at their current institutions regarding which specific classes fit these categories. Lower-division transfer modules currently exist for:

- Biological Sciences
- Business
- Early Childhood Education
- Engineering
- Physical Sciences
- Social and Behavioral Studies
- Teacher Education

Modules for additional areas of study are being developed. Copies of these transfer modules may be obtained at

<http://hed.state.nm.us/colleges/transfercredits.asp>

### New Mexico Common Course Numbering System (NMCCNS)

A common course numbering system has been devised by New Mexico colleges and universities in compliance with the New Mexico Post-Secondary Education Articulation Act. The purpose of the system is to assist New Mexico students who are transferring between institutions within the state. The system provides a neutral state wide course identifier for those courses that are similar in nature and considered to be equal in transfer. Students will find in the course description section of the catalog the state wide **course** identifier and the area of the General Education Common Core in brackets following the New Mexico Tech course for which the course can meet general education requirements.

<b>Transfer among New Mexico Higher Education Institutes</b>				
<b>New Mexico Transfer Module by Discipline</b>				
	<b>NMCCN</b>	<b>Course Title</b>	<b>Credit Hour</b>	<b>NMT Course</b>
<b>Business</b>	2113	Principles of Accounting I	3	ACCT 201
	2123	Principles of Accounting II	3	ACCT 202
	2113	Principles of Macroeconomics	3	ECON 251
	2123	Principles of Microeconomics	3	ECON 252
	2114	Business Law I	3	BA 315
	2113	Business Statistics	3	BCS 283
	1113	Business Information Systems	3	BCS 209
<b>For Majors</b>	2113	Principles of Finance	3	FIN 302
	2113	Principles of Marketing	3	MKT 335
	2133	Intermediate Accounting	3	ACCT 371
	2123	Business Law II	3	BA 317
<b>Early Childhood Education</b>	1113	Child Growth & Development & Learning	3	PSY 323

# Financial Aid for Undergraduate Students

[Contact: Financial Aid Office, New Mexico Tech, 801 Leroy Place, Socorro, N.M. 87801; 575.835.5333; fax: 575.835.6519]

New Mexico Tech makes every effort to make our undergraduate education affordable for everyone: new students, returning students, and transfer students. Assistance comes in the form of institutional scholarships, state scholarships, financial aid, and student employment.

1. **Institutional scholarships** are based solely on your grades (high school GPA, standardized test scores, and college grades if you are a transfer student).

Institutional scholarships include

First-Time Students (Gold, Silver, Presidential, Copper, Bronze)

Transfer Students (Phi Theta Kappa, Transfer Excel, Tech Transfer, Regents)

Tuition Reduction Programs for Non-Residents (Competitive, Colorado Reciprocity, Western Undergraduate Exchange)

You do not need to demonstrate financial need for an institutional scholarship—only your own academic merit.

2. **State scholarships** are awarded to US citizens who are New Mexico residents and include the

Legislative Lottery Scholarship,

New Mexico Scholars Program

Education Trust Board Pathways Scholarship

These scholarships are awarded based on the criteria listed below.

3. In addition to scholarships, we offer **financial aid**, which includes

- Federal grants (e.g., Pell Grant and SEOG Grant)
- Federal loans (e.g., Perkins Loan, Stafford Loan, PLUS Loan)
- Federal work study
- New Mexico grants (State Student Incentive Grant, College Affordability Grant)
- New Mexico work-study

Details on this year's institutional scholarships and financial aid programs, including dollar amounts, are available at <http://www.nmt.edu/financial-aid> or in a brochure available from the Admission Office.

## Institutional Scholarships

When you are admitted to New Mexico Tech, your application is automatically reviewed for an institutional scholarship. (*Tech gives only one institutional scholarship per person. If, by accident or oversight, you are offered two institutional scholarships, you may keep only one.*)

Deadlines for consideration of scholarships for the fall semester for first-time students are February 1 for the Gold and Silver scholarships and March 1 for the other scholarships. For consideration for a scholarship for the spring semester, the deadline is November 1.

Deadlines for scholarships for transfer students are June 1 for the following fall semester and November 1 for the spring semester.

If you did not qualify for an institutional scholarship when you entered Tech and you complete two semesters at Tech, earning a minimum of 24 credit hours with at least a 3.0 GPA, you may be eligible for an Endowed Scholarship. Inquire at the Financial Aid Office.

Generally for scholarship consideration, a student must:

1. Be a U.S. citizen or an eligible non-citizen; or be an international student in legal F1 or J1 student status. (International students are eligible only for transfer scholarships and certain tuition reduction programs.)
2. Be pursuing a first bachelor's degree;
3. Be enrolled in a regular degree program at New Mexico Tech; and
4. Carry at least 12 credit hours per semester.

## Institutional Scholarship Renewal

Each year, your institutional scholarship is automatically renewed. You must maintain the GPA specified by your specific scholarship to keep the scholarship and have earned a minimum of 24 credit hours in the regular academic year. The requirements for your institutional scholarship are listed below under the Scholarship Conditions and Requirements. If your GPA falls below the requirements, the Financial Aid Office will award you whichever scholarship you do meet the requirements for. If your GPA again rises to meet the criteria of the higher level scholarship, your scholarship may return to the higher one. It is your responsibility to bring this change of eligibility to the attention of the Financial Aid Office. Please note that you may not qualify for a scholarship higher than the one you were awarded when you entered New Mexico Tech.



CUMULATIVE GRADE POINT AVERAGE REQUIRED FOR RETENTION OF SCHOLARSHIP					
Academic Year	CATEGORY OF SCHOLARSHIP				
	Gold Silver PTK Transfer Excel	Endowed NM Scholars International Competitive*	Presidential Tech Transfer Competitive (U.S. Citizens)	Copper Minerals Regents CORE WUE NM Lottery	Bronze
End of first year	3.00	3.00	2.75	2.50	2.00
End of second year	3.25	3.00	3.00	2.50	2.00
End of third year	3.25	3.00	3.00	2.50	2.00

### Scholarship Conditions and Requirements:

Students must earn 24 credit hours in the academic year (fall & spring), in addition to the above GPA requirements, to meet retention criteria. Credit hours completed during the summer semester may count as completed credit hours for purposes of scholarship reinstatement. It is your responsibility to request reinstatement at the end of the summer semester.

**RETENTION OF AWARD:** 1) Scholarship recipients must maintain a minimum of twelve (12) credit hours of course work for each Fall and Spring semester.

\*International Competitive recipients must maintain fifteen (15) credit hours per semester. Grades of U, F, W, I, and audits do not count as completed credits for scholarship retention purposes. 2) Scholarship eligibility is reviewed yearly at the end of the spring semester. (If a student attends summer school, eligibility will be reviewed again at the end of the summer semester to ensure GPA requirements are maintained.) 3) Inability to meet minimum requirements by the end of the spring semester will result in Scholarship loss for the following academic year. 4) Students who lose scholarship eligibility may submit a written appeal (by the posted deadline) of extenuating circumstances with appropriate documentation. 5) If a Scholarship is cancelled for academic ineligibility and the student later regains eligibility, it is the student's responsibility to request reinstatement of the scholarship. Renewal of a scholarship is made only if the originally specified consecutive time period has not expired.

Reinstatement requests are only accepted after the spring and summer semesters.

Gold, Silver, and Presidential Scholarships will be replaced by an award to Presidential or Copper Scholarship level when the student's GPA meets the retention criteria specified for the next tier award. Competitive Scholarships, CORE, and WUE program participants will lose their respective awards if the established retention criteria are not met and no scholarship replacement will be offered. The student's tuition rate will revert to non-resident status

**Note: Students awarded the Competitive Scholarship or who are participating in the CORE and WUE programs are not eligible to establish New Mexico residency while on the program or use any time in New Mexico while on the program toward meeting the requirement for New Mexico residency.**

### Time Limits

Institutional scholarships are offered for a maximum of four years for first-time students and a maximum of three years for transfer students. The length of your scholarship is on your scholarship offer. Work closely with your advisor and check with the Registrar's Office to make sure you are on track to finish your program in the time specified. If you need additional funding to finish your bachelor's degree, you should consider applying for financial aid.

If your scholarship is cancelled due to academic ineligibility, and you then re-establish eligibility, you may apply for reinstatement of the scholarship. This request should be made as soon as possible after the spring or summer semester, whichever is applicable. The originally specified time period of the scholarship is not extended.

## State Scholarships

Legislative Lottery Scholarship pays 100% of tuition at NM Tech for students that meet the following requirements: Must be a New Mexico Resident; must have graduated from a New Mexico public high school, an accredited New Mexico private high school, or have obtained a New Mexico GED; must be enrolled full-time and complete 12 credit hours at an [eligible New Mexico public college or university](#) in the first regular semester immediately following their high school graduation; must obtain a 2.5 GPA during their first college semester. Eligible students do not begin receiving the award until their second semester of full-time enrollment, provided that all eligibility requirements have been met. A student may be eligible for up to eight consecutive semesters of support or until the student graduates with a bachelor's degree from an eligible institution, whichever is sooner.

**Renewal** - The Legislative Lottery Scholarship is renewable for up to eight (8) semesters with the following conditions/requirements: 1) Successfully complete the first semester (eligibility semester) with 12 credit hours and a GPA of 2.5 or higher. Grades of U, F, W, I and audits do not count as completed credits for scholarship retention purposes. 2) Completion of 12 credit hours with a cumulative GPA of 2.5 or higher each semester thereafter. 3) Scholarship eligibility is reviewed at the end of each semester. 4) Continuing students who do not meet these requirements will be placed on probation. 5) Appeals will not be accepted for failure to meet first semester requirements. All other appeals will be held to state regulations.

### Legislative Lottery Scholarship Probation Policy

New Mexico Tech defines the probation period as the semester immediately following the semester in which the student did not meet the eligibility requirements. Students will not receive the Legislative Lottery scholarship while they are on probation. The probation semester counts as a semester used and under no circumstances shall the student receive program awards in excess of the eight regular

semesters originally awarded. For example, if a student completed 9 hours with a 2.0 cumulative GPA in the Fall semester, the student would be placed on probation for the Spring semester and must complete at least 15 hours with a 2.5 cumulative GPA before the beginning of the following Fall semester. Students may use the summer session to make up hours and/or raise GPA to get back in good standing before the fall semester. All students attending summer school will be evaluated to ensure eligibility has been maintained. If the student does not meet the eligibility requirements as stated, the scholarship will not be reinstated. If the student does meet the requirements after the probation semester, the Financial Aid Office will automatically reinstate the scholarship.

New Mexico Scholars Program is an award that pays for tuition, books and fees. To be eligible a student must be a New Mexico resident attending a postsecondary institution in New Mexico who has not yet turned 22, have a composite score of at least a twenty-five on the ACT or be in the top five percent of the students high school graduating class, and have a combined family adjusted gross income of no more than thirty thousand dollars per year. This award replaces the Legislative Lottery Scholarship.

**Renewal** – The New Mexico Scholars Program is renewable for up to four (4) years with the following conditions. Students must earn 24 credit hours in the academic year (fall & spring), with a cumulative GPA of at least a 3.0. Credit hours completed during the summer semester may count as completed credit hours for purposes of scholarship reinstatement. It is your responsibility to request reinstatement at the end of the summer semester.

Education Trust Board Pathways Scholarship is a one-time award in an amount of up to \$1,000. The eligibility requirements are that you are a first time freshman, have a FAFSA Expected Family Contribution of \$1000 or less and be graduating from a New Mexico high school with a 3.25 GPA.

## Financial Aid

To apply for financial aid you must complete the **Free Application for Federal Student Aid (FAFSA)**. There are a couple of ways to submit your FAFSA for processing. You may send the completed paper copy of the application form in the envelope provided with the application, OR you may apply over the internet at [www.fafsa.gov](http://www.fafsa.gov). New Mexico Tech's Title IV code for the FAFSA is 002654.

For maximum consideration, please submit your FAFSA for processing before May 1, if you plan to enter the following fall.

Approximately 30 percent of all applications are selected for review in a process called verification. If your file is selected for verification, additional documents are needed. The financial aid office will notify you if additional paperwork is needed and inform you what that paperwork is. Verification must be completed before a financial aid package will be calculated for the student.

The FAFSA results from the federal processor contain your Expected Family Contribution (EFC) number. This number is used to determine your eligibility for the various financial aid programs.

We will offer you a package to meet your needs at New Mexico Tech. Our offer to you may include grants, loans, work-study, and/or an institutional scholarship. To accept our offer, please sign the award letter and return it to the Financial Aid Office.

To qualify for financial aid at Tech, you must:

1. be a U.S. citizen or an eligible non-citizen,
2. show satisfactory academic progress,
3. be enrolled in a regular degree program at Tech
4. not be in default on a federal student loan or owe a repayment on a federal grant.

### Continuing Your Financial Aid at Tech

Each year, you must fill out the FAFSA. This form should be filed as soon as possible after January 1. For maximum consideration you should fill out the FAFSA before our priority deadline of May 1.

### Satisfactory Academic Progress for Financial Aid

Financial Aid Offices are required to have a policy regarding Satisfactory Academic Progress. The purpose of this policy is to measure a student's academic progress in both a qualitative and quantitative way. This is done by measuring both

cumulative grade point average and credit hours earned. To continue receiving Federal and/or State Financial Aid, students must meet the minimum requirements set in New Mexico Tech's Satisfactory Academic Progress Policy. Be aware that these standards are not the same as New Mexico Tech's standards for academic probation and suspension.

At New Mexico Tech, satisfactory academic progress is reviewed at the end of each payment period (semester). The Satisfactory Academic Progress Policy applies to both undergraduate and graduate level students that participate in the following programs: Federal Pell Grant, Supplemental Grant, New Mexico State Student Incentive Grant, College Affordability Grant, Federal Work Study, New Mexico Work Study, New Mexico Non-need Work Study, Perkins Loan, Federal Direct Stafford Loan, Federal Direct Grad PLUS Loan, and Direct PLUS loan. The three components of the Satisfactory Academic Progress Policy (qualitative, quantitative, and maximum time frame) are explained below.

#### Quantitative Standard

Students must earn (successfully complete) at least 67% of the total credit hours they attempt. This is calculated

$$\frac{\text{Cumulative hours successfully completed}}{\text{Cumulative hours attempted}}$$

Total hours attempted includes grades of A, A-, B+, B, B-, C+, C, C-, D+, D, F, S, U, W, WO, IN, SA, UA, NR, NG and all transfer credits.

Total hours earned includes grades of A, A-, B+, B, B-, C+, C, C-, D+, D, S and all transfer credits.

Repeat courses - count as attempted hours, but the hours can only be earned once. For example, if a student takes a 3 credit hour course one semester and earns a D the hours are counted as attempted and earned. If the student later repeats the course, the 3 hours are added to the attempted, but hours earned will not increase because of the repeat. However, because a grade of F does not count as earned hours, a student repeating a grade of F at a later time and earning a D will have the hours count as attempted and earned when the course is repeated.

IN, NR, NG grades - It is the student's responsibility to notify the Financial Aid Office when a grade of IN, NR, NG is changed to a grade by the instructor so Satisfactory Academic Progress can be re-evaluated.

### Qualitative Standard

Students must meet the following GPA requirements:

<u>Degree</u>	<u>Attempted Credit Hours</u>	<u>Minimum NMT GPA</u>
<u>Bachelor's</u>	<u>(Includes all transfer hours.)</u>	
	<u>0-29</u>	<u>1.6</u>
	<u>30-59</u>	<u>1.8</u>
	<u>60 or more</u>	<u>2.0</u>
<u>Second Bachelor's</u>	<u>All hours attempted at NMT after first Bachelor's degree was earned.</u>	<u>2.0 – calculated on the grades earned after first Bachelor's degree was earned.</u>
<u>Master's</u>	<u>All</u>	<u>3.0</u>
<u>Doctor of Philosophy</u>	<u>All</u>	<u>3.0</u>

Cumulative gpa calculation includes grades of A, A-, B+, B, B-, C+, C, C-, D+, D, and F.

#### Maximum Time Frame

- Students seeking their first bachelor's degree may be eligible for Title IV aid up to a maximum of 195 attempted credit hours.
- Students pursuing a second bachelor's degree have a maximum timeframe of 150% of the number of hours needed to complete the degree. This is determined through a credit evaluation done by the Registrar's Office. For instance, if the student has 140 credit hours and needs 60 hours to earn a second degree, the student will have financial aid eligibility for a maximum of 90 attempted credit hours.
- Students pursuing a master's degree may be eligible up to a maximum of 45 attempted credit hours. This includes all hours attempted as a graduate student regardless of the course level.
- Students pursuing a doctor of philosophy degree may be eligible up to a maximum of 75 attempted

credit hours. This includes all hours attempted at that level.

When you fall below the SAP policy requirements you will automatically be placed on financial aid warning for your next semester of enrollment. During this semester you will be eligible to receive aid.

If you are still below the policy standards after the financial aid warning semester, you are no longer eligible for Title IV aid.

Once a student is on financial aid suspension, he/she is not eligible for any Federal or State Financial Aid until the standards of the Satisfactory Academic Progress Policy have been met or an appeal is approved.

**Satisfactory Academic Progress Status**

<u>Result of SAP measurement</u>	<u>Status</u>	<u>Description</u>	<u>Eligibility</u>
<u>Never received Title IV aid before</u>	<u>X</u>	<u>Not reviewed</u>	<u>Eligible</u>
<u>Meeting SAP policy standards</u>	<u>OK</u>	<u>Satisfactory</u>	<u>Eligible</u>
<u>1<sup>st</sup> Failure to meet SAP policy standards</u>	<u>WARN</u>	<u>Warning</u>	<u>Eligible for 1 payment period</u>
<u>Failure to meet SAP policy standards at end of warning period</u>	<u>SUSP</u>	<u>Suspension</u>	<u>Not eligible</u>

**Appeals for Exception to Standards of Satisfactory Academic Progress Policy**

Students have the opportunity to appeal the determination that they are not making satisfactory academic progress. To appeal the student will need to complete an Appeal Form. On that form the student will need to explain why he/she failed to meet our Satisfactory Academic Progress standards and what has changed that will allow him/her to meet the standards by the end of the next semester.

If an appeal is approved the student's SAP status will change to either Probation or Probation with a plan.

A student can remain eligible for aid once they have had an appeal approved with conditions (probation with a plan) as long as the student continues to earn 100% of the hours attempted each semester with a 2.25 semester gpa.

Satisfactory Academic Progress is measured at the end of each semester. Summer is considered a separate semester. If a student's earned hours or cumulative gpa falls below the minimum standard indicated in the policy, he/she will be notified in writing. The student will also be notified if he/she has met the maximum time frame.

<u>Result of appeal</u>	<u>Status</u>	<u>Description</u>	<u>Eligibility</u>
<u>Approved</u>	<u>PROB</u>	<u>Probation</u>	<u>Eligible for 1 payment period</u>
<u>Approved with conditions</u>	<u>PROBPL</u>	<u>Probation with a plan</u>	<u>Eligible as long as conditions of plan are met</u>

## Financial Aid Policies

### Return of Title IV Funds Policy

This policy applies to all students that participate in the following Title IV financial aid programs.

- Federal Pell Grant
- Supplemental Grant
- Perkins Loan
- Federal Direct Stafford Loan
- Federal Direct Grad PLUS Loan
- PLUS Loan

Federal regulations require that if a recipient of Title IV financial aid funds (those programs listed above) withdraws from New Mexico Tech after beginning attendance for the semester, the amount of Title IV assistance earned by the student must be determined. This is done through a calculation developed by the United States Department of Education. If the amount disbursed to the student is greater than the amount the student earned, unearned funds must be returned. If the amount disbursed to the student is less than the amount the student earned, and for which the student is otherwise eligible, he or she is eligible to receive a post-withdrawal disbursement of the earned aid that was not received.

The amount of assistance the student has earned is based upon the percentage of the semester in which the student was enrolled.

Enrolled days / total number of days in the semester = % of aid earned.

Once the student has completed more than 60% of the semester, he/she is considered to have earned all of the funds awarded and is not subject to the calculation.

There are two types of withdrawals for Title IV financial aid purposes:

• **Official Withdrawals**—If the student officially notifies New Mexico Tech of his or her intentions to withdraw, this date is considered to be your last date of attendance and will be the official withdrawal date for calculating the amount of Title IV financial aid funds earned. This applies to both withdrawal (W) and withdrawal without prejudice (WO).

• **Unofficial Withdrawals**—If a student receives grades of all F, U, or UA for a semester, the student is considered to have unofficially withdrawn from New Mexico Tech. The midpoint of the semester is used as the student's unofficial withdrawal date unless documentation is submitted to show a different last date of attendance at an academically related activity.

### Entrance Loan Counseling Policy

According to federal law, if you intend to borrow money on the Perkins Loan or Federal Direct Loan programs, you must complete entrance loan counseling. Go to [www.studentloans.gov](http://www.studentloans.gov) and sign in to complete Entrance Loan Counseling. Complete the entrance loan counseling for the type(s) of student loans you intend to borrow or have been offered.

### Exit Loan Counseling Policy

If you receive an education loan and you graduate, withdraw, drop below six credit hours, or do not re-enroll; you must complete exit loan counseling. Go to [www.mappingyourfuture.org](http://www.mappingyourfuture.org) and click Student Loan Counseling interview on the left side. Complete the exit loan counseling for the type(s) of student loans you borrowed.

### Student Employment Policy

All student employment is limited to a maximum of 20 hours per week during the fall and spring semesters. Maximum hours per week during the summer semester depend on the number of credit hours the student is taking. **Any student employed under the work-study program must demonstrate satisfactory academic progress for financial aid (page 40).** Students employed on a part-time basis must be enrolled as regular, full-time students. Students attending less than full-time are subject to IRS regulations regarding FICA/Medicare deductions.

A Student Employee Handbook is available online at <http://www.nmt.edu/financial-aid> and at the Financial Aid Office.

(A cooperative education program is available, in which students alternate periods of off-campus, full-time employment with on-campus, full-time study. See the Director of Student Services for more information.)

# The Graduate Program

([www.nmt.edu/~grad/](http://www.nmt.edu/~grad/))

The graduate program provides opportunities for advanced study and research in the basic sciences, computer science and mathematics, the earth sciences, and several engineering fields. Our Master of Science for Teachers' program provides a growing number of New Mexico secondary school teachers with science and mathematics tools to challenge students in their classrooms. The Master of Engineering Management program provides a unique opportunity for working engineers and scientists to obtain the skills needed for expanding responsibilities in the technology fields. Students are provided the opportunity to learn the spirit as well as the methods of productive scholarship.

## Research Opportunities

Outstanding opportunities for a wide range of field investigations in the sciences and engineering disciplines are made possible by New Mexico Tech's location in the Southwest.

Langmuir Laboratory, at an elevation of 3,240 m (10,630 ft) in the nearby Magdalena Mountains, is a unique facility for the study of thunderstorms and other atmospheric phenomena.

The Very Large Array (VLA) radio telescope on the plains to the west of Socorro and the Magdalena Ridge Observatory located on the mountain near the Langmuir Laboratory, provide extraordinary opportunities for astronomical research. Headquarters for the VLA and Very Long Baseline Array (VLBA) radio telescopes are located on campus (the VLA and VLBA are facilities of the National Radio Astronomy Observatory, distinct from New Mexico Tech).

Graduate students in the earth sciences are afforded expanded research and funding opportunities through the National Science Foundation research consortium, the Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL), located on campus and tasked with exploring the Earth's interior through the collection, distribution, and analysis of seismic data.

Present on campus are the New Mexico Bureau of Geology and Mineral Resources and the Petroleum Recovery Research Center, making New Mexico Tech

especially attractive for graduate study in the Earth, mineral science and engineering fields.

The Energetic Materials Research and Testing Center provides opportunities for graduate work in materials and mineral engineering, mechanical engineering, chemistry, physics, geophysics, and applied mathematics. The Playas Training and Research Center provides a unique setting research related to urban combat, drug interdiction and border security training programs, complete with state-of-the-art surveillance and monitoring equipment.

The Institute for Complex Additive Systems Analysis (ICASA) is a venture dedicated to studying the behavior, vulnerabilities and predictability of complex systems. ICASA's unique, interdisciplinary, strategic approach harnesses information-age relevant research, the application of that research to real-world problems, development of key enabling technologies, and the training and education of our nation's next generation of critical systems thinkers.

Faculty and facilities from all divisions of Tech provide advanced courses and research opportunities for graduate students.

## Applying for Graduate Admission Regular Admission

Interested persons who have completed or will complete a bachelor's degree prior to admission and have a record that indicates good potential for advanced study (undergraduate GPA of 3.0 is used as a guideline) and research in Tech's programs are encouraged to apply for admission to graduate study. Applicants are strongly encouraged to submit online applications available on the internet at [www.nmt.edu/~grad/](http://www.nmt.edu/~grad/). Printed forms can be requested by e-mail from [graduate@nmt.edu](mailto:graduate@nmt.edu) or by mail from:

Graduate Office  
New Mexico Tech  
801 Leroy Place  
Socorro, New Mexico 87801

To be assured of consideration for assistantships and fellowships, completed applications must be received by:

- February 15 for the fall semester
- September 15 for the spring semester
- May 1 for the summer semester.

Individual departments may have earlier dates for

consideration of assistantships. To be assured of consideration for admission, completed applications must be received no later than August 1 for the fall semester, January 2 for the spring semester, and May 1 for the summer semester. To allow enough time for the admission decision and the acquisition of passports and visas, international students are advised to make sure their application, supporting documents, and application fee are in the Graduate Office by April 1 (for summer and fall semesters) or by October 1 (for spring semester).

Admission to graduate study at New Mexico Tech and the award of financial aid are made to qualified individuals without regard to race, color, creed, sex, or national origin.

### **Master of Science and Doctor of Philosophy Degrees**

In addition to completed application forms, applicants for Master of Science and doctoral programs must provide:

- 1) Sealed, official transcripts of all college work
- 2) References from three professors familiar with the applicant's academic performance
- 3) An application fee of \$45.00 for those using domestic and online international applications, or \$60 for international application packets mailed to applicants
- 4) Official Graduate Record Examination (GRE) scores. GRE General Exam scores are not required for the Master of Science for Teachers program, but are required for many other Master of Science, Master of Engineering Management and Doctor of Philosophy programs. Please refer to the listings at <http://www.nmt.edu/graduate-degree-programs> for the GRE General Examination requirements for each program. If your GRE scores are required by the program to which you are applying, but they are no longer available because you took the examination too long ago, you must retake the GRE examination.

A few departments may also require a subject test score. Information related to departmental requirements for the subject GRE may be obtained online, from the Graduate Office, or by contacting the department to which you are applying. The subject test must be in the same field in which the applicant intends to major.

- 5) Domestic applicants seeking financial aid of any kind are strongly encouraged to submit a completed Free Application for Federal Student Aid (FAFSA) form. The FAFSA form is available online from <http://www.fafsa.ed.gov/>.

### **Master of Engineering Management (MEM)**

Tech's MEM program offers a terminal degree to individuals with undergraduate backgrounds in calculus-based engineering or applied science and work experience in an engineering and/or applied science discipline. Individuals with undergraduate backgrounds in other areas who have at least two years of work experience in a technical environment will also be considered for admission to the program. Preference among all applicants will be given to individuals with at least two years of relevant work or military experience.

In addition to completed application forms, applicants for the Master of Engineering Management program must provide:

- 1) Sealed official transcripts of all college work;
- 2) References from three individuals familiar with the applicant's academic and professional capabilities. We prefer that at least one reference form/letter be submitted by a past or current supervisor. If the applicant is an entrepreneur with no supervisor, a reference form/letter from a business associate is acceptable;
- 3) An application fee of \$45.00 for those using domestic and online international applications, or \$60 for international application packets mailed to applicants;
- 4) Official general Graduate Record Examination (GRE) scores. If your GRE scores are no longer available because you took the examination too long ago, you must retake the GRE examination.
- 5) A current resume that includes information about the applicant's work history, especially in engineering or applied science;
- 6) Applicants with three or more years of work experience with an undergraduate GPA of less than 3.0 must provide detailed information about recent work experience and references from at least two recent supervisors who are able to evaluate the applicant's potential for success in the Tech MEM program;



7) A statement of the applicant's goals. This short (two pages or less) statement should summarize the applicant's career goals and briefly describe how the Tech MEM program will aid in achievement of those goals.

### **Master of Science for Teachers (MST)**

Applicants to the Master of Science for Teachers program must provide the following in addition to the completed Master of Science for Teachers' application materials:

- 1) Sealed, official transcripts of all college work;
- 2) A letter of reference, preferably from your department chair or principal, indicating your interest and abilities related to the pursuit of your MST degree; and
- 3) An application fee of \$45 for those using domestic and online international applications, or \$60 for international application packets mailed to applicants.

### **Certificate Programs**

The Electrical Engineering and Hydrology graduate programs offer post-baccalaureate certificates. Certificates provide an opportunity for students and working professionals to expand and update their knowledge in these fields at the graduate level without committing to a graduate degree at this time.

### **International Students**

New Mexico Tech is authorized under federal law to enroll nonimmigrant alien students. Such applicants wishing to be regular graduate students must complete the international (rather than the domestic) application form. International applicants whose native language is not English are required to take the Test of English as a Foreign Language (TOEFL) examination in addition to the GRE. An internet-based TOEFL (iBT) score of 76, computer-administered score of 207 or paper-administered score of 540 is used as a guide for admission. Information about these examinations is available from the Educational Testing Service, Princeton, New Jersey 08540.

For the 2011-2012 academic year graduate students paying out-of-state tuition at New Mexico Tech may expect to spend \$40,000 (including tuition, fees, room and board, and reasonable personal expenses) for one calendar year of study. Visit the web page at <http://www.nmt.edu/tuition-and-fees> for up to date information on costs. In-state tuition rates,

which would reduce the total by about \$14,000, are available to international students only if they have been granted assistantships or qualified fellowships. Financial statements must be included with the application. Applications from international students, complete with supporting documents, and application fee should arrive in the Graduate Office by April 1 (for summer and fall semester) or by October 1 (for spring semester) to allow enough time for the admission decision and the acquisition of passports and visas. To be assured of consideration for assistantships and fellowships, completed applications must be received by February 15 for the summer and fall semesters and by September 15 for the spring semester. Individual departments may have earlier dates for consideration of assistantships. Tuition and fees are payable upon registration. Deferred payment plans are available for those holding assistantships.

### **Provisional Admission**

Applicants for regular admission may be granted provisional admission if their previous work is deficient in either quality or quantity. Subject to the major department's approval, students admitted provisionally may be advanced to regular graduate student status after one or more semesters of satisfactory academic performance and completion of the designated deficiencies. Students admitted or placed on provisional status must advance to regular status before a degree can be conferred. Students admitted or placed on provisional status are not eligible for financial support and cannot work on campus.

### **Special Admission**

Those who have baccalaureate degrees and who wish to earn graduate credits as their qualifications warrant may be admitted as special graduate students. Special graduate students are not degree candidates and are not eligible for most forms of financial aid including assistantships, fellowships, and student employment. Special graduate status does not qualify international students for student visas. Application for special graduate status must be made using an application for Admission as a Special Graduate Student available online or from the Graduate Office (see contact information under Regular Admission). Request for transfer to regular status must be made using the application for regular admission. No more than 12 credit hours earned as a special graduate student may be applied toward the graduate program.

## Dual Registration

Simultaneous registration as a graduate student and undergraduate student may be approved subject to the following conditions:

- 1) Admission to a five-year program:
  - a) The student admitted to one of the approved five-year programs who wishes to qualify as a graduate student during his or her senior year must apply for admission and be admitted to the graduate program before the end of their junior year.
  - b) Once admitted to the graduate program, the five-year student will spend his or her senior year as a dual registered student.
- 2) In the last semester before graduation, any student may apply for dual registration in his or her last semester before graduation under the following criteria:
  - a) the student has applied for admission and been accepted to the graduate program;
  - b) the student is within nine credit hours of the undergraduate degree;
  - c) the required undergraduate credits must be completed in the first semester;
  - d) the student has a minimum grade-point average of 3.0; and
  - e) where more than one department is involved, the approval of the undergraduate's major department must be obtained.

Students holding dual registration are eligible for assistantship appointments.

## Financial Assistance for Graduate Students

A majority of regular graduate students at New Mexico Tech receive financial aid in the form of assistantships, fellowships, study grants, or part-time employment. Requests for financial support should be made on the Application-for-Admission form or in writing to the department if the student is already registered. To qualify for these aids, the student must first be admitted as a regular full-time student. Continuation of the award is contingent upon the student maintaining the minimum level of registration and satisfactory academic progress as described below. A student failing to complete the length or terms of his or her contract forfeits the right to obtain a new or replacement contract during the interval covered by the original contract. Fellowships are

grants-in-aid for full-time study and research leading to an advanced degree. Assistantships normally require half-time service in teaching or research. Quarter-time appointments may be made in some cases. Students holding appointments qualify for resident tuition.

Assistantships and fellowships are awarded to qualified U.S. citizens and international students to support them in their educational objectives. The advisor, the department chair, and the Graduate Dean must approve any additional employment or remuneration.

## Teaching Assistantships

Teaching assistants are typically appointed for nine months at competitive stipend levels. Additional teaching duties or research opportunities during the summer are sometimes available. Teaching assistants will have from six to ten contact hours per week plus preparation and grading of assigned recitation, laboratory, or tutorial duties. The maximum teaching load for regular instructional duties is six credit hours.

## Research Assistantships

Many graduate students are supported on grants, contracts, or division research funds under the supervision of a faculty member. Research done under the assistantship may be applicable to thesis or dissertation requirements. As is the case throughout the United States, New Mexico Tech is increasingly involved in contract research for corporations and governmental entities, and many times, portions of these research projects cannot be published because of commercial or national security concerns. While a research assistant may complete conditions of employment by working on such projects, there must be a prior understanding between the student, advisory committee, and funding source regarding precisely what will be available for the student's thesis or dissertation, and what will not be available. Forms to document this understanding are available through the Graduate Office and must be on file with the Graduate Office prior to the beginning of graduate student involvement in the research project. Research assistants commonly receive summer appointments as well as nine-month academic year appointments.

## **Fellowships**

Fellowships for the support of graduate students are available from the Institute, professional and industrial organizations and certain federal agencies. Amounts range from those covering tuition and fees to full support through monthly stipends. Fellows must devote full time to studies and research.

## **Need-Based Financial Aid for Graduate Students**

Graduate students who are U.S. citizens or resident aliens are eligible to apply for Direct Stafford Unsubsidized Student Loans and Direct Graduate PLUS Loans. Regular graduate students must be registered for at least six hours per semester to be eligible for federal aid.

## **Satisfactory Academic Progress for Financial Aid**

Financial Aid offices are required to have a policy regarding Satisfactory Academic Progress. The purpose of this policy is to measure a student's academic progress in both a quantitative and qualitative way. This is done by measuring both credit hours earned and cumulative grade point average. To continue receiving Federal Financial Aid students must meet the minimum requirements set in New Mexico Tech's Satisfactory Academic Progress Policy. Be aware that these standards are not the same as New Mexico Tech's standards for academic probation and suspension (page 70-71).

At New Mexico Tech, satisfactory academic progress is reviewed at the end of each payment period (semester). The Satisfactory Academic Progress Policy applies to graduate students that participate in the Federal Direct Loan or Federal Direct Grad PLUS Loan programs.

To be in good standing for Financial Aid purposes a graduate student must earn at least 67% of the hours they attempt with a cumulative G.P.A. of at least 3.0. If you fall below this standard you will be placed on financial aid warning for the following semester. During this semester, you will still be eligible to receive aid. To get back in good standing you will need to meet the policy requirements by the end of the warning semester. If you do not meet the policy requirements by the end of the warning semester, you will be placed on financial aid suspension. Once a student is on financial aid

suspension, he/she is not eligible for any Federal Financial Aid until the standards of the Satisfactory Academic Progress Policy have been met or an appeal is approved.

Students have the opportunity to appeal the determination that they are not making satisfactory academic progress. To appeal the student will need to complete an Appeal Form. On that form the student will need to explain why he/she failed to meet our Satisfactory Academic Progress standards and what has changed that will allow him/her to meet the standards by the end of the next semester. If an appeal is approved the student's Satisfactory Academic Progress status will change to either Probation (1 semester of eligibility) or Probation with a plan (Continued eligibility as long as conditions of individual plan are met).

There is also a maximum timeframe that a student has to complete a graduate degree. The maximum for a master's degree is 45 attempted credit hours. This includes all hours attempted as a graduate student regardless of the course level. The maximum timeframe for a doctor of philosophy degree is 75 attempted credit hours. This includes all hours attempted at that level.

## **Employment**

Part-time, on-campus employment is sometimes available to regular, full-time graduate students for up to 20 hours per week. Campus employment requires a minimum registration of twelve credits in the fall and spring semesters. Students who are not progressing towards their degree over the summer may have campus employment if they are preregistered full-time for the fall semester.

## **Annual Leave**

Graduate students on twelve-month assistantship or fellowship contracts are allowed two weeks of annual leave. Scheduling of the vacation period will be worked out with the advisor. Teaching assistants follow the regular academic calendar.

## **Academic Freedom and Tenure**

Graduate student teaching and research assistants are included in New Mexico Tech's academic freedom and tenure policy.

## Graduate Program Policies

See the *Graduate Student Handbook* at [www.nmt.edu/grad-current/](http://www.nmt.edu/grad-current/) for more information.

### Graduate Student Status

#### Regular

A regular graduate student is a degree-seeking student admitted to a graduate degree program at New Mexico Tech.

A **regular full-time graduate student** is one enrolled for nine to thirteen credit hours per fall or spring semester (six credit hours in the summer semester). Graduate students may register for a 13th credit of Community College or Physical Recreation courses at the 100-200 levels. Such registrations carry no additional tuition charge. Courses numbered 300+ to be counted for the graduate degree, non-credit Community College classes and 100/200- level classes required as leveling courses do not qualify for the tuition free 13th credit.

A **regular part-time graduate student** is one enrolled for eight or fewer credit hours per semester and is not eligible for financial support. To be admitted as a part-time graduate student, an applicant must meet the same standards for admission as a regular full-time graduate student. A full-time graduate student may request transfer to part-time status provided the student is in good standing. Similarly, a part-time graduate student may request transfer to full-time status provided the student has a cumulative grade-point average of at least 3.0 for those courses in which a standard letter grade is received.

A **regular distance graduate student** is one admitted to one of the graduate degree programs that incorporate distance delivery as a major component of its instructional offerings. There are currently no graduate degrees that may be obtained solely by distance delivery. Distance graduate students are typically place bound or employed full-time. To be admitted as a regular distance graduate student, an applicant must meet the same standards for admission as a regular full-time or part-time graduate student. Distance students register for as many credits as are necessary, but typically not for more than 13 credits. Each distance student must register for at least one semester in each academic year to be regarded as a continuing student. Failure to do so will require that the student reapply for admission to the graduate program.

#### Provisional

Provisional (full-time, part-time, or distance) graduate status may be granted to students whose previous work is deficient in either quality or quantity. Subject to the major department's approval, students admitted provisionally may be advanced to regular graduate student status after one or more semesters of satisfactory academic performance and completion of the designated deficiencies. Students admitted or placed on provisional status must advance to regular status before a degree can be conferred. Provisional students are not eligible for financial support and cannot work on campus.

#### Special

Special graduate status provides an opportunity for those who have baccalaureate degrees to earn up to nine graduate credits hours per semester. Special graduate students are not degree candidates and are not eligible for assistantships, fellowships, and student employment. The Graduate Dean will either serve as the advisor for special graduate students or designate a faculty member as advisor. Request for transfer to regular status must be made using the application for regular admission. No more than 12 credit hours earned as a special graduate student may be applied toward the graduate program.

#### Advisor and Advisory Committee

Each regular and provisional graduate student will be assigned a temporary advisor by the department from the student's major field of study at the time of first registration. The full time student will formalize a thesis, dissertation, or independent-study advisor and an advisory committee by the end of the student's second semester of residency. Part-time and distance education students must formalize their committees by the time they complete 12 credits. The student's academic advisor must be a regular (tenured, tenure-track or emeritus) faculty member of the department in which the student is pursuing his or her degree. The academic advisor will typically serve as the student's research advisor, however, in some cases a separate research advisor may be designated. The research advisor is responsible for guiding the student to the completion of their research project and for supervision of the preparation of the research report (thesis, dissertation or independent study paper). A research

advisor need not be a regular departmental faculty member. Regular faculty members from the department or interdisciplinary program may not be in the minority on a committee. The department chair and the Graduate Dean must approve the advisor and members of the advisory board. Committee forms are available online and from the Graduate Office.

At the master's level, the advisory committee consists of at least the academic advisor and two other members. At the doctoral level, the advisory committee consists of at least the advisor and three other members. One of these members must be from outside the department and must be assigned or approved by the Graduate Dean. Some departments require five members on the advisory committee. The academic advisor serves as chair of the advisory committee. The student should meet with his or her advisory committee at least once a year.

### **Course Program**

Courses to be used towards each of the graduate degrees at New Mexico Tech must meet the requirements of the degree being pursued and must meet with the prior approval of the student's advisory committee. These courses constitute the student's Course Program. The approved Course Program must be on file in the Graduate Office no later than the end of the second semester of residency. Part-time and distance education students must formalize their committees by the time they complete 12 credits. The course program is reported on the committee report form, available online and from the Graduate Office.

### **Course Load**

Regular and provisional full-time and part-time graduate students are required to continue registration each semester until certified for the degree. Regular distance students must register for a minimum of one semester each academic year and their registrations must conform to the plan of study developed with their advisory committee and on file in the Graduate Office. The minimum course load for a full-time graduate student is nine credit hours (12 credit hours if on support) per fall or spring semester; six credit hours during the summer semester if they are progressing towards the degree. Part-time graduate students must register for eight or fewer credits per semester. Credits taken to satisfy minimum registration requirements must be numbered 300 or above and must be

applicable to the graduate program as determined by the advisory committee. Written permission from the advisor, the department head, and the Graduate Dean is required for exceptions to the described course load. Regular and provisional graduate students registered for other classes may audit one class and associated lab if applicable. Audit credits apply to the semester course requirements.

Part-time status is not granted as a means to reduce registration for a full-time student while completing the final requirements leading to their degree. A full-time graduate student in good standing who has two or more years of residence, has completed all course work, has filed an Intent to Graduate, and who has no work authorization, assistantship, or fellowship support, may elect to become a part-time student for one semester. While in this category, the student must enroll for at least three credit hours of thesis, independent study, or dissertation.

### **Grades**

At the time of graduation, the cumulative GPA must be 3.0 for all courses numbered 300 or above with no grade less than "C." The grade point average for course credits designated for the degree must be 3.0 or above. Independent study (590), thesis (591), or dissertation (595) courses will be graded with either PR (progress) or U (unsatisfactory). A student will be placed on probation for earning a "U" in independent study, thesis, or dissertation. A second "U" in independent study, thesis, or dissertation may result in dismissal from graduate school. Only those credits graded PR (progress) accumulate toward the minimum required number of credits for research.

Directed research (500) and other courses taken on a S/U basis may not be used to fulfill graduate degree requirements.

### **Graduate Co-op Experience**

Graduate students may choose to gain research experience as part of their graduate program by performing sponsored work away from campus. To be involved in co-op experiences students must:

- 1) submit a letter of application to the Graduate Dean with supporting letters from the student's advisor or graduate committee;
- 2) be a regular full-time student in the semester of application;

- 3) enroll in a Directed Research course (500) in their department during the co-op period, maximum of 12 months;
- 4) provide a final report and any other requirements placed on the student to their graduate committee on completion of the co-op experience.

The student is responsible for arranging the co-op experience with both their advisor and with the work sponsor.

### **Graduate Degrees for Faculty and Staff**

Instructors in the College Division and staff members of the Bureau of Geology and Mineral Resources, Petroleum Recovery Research Center, Institute for Complex Additive Systems Analysis, and Research and Economic Development Office who are not on tenure may pursue programs leading to Master's or Ph.D. degrees. Tech policy does not permit administrative officers and members of the faculty with the rank of assistant professor or above to take advanced degrees.

Employees who wish to pursue a degree program should apply for admission to the department desired by using standard forms available online or from the Graduate Office. Time limits for degree programs apply.

### **Leave of Absence**

In certain circumstances, a candidate may interrupt progress toward the degree by petition to the Graduate Dean for leave of absence for one or more semesters. Such letters must carry the endorsement of the student's advisor and the department chair. While on leave, the student does not have access to the facilities and staff of the Institute.

### **Satisfactory Academic Progress**

To demonstrate satisfactory academic progress, each regular graduate student must:

- 1) earn a grade-point average of 3.0 or better each semester;
- 2) receive no grade less than C for those courses in which a standard letter grade is received;
- 3) full-time students must formalize their advisory committee and establish their Course Program no later than the end of the second semester of residency as a regular graduate student;

- 4) Part-time and distance education students must formalize their advisory committee and establish their Course Program before the completion of 12 credits;
- 5) In addition, full-time students must satisfactorily complete a minimum of nine credit hours (12 credit hours if on support) each fall or spring semester; six credit hours must be completed during the summer semester if in residence (as described under Course Load, page 53); part-time students must be registered for eight or fewer credits each semester; distance students must register according to the plan on file with the Graduate Office.

Assistantships or fellowships are subject to immediate termination if satisfactory academic progress is not achieved. Any student who fails to maintain satisfactory progress for two consecutive semesters will be dropped from regular graduate student status. Such students may apply for special (non-degree) status without financial support. After completion of nine credit hours within a single semester in courses approved for the degree program with a grade-point average of 3.0 or better and no grade less than C, the student may petition the department for return to regular graduate status.

### **Thesis, Independent Study, and Dissertation Requirements**

The thesis or dissertation is to be written with the intention of publication. The thesis or dissertation must include a preliminary, roman-numbered section containing the title page, acknowledgments, abstract, table of contents, list of figures, and list of tables. The acceptance sheet, signed by the members of the committee, is included at the end of the preliminary section of the thesis or dissertation. Arabic page numbering should begin with page 2 of the body of the thesis. Appendices may be included. The bibliography should include only references cited in the text. Detailed instructions for completion of the thesis manuscript are available online at: [infohost.nmt.edu/~grad/studentinfo/manuscript.html](http://infohost.nmt.edu/~grad/studentinfo/manuscript.html) Master's theses and Ph.D. dissertations must be publicly presented and defended. After a successful defense, a thesis or dissertation must be immediately submitted to the Graduate Office for publication online, through the Joseph R. Skeen Library, and be made available for publication elsewhere. As is the case throughout the

United States, New Mexico Tech is increasingly involved in contract research for corporations and governmental entities, and many times portions of these research projects cannot be published because of commercial or national security concerns. While a research assistant may complete conditions of employment by working on such projects, there must be a prior understanding between the student, advisory committee and funding source regarding precisely what will be available for the student's thesis or dissertation, and what will not be available. Forms to document this understanding are available through the Graduate Office and must be on file with the Graduate Office prior to the beginning of graduate student's involvement in the research project.

### **Deposit**

Completed digital and printed theses or dissertations and digital copies of independent study abstracts must be submitted to and approved by the Graduate Office no later than two weeks prior to the end of the semester in which the requirements for the degree are to be completed.

### **Digital Theses and Dissertations**

Students writing theses or dissertations must deposit complete digital copies of their manuscripts with the Institute's online digital thesis and dissertation database. Theses and manuscripts or portions thereof that are published must be uploaded and circulated locally pending receipt of approval from the publisher for global circulation. If the publisher denies permission, only those portions affected will be limited to local circulation. Please visit the Graduate Studies web pages or the Graduate Office for information on submission of digital manuscripts. Digital manuscripts must be submitted and approved by the Graduate Office two weeks prior to the end of the semester in which the requirements for the degree are to be completed. A copyright form must be completed and signed at time of submission of the digital manuscript.

### **Bound Volumes**

Three printed copies must be submitted to and approved by the Graduate Office two weeks prior to the end of the semester in which the requirements for the degree are to be completed. These three volumes must be printed using permanent ink or toner on 20-pound bond paper, or a high quality, low acid

photocopy paper. The text must be double-spaced and all materials (text, tables, and diagrams) must be within page margins of one and one-half inches for the left (bound) margin, and one inch for the top, bottom, and right margins. Photographic reproductions must be of a permanent nature and be securely bonded to each page. Complete guidelines for manuscript preparation are available on line at [infohost.nmt.edu/~grad/studentinfo/manuscript.html](http://infohost.nmt.edu/~grad/studentinfo/manuscript.html).

### **Independent Study Requirements**

Formats for the preparation of Independent Study papers should conform to the requirements of the advisor, advisory committee and department where the student is enrolled, but may follow the guidelines for theses and dissertations (above). A digital version of the independent study abstract must be submitted to the New Mexico Tech online digital thesis and dissertation database no later than two weeks before the end of the semester. If for any reason, an Independent Study report is published through the New Mexico Tech Library, it must also be submitted to the New Mexico Tech online digital thesis and dissertation database.

### **Time Limits**

All work presented to fulfill the requirements for a master's degree must be completed within three calendar years from the date of first registration. The corresponding limit for the doctoral degree program is a total of five years past the master's degree or a maximum of seven years if the student enters the program after completing a bachelor's degree.

Extensions of these limits may be made in special cases, but only upon recommendation by the department and with the approval of the Graduate Dean. Time limitations for part-time students will be considered on an individual basis.

Funding limits for graduate students holding fellowship or assistantship appointments are two years for a master's level degree or three years beyond the master's level for the doctoral degree. Consideration for extension beyond these limits can be given through petition to the Graduate Dean.

### **Transfer Credits**

A maximum of 12 credit hours of course work with grade B or better earned at another accredited institution may be approved by the student's advisory committee and major department for transfer credit

into the master's program. The student's advisory committee considers transfer credit in doctoral programs on an individual basis. To be approved, such credits must not have been used to satisfy the requirements for a previous degree.

For details of the transfer credit policy applicable to the Master of Science for Teachers program, see page 2012.

### **Tuition and Fees**

Please refer to pages 60-61 for information on the costs of tuition, housing, medical insurance and other fees affecting graduate students.

### **Completion of Degree Requirements**

- 1) During the final semester of residence, the student must have on file a Declaration of Intent with the Registrar's Office. Deadlines are July 1 for those completing their degrees in December and December 1 for those completing their degrees in May and August. The Declaration communicates the candidate's intent to fulfill the degree requirements.
- 2) At least eight weeks prior to the end of the candidate's final semester, printed preliminary copies of the candidate's thesis or independent study paper must be in the hands of the advisor.
- 3) Two weeks prior to the defense, the complete defense draft (with the preliminary section, figures, bibliography, and appendices) must be in the hands of the committee.
- 4) The student must be registered for the semester during which the thesis or dissertation is defended or the Independent Study is approved.
- 5) The chair of each graduate advisory committee will submit a written report to the student with copies to the chair of the department and Dean of Graduate Studies within five days of the defense of a thesis or dissertation. In this report, the chair shall state that the thesis or dissertation is accepted as submitted and defended or explain what needs to be done in order for the thesis or dissertation to be accepted. The report will be initialed by the members of the advisory committee.
- 6) Two weeks prior to the end of the semester the completed report of the advisory committee and either three final copies of the accepted, successfully defended thesis must be submitted to the Graduate Office or one final

copy of an accepted independent study paper must be submitted to the student's advisor and advisory committee. At this time, approved digital versions of thesis, dissertation, or independent study abstracts must be uploaded into the Tech Digital Thesis Database.

### **Appeal**

All requirements for graduate degrees are subject to appeal to the Graduate Council through the appropriate department.

## **Graduate Degree Requirements**

### **Graduate Minors**

A graduate minor at the master's level requires at least 12 hours in the minor area, at least 6 of them at the 500 level. At the doctoral level, a minor requires at least 18 hours, 12 of them at the 500 level. Courses used for a bachelor degree or bachelor minor may not be used for a graduate minor. Specific requirements for minors must be approved by the Graduate Council and Faculty Senate.

### **Master of Science Degree**

General requirements are common to all Master of Science degree curricula in the science and engineering fields. Specific requirements are listed under appropriate departments.

### **General Requirements**

It is required that a student preparing for the M.S. degree:

- 1) Have competence in the subject matter of the standard introductory college courses in chemistry and physics.
- 2) Have a working knowledge of calculus and the content of one additional course in mathematics beyond calculus;
- 3) Have a minimum of six credit hours of approved upper-division or graduate course work from another department. The advisory committee may determine that a student's previous academic experience has provided breadth and may recommend modification of this requirement; and
- 4) Complete a research project culminating in a thesis or independent study paper.

### **Approvals**

- 1) The appropriate department grants admission to its graduate program.
- 2) The appropriate department and the Graduate Dean must approve the composition of each graduate student's advisory committee.



- 3) The graduate student's advisory committee must approve both thesis and independent study research projects. The MS degree will not be awarded until the thesis or independent study paper has been approved by the advisory committee.
- 4) Coursework to be applied toward the degree must meet the associated degree requirements and be approved by the graduate student's advisory committee.

### Research Options

There are two research options, M.S. with Independent Study and M.S. with Thesis. Each option requires a minimum of 30 credit hours. Some departments do not recognize the first option.

- 1) M.S. with Independent Study requires:
  - a) Completion of at least 27 credit hours of approved course work, with at least 15 credit hours of 500-level courses, exclusive of research credits;
  - b) Completion of at least three credit hours of independent study; and
  - c) Submission of a formal paper describing the results of the research to the candidate's advisor and advisory committee.
  - d) Submission of a digital abstract of the independent study to the Graduate Office.
- 2) M.S. with Thesis requires:
  - a) Completion of at least 24 credit hours of approved course work, with at least 12 credit hours of 500-level courses, exclusive of research credits;
  - b) Completion of at least six credit hours of thesis work;
  - c) Satisfactory oral defense of the thesis research; and
  - d) Submission of three final copies of the thesis to the Graduate Office.
  - e) Submission of a digital copy of the thesis to the Graduate Office.

### Combined Five-Year Bachelor of Science/Master of Science Programs

Three programs in which a student may earn a Bachelor of Science degree as well as a Master of Science degree in five years are available:

Biology: Five-Year Program (page 98),  
 Earth Science: Five-Year Program (page 138),  
 Environmental Engineering: Five-Year Program (page 240),  
 Hydrology: Five-Year Program (page 138),  
 Materials Engineering: Five-Year Program (page 248),  
 Mathematics: Five-Year Program (page 173),

Electrical Engineering: Five-Year Program (page 231),

Students admitted to five-year programs must apply for admission to the graduate program during their junior year. During their senior year, these students will be dual registered (page 49).

### Master of Engineering Management

New Mexico Tech's Master of Engineering Management graduate program is designed to provide working engineers and on-campus graduate students with a one-year terminal degree in Engineering Management. The curriculum is designed to be innovative and can be delivered both on campus and, via distance education, in other areas of New Mexico. Specific requirements related to the Master of Engineering Management degree curricula are listed under department (see page 236).

### General Requirements

#### Approvals

- 1) The Management Department grants admission to its graduate program.
- 2) The Management Department and the Graduate Dean must approve the composition of each graduate student's advisory committee.
- 3) The graduate student's advisory committee must approve both thesis and independent study research projects. The MS degree will not be awarded until the thesis or independent study paper has been approved by the advisory committee.
- 4) Coursework to be applied toward the degree must be approved by the graduate student's advisory committee.

#### Research Option

In addition to a final project, the Master of Engineering Management degree requires:

- 1) Completion of at least 27 credit hours of approved course work, with at least 15 credit hours of 500-level courses;
- 2) Completion of at least three credit hours of independent study; and
- 3) Submission of a formal paper describing the results of the final project to the candidate's advisor and advisory committee.
- 4) Submission of a digital abstract of the formal paper to the Graduate Office.

## Master of Science for Teachers

The graduate program in science for teachers provides graduate-level classroom and laboratory instruction for secondary school teachers of science and mathematics and leads to the Master of Science for Teachers (MST) degree. Courses for science teachers are offered on the campus during the summer session and through distance education during the academic year. Specific requirements for the Master of Science for Teachers degree curricula are listed under department (see page 201).

## General Requirements

### Approvals

- 1) The Master of Science for Teachers program grants admission to its graduate program.
- 2) The Master of Science for Teachers program and the Graduate Dean must approve the composition of each graduate student's advisory committee.
- 3) The graduate student's advisory committee must approve both thesis and independent study research projects. The MS degree will not be awarded until the thesis or independent study paper has been approved by the advisory committee.
- 4) Coursework to be applied toward the degree must be approved by the graduate student's advisory committee.

### Research Options

There are two research options, MST with Independent Study and MST with Thesis. Each option requires a minimum of 30 credit hours.

- 1) M.S. with Independent Study requires:
  - a) Completion of at least 27 credit hours of approved course work, with at least 15 credit hours of 500-level courses;
  - b) Completion of at least three credit hours of independent study; and
  - c) Submission of a formal paper describing the results of the research to the candidate's advisor and advisory committee.
  - d) Submission of a digital abstract of the independent study to the Graduate Office.
- 2) M.S. with Thesis requires:
  - a) Completion of at least 24 credit hours of approved course work, with at least 12 credit hours of 500-level courses;
  - b) Completion of at least six credit hours of thesis work;

- c) Satisfactory oral defense of the thesis research; and
- d) Submission of three final copies of the thesis to the Graduate Office.
- e) Submission of a digital copy of the thesis to the Graduate Office.

## General Requirements for a Second Master of Science Degree at Tech

Students who wish to earn a second master's degree at Tech must:

- 1) Satisfy the specific course requirements in both fields, and
- 2) Complete either:
  - a) 9 additional approved credit hours plus a thesis (6 or more credit hours) in the second field, or
  - b) 12 additional approved credit hours plus an independent study (3 or more credit hours) in the second field.

Second degrees may not be available from some departments.

## Doctor of Philosophy Degree Requirements

The degree of Doctor of Philosophy requires a high level of competence in a recognized field of learning, and only those students showing unusual promise are accepted. A dissertation that contributes to the general field of knowledge must be written and defended before a committee of the faculty.

The doctoral student can expect to spend five or more years of study and research beyond the bachelor's degree in order to complete the program. In addition to dissertation credits, course requirements for each specialty are listed under the programs and courses of instruction for each department.

Doctoral degree programs are available in chemistry, computer science, the earth science fields, materials, mathematics, petroleum engineering, and physics. Faculty, courses, research fields, and specific requirements for these programs are given under the appropriate department listing.

### Preliminary Examination

Each department may require a preliminary or qualifying examination for the students admitted to its doctoral degree program. Students contemplating doctoral studies at the university should contact the respective department regarding the administration of these examinations.

### Candidacy Examination

The purpose of the candidacy examination is to evaluate the student's ability to complete dissertation research. The exam is taken before accumulation of

dissertation credits, typically after completion of graduate course work. The candidacy exam is the responsibility of the individual department; the graduate student should consult the respective departments about candidacy exams. Passing the candidacy exam is one of several steps that must be completed prior to Admission to Candidacy.

### **Admission to Candidacy**

A doctoral student may apply for candidacy upon completion of a minimum of one year of study at Tech. A student qualifies for admission to candidacy by:

- 1) Averaging B or better in coursework taken;
- 2) Passing the preliminary or qualifying examination at an approved level;
- 3) Passing the candidacy examination; and
- 4) Showing preliminary work under way on a dissertation subject.

Candidacy must be achieved at least one year prior to the time the degree is conferred.

### **Dissertation**

The doctoral dissertation demonstrates the candidate's capacity for independent research. The student may register for dissertation hours only after successfully advancing to candidacy. A minimum of 24 credit hours distributed over one or more years must be devoted to the dissertation after candidacy has been achieved. The student is encouraged to explore the various current research projects in his or her field of interest before choosing a dissertation subject. The dissertation must be defended before the Tech faculty under the supervision of the student's advisory committee. Manuscript requirements are on page 55. An external examiner will be included on the defense committee. The candidate must be registered during the semester in which the completed dissertation is submitted to the Graduate Office. Doctoral candidates are required to present at least one departmental or general seminar on the dissertation during their tenure as a graduate student. Before the degree is approved and granted, at least one paper on the subject matter of the dissertation must be submitted to a recognized journal acceptable to the doctoral committee of the student.

### **Departmental Certification**

The appropriate department must certify to the Graduate Office that the general requirements are being satisfied and that the candidate is making required progress. The method of evaluation varies with the department. Certification is transmitted to the Graduate Office on forms provided by the Graduate Office. These forms are:

- 1) The Advisory Committee Form, and
- 2) The Report of the Advisory Committee, which records the actions of the student's advisory committee.

### **Completion of Requirements**

A record of all steps completed in a particular student's program is kept in the Graduate Office. When all the requirements are completed, the record of the program is sent to the Registrar. If the graduation and other fees have been paid, and a Declaration of Intent has been filed and approved by the Registrar, the candidate's name will be presented to the Faculty Council for recommendation to the Regents.

### **Postdoctoral and Visiting Scholars**

Postdoctoral fellows, research associates, and visiting scholars are accommodated as appropriate in research programs within departments. The faculty host and department negotiate arrangements, with an official appointment made by the Tech administration. International guests may visit classes on an informal basis by arrangement with the instructor. If credit or audit privileges are desired, application must be made through the Graduate Office.

# Expenses

The information below is for the 2012-2013 school year. For current information on Tuition and Fees, check our web page at [www.nmt.edu](http://www.nmt.edu) or call the Admission Office at 1.800.428.TECH. All fees are subject to change without prior notice.

## Nonrefundable charges

### Application Fees

\$15	Undergraduate
\$45	Graduate

### Admission Fees

\$50	Undergraduate
\$25	Graduate

### Miscellaneous Fees

\$10	Challenge Exam fee (per semester hour)
\$25	Deferred Payment Plan Fee
\$25	ID Card Replacement Fee
\$30	Late Registration Fee (per day)
\$65	Late Validation Fee (per day)
\$65	Orientation Fee
\$15	Transcript Fee (per transcript/per academic year)
\$3.82	Withdrawal Fee

### Graduation Fees

\$30	Associates Degree
\$40	Bachelors Degree
\$50	Masters Degree
\$60	PhD Degree

## Refundable Charges

### Tuition per semester, Full Time Resident

\$2,414.16	Undergraduate (12 - 18 credit hours)
\$2,521.71	Graduate (9 - 13 credit hours)

### Tuition per semester, Full Time Non-Resident

\$7,849.44	Undergraduate (12 - 18 credit hours)
\$8,341.20	Graduate (9 - 13 credit hours)

### Tuition per semester, Part Time Resident, per credit hour

\$201.19	Undergraduate
\$280.19	Graduate

### Tuition per semester, Part Time Non-Resident, per credit hr

\$201.19	Undergraduate, 1 to 6 credit hrs
\$280.19	Graduate, 1 to 6 credit hrs
\$654.12	Undergraduate, 7 to 11 credit hrs
\$926.80	Graduate, 7 to 8 credit hrs

### Fees and Deposits

\$6.00	Auxiliaries Fee (per credit hour)
\$1.00	Institute Activities Fee (per credit hour)
Variable	Laboratory Usage Fee
\$4.50	Sports Activity Fee, (per credit hour)
\$93.00	Student Activity Fee, Undergraduate, 7 credit hours or more
\$46.50	Student Activity Fee, Undergraduate, 6 credit hours or less
\$82.84	Student Activity Fee, Graduate, 7 credit hours or more
\$41.43	Student Activity Fee, Graduate, 6 credit hours or less
\$6.50	Student Center Fee (per credit hour)
\$5.00	Student Center Base Fee, (per student)
\$20.00	Wireless Service Fee (per semester)
\$100.00	Room Reservation/Damage Deposit
\$200.00	Housing Deposit (Student Family Housing)

## Housing and Meal Plan Charges

See the current rate sheet at:

<https://www.nmt.edu/prospective-a-incoming-students/135-rate-sheets>

The minimum estimated expenses which must be met **per semester** by single, full-time students living on campus at New Mexico Tech during the 2011-2012 school year are:

### Undergraduate Costs per Semester

<i>Resident</i>	<i>Non-Resident</i>	
\$2,414.16	\$7,849.44	Tuition (based on 12-18 credit hours)
\$334.00	\$334.00	Student fees (est. total based on 12 cr hrs)
\$664.00	\$664.00	Personal expenses (estimated total)
\$2,898.00	\$2,898.00	Room and board (double room, 150 + 75 Tech Dollar meal plan)
\$433.00	\$433.00	Books and supplies (estimated)
<b>\$6,743.16</b>	<b>\$10,12,178.44</b>	<b>Total Estimated Minimum Costs per Semester</b>

### Graduate Costs per Semester

<i>Resident</i>	<i>Non-Resident</i>	
\$2,521.71	\$8,341.20	Tuition (based on 9-13 credit hours)
\$323.84	\$323.84	Student fees (est. total based on 9 cr hrs)
\$664.00	\$664.00	Personal expenses (estimated total)
\$2,898.00	\$2,898.00	Room and board (double room, 150 + 75 Tech Dollar meal plan)
\$433.00	\$433.00	Books and supplies (estimated)
<b>\$6,840.55</b>	<b>\$12,660.04</b>	<b>Total Estimated Minimum Costs per Semester</b>

The student should add travel costs and laboratory and special fees where applicable. **Tuition, fees, and charges for room and board are subject to legislative and administrative change at any time.** Charges for damage to property beyond normal wear and tear may be levied at the discretion of Tech.

A complete list of possible charges and an explanation of each appears on the next pages. Schedules outlining refund procedures follow. All charges are due and payable on or before registration or whenever they are incurred (page 63).

## Tuition

### Undergraduate Students

Any undergraduate who registers for 12 to 18 credit hours pays full tuition. Additional tuition for all hours carried above 18 credit hours will be charged at the semester hourly rate for residents or nonresidents as applicable. Students registered for 11 credit hours or less pay tuition at the semester hourly rates.

### Graduate Students

Any graduate student who registers for 9 to 13 credit hours pays full tuition. Additional tuition for all hours carried above 13 credit hours will be charged at the semester hourly rate for residents or nonresidents as applicable. Graduate students registering for fewer than nine credit hours pay tuition at the semester hourly rates.

### Auditors, Special Students, and Senior Citizens

Students who audit courses (those who enroll in one or more courses for no credit) pay the same tuition and fees as credit students.

Special students, as classified by the Admission Office or Registrar, pay required tuition and fees per credit hour. Special students may not register for more than six credit hours per semester. Non-resident tuition is waived for special students enrolled for no more than six credit hours.

The non-degree-seeking student who has a bachelor's degree is regarded by New Mexico Tech as a Special Graduate Student. Special Graduate Students will be charged tuition at undergraduate rates for courses numbered less than 300 and graduate tuition for all courses numbered 300 and above.

Tuition for students 65 or older is \$5.00 per credit hour and must be requested at time of registration. Applicable fees must also be paid.

### Residency

You are considered a resident of New Mexico if your parents or legal guardians are residents of New Mexico.

If you are over 18 years of age, you may become a legal resident of New Mexico while attending New Mexico Tech. See page 74 for information on changing your residency.

Non-resident aliens cannot obtain New Mexico residency.

With the exception of graduate students employed as teaching or research assistants, international students do not qualify for in-state tuition.

### Navajo Residency

Registered members of the Navajo Tribe who reside anywhere within the Navajo Nation are considered New Mexico residents for tuition purposes.

## Refunds

### Tuition and Applicable Fees, Fall and Spring Semesters

The student who drops all fall and spring classes at New Mexico Tech prior to 5 p.m. on the third Friday after classes begin will receive a refund according to the following schedule:

	<i>Refund of tuition and fees</i>
Registration week (days 1 through 5)	100%
Days 6 through 12	75%
Days 13 through 19	70%
Days 20 and beyond	0%

The student who drops some, but not all, classes (reduction in class load) prior to 5 p.m. on the third Friday after classes begin will receive a 100% refund for the classes dropped.

#### After the third Friday after classes begin:

No refunds are made to students who withdraw from any or all fall or spring classes after the third Friday after classes begin.

### Tuition and Applicable Fees, Summer Semester

#### Prior to 5 p.m. on the first Friday after summer classes begin

The student who drops any or all summer classes at New Mexico Tech prior to 5 p.m. on the first Friday after classes begin will receive a 100% refund.

#### After the first Friday after classes begin

No refunds are made to students who withdraw from any or all summer classes after the first Friday after classes begin.

### Financial Aid Implications

Student receiving financial aid who withdraw from all classes are subject to a Return of Title IV Funds policy, which returns funds to the financial aid programs. For further information, see Return of Title IV Funds, page 46.

### Room (Apartment or Residence Hall)

#### Cancellation Policy

*All refunds are based upon the student being formally released from the housing agreement.*

The \$150 Room Reservation/Damage Deposit

serves as both a reservation fee and contractual guarantee. Refunds are made as follows:

- The student may cancel his or her agreement without penalty by June 1 for the fall semester, December 1 for the spring semester, and May 1 for the summer semester.
- The student who cancels his or her agreement after the above dates but before the beginning of the term will be charged a \$250 fee for breaking the contract. The Room Reservation/Damage Deposit will be released into the student's account.
- The student who cancels his or her agreement after the beginning of the term will receive a refund based on the following schedule:
 

70%	during the first week of the term
60%	during the second week of the term
50%	during the third week of the term
40%	during the fourth week of the term
30%	during the fifth week of the term
0%	during and after the sixth week of the term

The Room Reservation/Damage Deposit will be released into the student's account.

Students with extenuating circumstances for canceling the residence hall agreement must request, in writing to the Residential Life Office, a waiver of the fee charged for breaking the contract and/or waiver of the refund schedule.

### Board

Should a student cancel before or during the third week of the Residence Hall Term (regardless of where they live), the student will be charged for the number of weeks he/she has been on the board plan (half weeks will be rounded up to the following full week) and will be refunded the rest of the board fee. After the third week of the Residence Hall Term (regardless of where they live), the student will not be refunded any portion of the board plan and may continue to use the board plan.

You may not make any changes to your board plan after the first Friday after registration each semester.

Students with extenuating circumstances for canceling the room and board agreement must request,

in writing from the Residential Life Office, a waiver of contract break fee and/or waiver of refund schedule.

### **Payment of Fees**

- 1) Tuition and fees must be paid by registration or the student must be enrolled in a payment plan available on NMT's secure TouchNet site accessed through their account on Banweb (see no. 4). Financial aid that has been awarded to the student will be credited to the student's account at this time.
- 2) Students with delinquent accounts will not be allowed to register for a new semester.
- 3) Payment for bookstore merchandise must be made in full at the time of purchase. (The bookstore accepts most major credit cards.)
- 4) Students are able to set up deferred payments and have two options through the e-billing system – three- or four-payment installment plans. Students can establish a payment plan on all costs – tuition, room-and-board and student fees – with a 20 percent down payment due at registration. A non-refundable \$25 setup fee will be charged for students who elect to enroll in the deferred payment plan.

To log in to the Tech e-billing page, visit [https://secure.touchnet.com/C22533\\_tsa/web/login.jsp](https://secure.touchnet.com/C22533_tsa/web/login.jsp)

- 5) Students whose accounts are not paid in full by the due date or who have not made alternate arrangements with the Student Accounts Office are subject to permanent loss of academic credit, as well as disenrollment from all classes. Students have the right to appeal to the Dean of Students in writing no later than one week (five working days) before the final payment date.
- 6) A check will automatically be issued to students with a credit balance of \$100 or more. Refund checks will be issued twice during registration week (actual days will be determined on a semester-by-semester basis) and every Friday afternoon thereafter. Students who have a credit balance of less than \$100 must request the refund at the Student Accounts office. Checks will be held at the Cashier's window for pick up by the student. A current, valid student ID must be presented.

Students can also elect to have their refunds direct deposited to their checking or savings account via the e-billing system.

- 7) All financial aid—including scholarships, loans, and grants—is applied during the semester in which it is awarded. Aid cannot be applied retroactively.
- 8) Rent for Student Family Housing must be paid in advance. Students with delinquent housing accounts may be asked to vacate campus residences.
- 9) Telephone charges must be paid by the tenth of the month, or service may be terminated.

## **Definitions of Fees**

### **Admission Fee**

An Admission Fee is payable when the applicant is admitted and ensures the student's inclusion in the registration procedures. The fee is not refundable.

### **Application Fee**

Each student applying for admission to New Mexico Tech must submit an application fee for undergraduate or graduate admission. This nonrefundable fee must be received before the application can be processed.

### **Auxiliary Services Fee**

This fee defrays expenses of various auxiliary services on the campus, including the Swim Center, Macey Center, Golf Course, Children's Center, and Student Activity Center.

### **Challenge Examination Fee**

Special or challenge examinations must be arranged in advance and a fee per semester hour is charged for each.

### **Computer Usage Fee**

The Tech Computer Center charges a basic fee to each student who uses the machines. Additional fees for file storage space and printouts beyond the minimum will also be charged.

### **Deferred Payment Plan Fee**

A fee is charged to students who qualify for a deferred payment plan covering room and board. One-third of the total amount is due at registration and the balance is due in accordance with a schedule set by the Business Office. Students will not be allowed to register for a new semester until their accounts are paid in full for the previous semester. Students who have delinquent accounts are subject to administrative withdrawal of current registration and loss of credits for the semester.

## Graduation, Thesis, and Dissertation Fees

When candidates for the associate's or bachelor's degree file their candidacy declaration, they pay a graduation fee to cover the cost of diploma, cap, gown, and miniature diploma. Students completing the master's and doctoral degrees are charged designated graduation fees.

### I.D. Card Replacement

A fee is charged for the replacement of or lost student identification cards. Broken or worn cards are replaced for no charge but must be turned in to the Registrar's Office at the time that the new card is printed.

### Institute Activities Fee

The Institute Activities Fee provides a base for the support of student social and cultural activities and corresponding facilities.

### Late Registration Fee

Students who fail to register during the designated period are charged a late fee. This stipulation applies to all regular undergraduate and graduate students. Special students are not charged this fee.

### Late Validation Fee

Students who fail to validate their registration on the day of registration are charged a late validation fee. Students who register late and who do not validate their registration that day will also be charged. This fee applies to all regular undergraduate and graduate students. Special students are not charged this fee.

### Orientation Fee

A fee is charged for new student orientation.

### Readmission Fee

A fee is charged for processing readmission to Tech.

### Room and Board

Room and board are charged through the Residential Life Office. The total amount varies depending upon the type of room occupancy and meal contract. The base rate is calculated for double occupancy of room with 150 block meal plan. Other meal plans are available. At an additional charge, single occupancy is offered when space permits. Students must supply all

linens, including a mattress pad protector. More information is provided in the housing agreement, which must be executed for each academic year.

The semester charge for room and board does not include meals during recesses nor during the few days at the beginning and end of each semester when most students are away from the campus. The student may only occupy the room during break periods upon payment of an additional fee and when Tech offers interim housing. The halls are generally closed between fall and spring semesters and may be closed at other times between terms when conditions warrant. Altamirano Apartments, Desert Willow Apartments, Mountain Springs Apartments, and Guest House remain open during semester breaks. Schedules for residence halls and dining facilities are published at the beginning of each residence period.

### Room Reservation/Damage Deposit Fee

A Room Reservation/Damage Deposit is required before housing will be assigned. The deposit will be refunded under the following conditions:

- 1) The student has been declared academically ineligible to enter, continue, or return to New Mexico Tech.
- 2) The term of the student's Room and Board Agreement has been completed (i.e., the student has remained in the Residence Hall the entire academic year), and no damage has been noted.

If the student has filled out the necessary paperwork to ensure himself/herself a room for the semester but cancels the room reservation or does not show up for check-in by the first day of classes, the student is subject to the Room Cancellation Policy (page 62). If a student is unable to check in by the first day of classes, he or she must request, in writing, to have the room set aside for a specific day. This specific day should not exceed a week from the first week of classes.

### Sports Activities Fee

This fee is charged each semester in support of the intramurals program and corresponding facilities.

### Student Activities Fee

All students pay a Student Activities Fee each semester. The funds collected are disbursed to the student organizations and activities according to a budget prepared by the Student Association and approved by the administration.



**Student Center Fee**

A Student Center Fee provides monies to amortize and support the Joseph A. Fidel Center.

**Transcript Fee**

Students are entitled to one official transcript of their academic records without charge per lifetime. A fee is charged for further copies. Free unofficial transcripts are available to currently enrolled students.

**Withdrawal Fee**

Students who withdraw from a class or classes after registration closes must pay a withdrawal fee for every withdrawal authorization form.

**Tech Dollars Fee**

Tech Dollars are the same as cash and may be used for the purchase of drinks, snacks, to go items, and all menu items sold in the Fire & Ice Coffee Shop. As an example, if you have 75 Tech Dollars after the purchase of \$3 worth of food items the remaining balance would be 72 Tech Dollars. Tech Dollars apply to one semester only and may not be carried over to the next semester. No **Refunds** will be given for Tech Dollars. At the end of each semester Tech Dollars remaining in a student's account will be zeroed out.

# Undergraduate Student Status

## Regular Students

Undergraduate students who are pursuing a degree program are classified as regular students. Full-time regular students are those who enroll for 12 or more credit hours during the fall and spring semesters; part-time regular students are those who enroll for fewer than 12 credit hours. (This designation does not apply to graduating seniors.) These students shall be subject to the following:

- Part-time students will be eligible for financial aid only in proportion to their course loads and will be subject to restrictions imposed by federal and/or state guidelines.
- In order to maintain satisfactory progress and remain in good standing, the part-time student must meet the same standards as full-time regular students.

## Classification of Regular Students

Undergraduate students are classified by the number of credit hours they have completed:

Freshman	0 to 29 credit hours
Sophomore	30 to 59 credit hours
Junior	60 to 89 credit hours
Senior	90 credit hours and above

## Special (Non-Degree) Students

Students who are not pursuing a degree program are classified as special students. While special students are free to choose a program best suited to meet their individual needs, they are expected to meet the prerequisite or corequisite requirements for a course. Special undergraduate students may enroll for no more than six credit hours per semester. Special students must change to regular status in order to graduate. (See Change of Student Status, page 66.)

## Transfer Students

Students in good academic standing at other colleges and universities (2.0 minimum GPA) are eligible for transfer admission to New Mexico Tech. Credits taken at another institution will be evaluated and transferred on a course-by-course basis. See page 38 for information about transfer of credit.

## Veterans

The Veterans Administration requires students on the GI Bill to carry a minimum of 12 credit hours (6 credit hours in summer) to qualify for full benefits. The minimum credit hours must apply toward the student's degree requirements. Physical Recreation (PR), Fine Arts (FA), and Community College (designated by the letter "C" in the course number) courses do not count toward the minimum credit hours for veterans.

If, for some reason, the student desires to drop a course during the semester that would bring the load below 12 credit hours, permission must first be obtained from the student's academic advisor. NMT's VA Representative must be notified that the student is dropping from full-time enrollment at the time the change of program card is returned to the Office of the Registrar.

Further information can be obtained from the VA Representative, located in Cramer Hall, Office 119.

## Change of Student Status Special to Regular Status

To change from special to regular student status, the student must meet all regulations governing regular admission and must submit an *Application for Undergraduate Admission and Scholarship* through the Admission Office. Students admitted under special status, who do not otherwise qualify for regular admission, may apply to the Admission Office for regular status after successful completion of 30 credit hours at Tech.

See Applying for Admission, page 31, for application deadlines.

## Regular to Special Status

A regular student who is no longer pursuing a degree program may petition to change to special student status at the Office of the Registrar.

# Registration

[Contact: Office of the Registrar, New Mexico Tech, 801 Leroy Place, Socorro, NM 87801; 575.835.5133; fax: 575.835.6511; registrar@admin.nmt.edu]

## Orientation

Orientation for incoming students begins the transition to New Mexico Tech and, for some, to living away from home. You'll have a chance to meet other students, tour the campus, talk to faculty and staff, meet with your advisor and set up your semester schedule.

Orientation is held at the beginning of each semester and summer session. A fee is charged.

## Math Placement

Mathematics is the backbone of all coursework at New Mexico Tech, and the selection of your initial math courses is critical to your success at Tech. Placement is determined by your ACT/SAT math score or the optional math placement test, described below.

ACT Math Score	SAT Math Score	Initial Math Course
20 or lower	490 or below	MATH 101
21 to 25	500 to 580	MATH 103
26 to 29	590 to 660	MATH 104
30 or higher	670 or higher	MATH 131

You may also enroll in MATH 131 (Calculus and Analytic Geometry I) if:

- 1) You are transferring college credit in pre-calculus and trigonometry.
- 2) You have earned a 3 or higher on the Advanced Placement (AP) Calculus AB exam or a 3 or higher on the AB subscore of the Calculus BC exam.

An optional math placement test, which covers algebra and trigonometry, is available to students who score below 30 on the ACT math test or received below 670 on the SAT mathematics test. **Waivers into 100-level math classes are not granted. You must take the math placement exam if you want to enroll in any math class other than those listed above for your ACT or SAT math score.**

## Registering for Courses

Regular students can register online at <http://banweb.nmt.edu>. You must obtain your "alternate PIN" from your advisor before registering.

Instructions for registering online can be found at the registrar's web page, [www.nmt.edu/registrar-office](http://www.nmt.edu/registrar-office).

Specific days are set aside for registration (see Academic Calendar). You may register online or in person through the second Tuesday of instruction. Registration after this period will depend upon the merits of each individual case.

Schedules of course offerings, with time and place of meeting and the name of the instructor in charge, are available at <http://banweb.nmt.edu> before the registration period of each semester or summer session.

A course may be cancelled if demand or resources are insufficient. Students are encouraged to discuss with their advisors their interest in courses not currently offered.

You must be enrolled in a class to attend that class. Students may not "sit in" on a class for which they are not registered at New Mexico Tech.

## Validation

You must settle your financial status (validate) with the NM Tech Business Office before your registration will be considered complete.

## Prerequisites and Corequisites

Some courses have prerequisites, courses you must successfully complete before enrolling in that course. Exceptions can be made with the instructor's approval. If you enroll in a course in which you do not have the prerequisites without the instructor's permission, you may be disenrolled.

Corequisites are courses that should be taken during the same semester.

Prerequisites and corequisites are not determined by the student's individual catalog, but rather by the catalog in effect at the time that the course is offered.

## Academic Advising

Academic advising is one of the most important keys to a student's success. Academic advising provides the student with the necessary information about courses and degree requirements, but more importantly, the academic advisor serves as a mentor as the student explores the discipline and develops his or her professional identity. The advising system is designed so that:

- Each student is assigned a faculty advisor from the major department.
- Undecided students work with the Center for Student Success to determine the best placement until the major is declared.
- Each student works with his or her advisor each semester to plan the next semester's courses. The

advisor must approve the selected coursework and sign the registration form.

- Students seeking to minor in a subject must obtain a faculty advisor for the minor.
- Advisor/Major changes are initiated in the Center for Student Success.
- It is the responsibility of the student, in cooperation with the appointed academic advisor, to arrange programs so as to satisfy the common requirements for all bachelor's degrees (page 100) and the specific requirements of the major department.

## Registration Fees

### Late Registration Fee

Students who fail to register during the designated period are charged a late fee. This stipulation applies to all regular undergraduate and graduate students. Special students are not charged this fee.

### Late Validation Fee

Students who fail to validate their registration on the day of registration are charged a late validation fee. Students who register late and who do not validate their registration that day will also be charged. This fee applies to all regular undergraduate and graduate students. Special students are not charged this fee.

## Proof of Insurance

Regular full- or part-time students must show proof of valid health and hospitalization insurance with another U.S.-based insurance company before registering for classes for the first time. Students are responsible for notifying the Student Health Center of any changes in their medical insurance.

Student who do not have coverage under another insurance plan can purchase insurance at [www.StudentResources.com](http://www.StudentResources.com).

## Changes in Registration

A student may change his/her program by filing a Change-of-Registration form with the Registrar. No classes may be added after the second Tuesday following the beginning of classes. During the first three weeks of a fall or spring semester, and through the second Tuesday of the summer session, a student may drop a class without penalty, and the course will not appear on the permanent record. After the third week of classes in a fall or spring semester or the second Tuesday of a summer session, the student must file a Withdrawal Authorization Form and pay the withdrawal fee. The grade "W" will appear on the student's permanent record. A student may not withdraw (W) from a class after the tenth week of a fall or spring semester, or the fifth week of a summer session. You may change to audit or S/U up to the end of the tenth week of the semester or the fifth week of the summer session.

## Repeating a Class

A computable grade is a grade with a numerical equivalent: A, A-, B+, B, B-, C+, C, C-, D+, D, or F. A non-computable grade is a grade with no numerical equivalent: SA, UA, S, or U. See page 69 for numerical equivalents of grades. Students may not repeat courses at other institutions.

### *If you received*

A, A-, B+, B, B-  
C+, C, or S

### *Then*

You may not repeat the class for a grade or credit unless the course description specifically says you may.

C-, D+, D, or F

You may repeat the class for a new letter grade and credit. (You may not repeat on an S/U basis.) The new grade will replace the old grade in calculation of your GPA, even if the new grade is lower. If you receive an F, you will receive 0 credit hours for the course, **even if you previously received credit. You may not repeat the class at an institution other than New Mexico Tech.**

SA, UA, or U

You may repeat the course for a grade and credit. If you repeat a course in which you received a U, you **must** take it for a computable grade.

## Withdrawing from a Course

(See also *Withdrawal without Prejudice*, page 70)

You may withdraw and receive the grade of “W” from a course until the tenth week during the fall or spring semester (or the fifth week in the summer session). Talking with your instructor and advisor about your progress at midterm will help you make this decision. Other options include:

- Change to Satisfactory/Unsatisfactory (S/U), which will not affect your GPA. See page 70 for more information on S/U grading.
- Change to Audit. (See page 70 for information on both S/U and audit grades. ) You are required to file the appropriate form with the Office of the Registrar in order to withdraw from a course or change to S/U or Audit.

## Academic Policies

[Contact: Office of the Registrar, New Mexico Tech, 801 Leroy Place, Socorro, NM 87801; 575.835.5133; fax: 575.835.6511; registrar@admin.nmt.edu]

### Grading System

A grade is reported for each course in which a student has enrolled to indicate the quality of performance in that course. The grading system used at NM Tech is as follows:

Grade	Grade Points Per Sem. Hr
A	4.00
A-	3.67
B+	3.33
B	3.00
B-	2.67
C+	2.33
C	2.00
C-	1.67
D+	1.33
D	1.00
F	0.00
S	Satisfactory (C- or better) n/a
U	Unsatisfactory (D+ or worse) n/a
SA	Satisfactory Audit n/a
UA	Unsatisfactory Audit n/a
W	Withdrawal n/a
WO	Withdrawal Without Prejudice n/a
PR	Progress n/a

### Grade Point Average (GPA)

The total semester hours in which grades of A, A-, B+, B, B-, C+, C, C-, D+, D, and F have been received at this institution divided into the corresponding total grade points earned is the student’s cumulative grade-point average (GPA) (see page 9). Likewise, the student’s GPA for any time period is found by dividing the credit hours in which grades other than S, U, SA, or UA were received into the total grade points earned during that period. The student’s GPA indicates scholastic standing. Results of challenge examinations shall not be included in the student’s class load for the semester in which the exam is taken.

### Satisfactory/Unsatisfactory (S/U)

Any student in good standing may take up to a total of 18 credit hours on an S/U basis in undergraduate courses not normally graded S/U, with a limit of 7 credits in any one semester. (Transfer credits from other institutions are not included in the 18-hour maximum.) Courses may not be taken in this manner without consent of the course instructor, the student's academic advisor, the student's major department, and the department in which the course is taken. Approval for the S/U grade basis must be obtained within the first ten weeks of classes. Decisions made at that time for either letter grade or S/U grade evaluation may not be subsequently changed. Students who receive a grade of S will receive credit for the course. Students who receive a grade of U will not receive credit for the course.

### PR (Progress)

A grade of "PR" for independent study, thesis, or dissertation is given when satisfactory progress on research has occurred during the semester. If research progress has not been satisfactory, a grade of "U" (unsatisfactory) is issued.

### Withdraw (W)

A student may not **withdraw (W)** from a class after the tenth week of a fall or spring semester, or the fifth week of a summer session. A W can only be assigned after consulting with the instructor and completing and submitting the appropriate form to the Office of the Registrar (see Changes in Registration, page 68). Under no circumstances can an instructor assign a W in a course.

### Change of Grade

The instructor of a course has the responsibility for any grade reported. Once a grade has been reported to the Office of the Registrar, it may be changed only in the case of clerical error or in the case of documented extenuating circumstances. The instructor who issued the original grade must submit in writing the reasons for the change. The change of grade must also be approved by the department chair.

Changes in grade must be made within five weeks after the start of the next semester, except for extenuating circumstances.

### Grade Appeal Procedure

Students seeking grade changes must speak first with the instructor, next with the department chair, and finally with the Vice President for Academic Affairs. A grade must be appealed no later than the end of the semester following the semester in which the student took the class. All questions can be referred to the Office of the Registrar.

### Withdrawal without Prejudice (WO)

(See also *Withdrawing from a Course*, page 69.)

Under extremely unusual circumstances (for example, serious illness or death in the student's immediate family), a student may petition for a withdrawal without prejudice. Such a petition must be presented in writing with supporting documentation (i.e., statement from a physician, obituary, etc.) before the end of the semester to the Dean of Students for review and consideration. Students may not withdraw without prejudice from a course they are failing due to plagiarism, cheating, or other disciplinary issues.

Charges for tuition and fees are not altered by such a withdrawal.

## Undergraduate Academic Probation and Suspension Academic Regulations

The academic regulations have a two-fold purpose:

- 1) to prevent the dissipation of the resources and time of students who fail to make reasonable progress in their academic programs at New Mexico Tech, and
- 2) to facilitate the maintenance of high academic standards at New Mexico Tech.

### Academic Probation

A student whose semester GPA falls below the minimum requirements needed for good standing (page 9) will be placed on academic probation for the next regular semester of enrollment. Students are continued on probation if they withdraw from New Mexico Tech while on probation.

### Academic Suspension

Students who fail to achieve the minimum semester GPA for a second consecutive semester will

be placed on academic suspension unless their cumulative GPA is 2.0 or better. A student on academic suspension is denied the privilege of enrolling at New Mexico Tech for the specified period of time.

### **Notification of Probation and Suspension**

Notification to the student of academic probation or suspension will appear on the student's grade report at the end of each grading period. Academic probation and suspension will appear on the student's official transcript.

### **Duration of Suspension**

The first suspension from New Mexico Tech will be for one regular (fall or spring) semester. Second and subsequent suspensions will be for one calendar year. A student suspended after the fall semester is suspended for the following spring and summer semesters. A student suspended after the spring semester is suspended for the following summer and fall semesters. A student suspended after the summer semester is suspended for the following fall semester. Credits earned at another institution during the period of suspension at New Mexico Tech will not be accepted for transfer at New Mexico Tech.

### **Appeal of Suspension**

A student who, after conferring with his or her advisor, feels that he or she has been unjustifiably placed on suspension may appeal for a change of status by written petition to the Academic Standards and Admission Committee. A student may appeal suspension by petitioning for readmission (page 35). Petitions must be submitted to the Office of the Registrar by the day before classes begin, when the Academic Standards and Admission Committee meets.

## **Requesting a Transcript**

*In order for your transcript to be released, you must have a zero or credit balance at New Mexico Tech.*

Our goal is to have your transcript ready to be picked up or mailed within two working days after your request, except during peak processing periods. All transcripts are mailed through the US Postal Service, First Class Mail. During final grades processing, transcript requests are held until final grades are posted for that semester.

The cost is \$15.00 per academic year, with an additional \$3 charge if 1) you want the transcript faster than two working days or 2) you want the transcript faxed.

All students are allowed ONE free official transcript per lifetime (students must indicate this on the transcript request)

### **Information Needed**

You must provide the following information to request a transcript:

- Transcript Request Form or a letter requesting your transcript
- Your name. If your name has changed, be sure to tell us the name you had when you attended NM Tech.
- Your address and phone number.
- Your NM Tech ID or Social Security number
- The approximate years you attended NM Tech
- Complete address(es) of where you want transcript(s) sent
- If transcript is to be sent to you, whether you want it in a sealed envelope. (Transcripts used for applications usually need to be in a sealed envelope.)
- Your signature

### **Methods**

You can request a transcript:

- In person at the Office of the Registrar, Joseph A. Fidel Center, Room 285. Pay your fee at the Cashier's Office.
- By mail. Include a check for \$15.00 (U.S.) per academic year, made out to New Mexico Tech.

Send your request to:

Office of the Registrar  
New Mexico Tech  
801 Leroy Place  
Socorro, N.M. 87801

- By fax. Include your MasterCard, Visa, or Discover card number and expiration date. If you are using a parent's card, that person should write "I'm authorizing [your name] to use my credit card," and add their signature. Our fax number is 575.835.6511.
- By e-mail. We can only accept a transcript request by e-mail if the e-mail contains a scanned copy of your signature. Follow the instructions above for requesting a transcript by fax. Send your e-mail to [registrar@admin.nmt.edu](mailto:registrar@admin.nmt.edu).

### **Rush and Faxed Transcripts**

You can request a rush transcript. The fee is an additional \$3 (total \$18.00). The transcript is usually sent out within one working day.

You can also request that we fax a copy of your transcript to a recipient. However, we require the recipient's physical address and will follow the fax with an official copy of your transcript. The fee is an additional \$3 (total \$18.00).

## **Other Policies**

### **Academic Load**

The academic year at NM Tech consists of two semesters. A class hour is 50 minutes in length; ordinarily, a laboratory period is about three times as long. One class hour or laboratory period a week through a semester gives one credit hour.

A full-time undergraduate should carry an academic load of approximately 16 credit hours per semester for the fall and spring semesters. During the summer session, 6 credit hours is a full-time academic load; 3 credit hours is half-time.

Graduate students: see page 53 for information about academic load.

The Veterans Administration requires students on the GI Bill to carry a minimum of 12 credit hours (6 credit hours in summer) to qualify for full benefits. Physical Recreation (PR), Fine Arts (FA), and Community College (designated by the letter "C" in the course number) courses do not count toward the minimum credit hours for veterans. Complete information can be obtained in the Office of the Registrar.

### **Attendance**

A student is responsible for all material covered in class; however, it is the decision of the individual instructor whether attendance is mandatory or optional. It is the student's responsibility to ascertain

this. Illness or other circumstances that necessitate extended absence from class work should be reported as promptly as possible to the Dean of Students, or designated representative who will notify the student's instructors.

Students on Military Active Duty must notify the Dean of Students, or designated representative and provide appropriate documentation.

### **Auditing a Class**

Students may attend classes as auditors; that is, they may enroll in a course for no credit, with the permission of the instructor of the course. Auditors pay fees on the same basis as those who enroll for credit. No student will be allowed to change registration from credit to audit or from audit to credit after the tenth week of a regular semester or the fifth week of the summer session. Students may not change from credit to audit or audit to credit more than once in a class. Auditors receive grades of SA (satisfactory audit) or UA (unsatisfactory audit) as determined by the instructor.

### **Challenge Examinations**

In lieu of registering for a course, a student may request a challenge examination. (Students who have received a grade in a class taken at NM Tech may not take a challenge exam in that course.) These exams allow students to receive credit or waive the requirement for a course by passing a comprehensive test of the course material.

Courses available through challenge exam are determined by department policy.

Permission must be granted by the instructor of the course. A challenge examination fee is charged (page 63). The form of the examination (written, oral, practical, combination, etc.) will be determined by the instructor. At the option of the student and instructor, the examination may be graded on either the standard or S/U basis, and the examination points earned will be equivalent to a final grade in the course. Some departments offer challenge exams on an S/U basis only.

Credit hours and grade points earned in this way are exactly equivalent to those earned through successful completion of that course. The following regulations will apply to all challenge examinations:

- Permission of the instructor of the course is required and the examination is given at a time of the instructor's choosing.
- Information as to the nature of the challenge examination will be made available to a student upon request.



- The student will be told the grade earned and has the right to decide whether the credit and grade will be entered on the transcript.
- If a student is registered for the course, the challenge exam must be taken during the first three weeks of the fall or spring semester so the student's schedule can be adjusted.

### Correspondence Courses

A student's total registration per semester, including all courses taken in residence and by correspondence, must not exceed 18 credit hours without the advisor's approval. Any student who is enrolled for a correspondence course must report this fact in writing to the Vice President for Academic Affairs before registering for classes and also must obtain the Vice President's approval before enrolling for a correspondence course during a semester when enrolled at NM Tech. Correspondence courses in progress during any semester must be recorded on the student's program. Approval of enrollment in a correspondence course does not necessarily imply that transfer credit will be allowed. If transfer credit is desired, regular evaluation procedures must be observed; moreover, a final grade for the course must be reported officially to the Registrar not later than 30 days before the end of the semester during which credit is desired.

### Directed Study Courses

To be included as part of a student's declaration of courses fulfilling degree requirements, directed study courses (courses numbered 491 or 581) require the approval of the department chair in the major department, the chair of the department offering the course, and the student's advisor. Approval must be obtained before the student takes the course.

### Privacy of Information

New Mexico Tech adheres to the provisions set forth by the Family Educational Rights and Privacy Act of 1974, as amended. Under the provision of this Act, the following policies apply:

1. If you are a currently enrolled student or former student, you may inspect your educational records by submitting an official request and obtaining an appointment to do so.
2. You may challenge inaccuracies or misleading items. However, you may not challenge the fairness of a grade under this provision.

3. Your record is not released without your written consent except to New Mexico Tech school officials with a legitimate educational interest. School officials are agents of the university in an administrative, supervisory, academic, research or support staff position; members of university committees, boards and/or councils; and persons under contract to the university to perform a specific task, such as an attorney or auditor. School officials have a legitimate educational interest in accessing or reviewing a student's educational records if they are:

- Performing a task that is specified in his/her position description or contract
- Performing a task related to a student's education or to student discipline
- Providing a service or benefit relating to the student or student's family.
- Maintaining safety and security on campus. Other exceptions are to comply with a judicial order, or in an emergency involving the health or safety of a student or other person.

4. When a record is released, the recipient is notified by NM Tech that the record may not be released to a third party.
5. With the exception of disclosures to academic personnel, a record is kept of disclosures of personally identifiable information for which the student has not given written consent.
6. **Directory Information:** New Mexico Tech designates the following as directory information: name, student ID number, address, telephone number, dates of attendance, class, previous institution(s) attended, major field of study, awards and honors (includes honor roll), and degree(s) conferred (including dates). You have the right to withhold the disclosure of directory information. Any requests for such information from non-Tech persons or organizations will be refused. NM Tech will honor your request to withhold directory information but cannot assume responsibility to contact you for subsequent permission to release them. Regardless of the effect upon you, NM Tech assumes no liability for honoring your instructions that directory information be withheld.

For more information, contact the Office of the Registrar, Joseph A. Fidel Center, Room 285, 575.835.5133.

## Changing Your Residency

**Requirements to establish New Mexico residency:** If you are over 18 years of age, you may become a legal resident of New Mexico for tuition purposes by meeting each of the following requirements as defined by the New Mexico Higher Education Department.

### A. Twelve month durational requirement.

A person must physically reside in New Mexico for the twelve consecutive months immediately preceding the term for which the resident classification is requested.

### B. Financial independence requirement.

Only persons who are financially independent may establish residency apart from parents or guardians. A student cannot be approved for residency who is financially dependent upon his or her parents or legal guardians who are nonresidents of New Mexico. Dependency is always determined by the status of the student on their parent's or guardians previous year federal income tax form. If the student is shown to be dependent, they will not be considered financially independent or eligible for residency during the current year.

### C. Written declaration of intent requirement.

The student or person must sign a written declaration of intent to relinquish residency in any other state and to establish it in New Mexico.

### D. Overt acts requirement.

Overt acts are required to evidence support of the written declaration of intent to establish permanent residency in New Mexico. The required overt acts are evidence of any two of the following:

- if the applicant is financially dependent, a copy of the parent or guardians' previous year income tax showing the applicant as a dependent and the parent address as New Mexico; or
- a New Mexico high school transcript issued in the past year confirming attendance at a New Mexico public or private high school within the past twelve (12) months; or
- a transcript from an online high school showing a New Mexico address confirming attendance within the past twelve (12) months; or
- a New Mexico driver's license or ID card with an original date of issue or a renewal date issued prior to the application date for admission; or
- proof of payment of New Mexico state income tax for the previous year; or

- evidence of employment within the state of New Mexico; or
- New Mexico vehicle registration; or
- voter registration in New Mexico; or
- a bank account established in New Mexico prior to the application date for admission; or
- proof of residential property ownership in New Mexico; or
- a rental agreement within New Mexico; or
- utility bills showing the applicant name and a New Mexico address; or
- other evidence which would reasonably support the individual's intent to establish and maintain New Mexico residency.

Any act considered inconsistent with being a New Mexico resident will cause the request for resident classification to be denied. As such, other relevant factors may be considered in addition to the items listed in this Section.

The Higher Education Department recognizes that there may be circumstances in which a student would not be able to fulfill the requirements of an overt act as listed in this section, such as: 1) individual is physically disabled and does not have a driver's license, or 2) individual is a convicted felon and therefore cannot vote, etc. In instances such as these, the institution will afford the student an opportunity to provide other documentary evidence or reasonable explanation which demonstrates that permanent residency in New Mexico has been established by the student.

All petitions for New Mexico residency are due on registration day and in no case later than the 21st day of the fall or spring semester.

You will not be entitled to any refund of tuition if you become a resident during a semester, summer session, or other term. Detailed information concerning residency requirements is available from the Registrar.

## Student Use of New Mexico Tech Facilities

Many Tech facilities are available for student use. In order to be eligible, a club or organization must be officially recognized by the Dean of Students, or designated representative and by the Student Association. Facilities may only be used for legal and otherwise legitimate purposes, and that use must not in any way hinder the academic mission of NM Tech. Further details regarding use of classrooms and other facilities may be found in the *New Mexico Tech Student Handbook*.

## Transfer Credits

New Mexico Tech accepts academic credits from regionally accredited institutions of higher education. All credits will be evaluated and transferred on a course-by-course basis. A grade of “C” or higher is required for all transfer credit. Credit earned at any institution while a student is on academic or disciplinary suspension from any institution will not be accepted at New Mexico Tech. Grades earned at other universities are not transferred to NM Tech.

## Withdrawing from the University

*Students leaving New Mexico Tech, including those who are graduating or transferring to another institution, must withdraw from the university.*

Before withdrawing from the university, you must

- 1) check in all NM Tech property (laboratory keys, gymnasium equipment, etc.);
- 2) settle or make arrangements for all financial obligations to the university;
- 3) complete a Statement of Withdrawal form (Forms are available at the Center for Student Success and at the Graduate Office);
- 4) complete an exit interview with the Financial Aid Office; and
- 5) notify the Office of the Registrar if you have preregistered for classes offered the next semester.

If you withdraw during the semester, you must complete the above steps and:

- 6) withdraw from all classes (see page 69).

If you do not complete these steps, your transcript and/or diploma will be withheld.

A student may petition for Withdrawal without Prejudice under extremely unusual circumstances, such as serious illness or a death in the student’s immediate family (see page 70 for details).

## Additional Policies

Students who enroll at New Mexico Tech should do so with the realization that they are presumed to be serious in purpose, and they are expected to conduct themselves as good citizens of the college

community. An effective guardianship of the health, general safety, and welfare of all students must be maintained.

The final responsibility for the accomplishment of these purposes must rest upon the administration and faculty of the institution, who may, therefore, prescribe certain rules and enforcement procedures for guidance toward these ends. Information concerning such rules and additional procedures is contained in the *New Mexico Tech Student Handbook* and in supplementary bulletins, which may be published from time to time.

New Mexico Tech is committed to the full support of the constitutional rights of its students, including due process in student disciplinary matters. Detailed procedures designed to safeguard students’ rights and to guarantee fair and impartial treatment of any disciplinary cases are published in the *New Mexico Tech Student Handbook*. Methods developed to provide due process in student disciplinary matters are based on the 1967 joint recommendations of the American Association of University Professors, the National Association of Students, and the National Association of Student Personnel Administrators, conforming to Title IX—Educational Amendments of 1972.

Continued enrollment in New Mexico Tech is dependent upon the maintenance of satisfactory grades and conformity to the rules of NM Tech.

Check Your *Student Handbook* for General Campus Rules and Policies on:

- Discipline
- Drug and Alcohol
- Grievance
- Privacy Rights
- Quiet
- Vehicles

# Responsible Conduct for Undergraduate Students

## New Mexico Tech's Academic Honesty Policy and Guide to Conduct and Citizenship for Undergraduate Students

### Responsible Academic Conduct Policies and Procedures

- 1.0 Academic Honesty Policy for Undergraduate Students
- 2.0 Academic Dishonesty and Research Misconduct
- 3.0 Fostering Academic Honesty and Research Integrity
- 4.0 Dealing with Incidents of Academic Dishonesty or Research Misconduct
- 5.0 Students' Right to Appeal a Penalty Action
- 6.0 Academic and Research Discipline Policy and Procedures
- 7.0 Students' Right to Appeal an Academic and Research Disciplinary Action
- 8.0 Records of Penalty Actions, Academic Disciplinary Actions and Hearings

### Responsible Non-Academic Conduct Policies and Procedures

- 9.0 New Mexico Tech's Guide to Conduct and Citizenship
- 10.0 Citizenship Misconduct/Causes for Disciplinary Measures
- 11.0 Non-Academic Discipline Policy and Procedures
- 12.0 Non-Academic Disciplinary Action
- 13.0 Students' Right to Appeal a Non-Academic Disciplinary Action
- 14.0 Records of Non-Academic Disciplinary Actions and Hearings

## 1.0 Academic Honesty Policy for Undergraduate Students

### 1.1 Introduction

New Mexico Tech has an outstanding academic reputation and excels as a teaching and research university specializing in areas of science, engineering, and related fields. This reputation is contingent on an environment of academic honesty and integrity.

Indeed, New Mexico Tech's Institutional Values statement recognizes integrity as a core value along with creativity, excellence, collegiality and citizenship, service, leadership, and commitment to economic prosperity and technological development. "Integrity is honored as a fundamental value at New Mexico Tech. Dishonesty, cheating, and plagiarism have no place in a respected institution of higher education. But real integrity goes further than these negatives. Integrity means having the courage to defend the truth, to act fairly and honestly in all our endeavors, and to be responsible members of the community." (See page 13).

Academic dishonesty and research misconduct is therefore unacceptable and will not be tolerated at this Institute.

**1.1.1** In the following, the role of the Associate Vice President for Academic Affairs pertains to cases involving incidents of academic dishonesty by undergraduate students.

**1.1.2** For cases involving incidents of academic dishonesty by graduate students, see the Graduate Policies section of this catalog.

**1.1.3** The term day/days/number of days shall mean the number of academic days within an academic semester or summer session. If the procedure of the incident occurs or continues when the final grades are due or after the end of the academic semester or academic session, the Associate Vice President for Academic Affairs will determine whether to proceed on non-academic session business days of the Institute or to continue the procedure when the next semester or session begins. Concerning this, the Associate Vice President for Academic Affairs will take into consideration requests by the student charged.

**1.1.4** Research Misconduct can occur as a result of academic research or Sponsored Research (Externally Funded Research). Academic Research Misconduct will be handled following the same policies as the handling of academic dishonesty, with the research supervisor reporting acts of research misconduct as described for instructors reporting academic dishonesty. Sponsored research misconduct is governed by the Policy to Assure the Integrity of Research, which can be found on the following webpage:

<http://www.nmt.edu/research-policies-a-forms>.

**1.1.5** The use of the term Academic Dishonesty serves to include the term Academic Research Misconduct.

**1.1.6** The use of the term Academic Honesty serves to include the term Research Integrity.

**1.1.7** The use of the term instructor serves to include the term research supervisor.

**1.1.8** The use of the term Sponsored Research or Externally Funded Research refers to research and development activities of the institute that are separately budgeted and accounted for on a specific project basis and research cost sharing.

## **2.0 Academic Dishonesty and Research Misconduct**

**2.1 Academic dishonesty is defined as an act of academic fraud. It could be any of the following:**

**2.1.1 cheating:** the use of unauthorized material during a test, or the act of copying from another student;

**2.1.2 plagiarism:** the unauthorized use or use without proper citation of either someone's published work, unpublished material in someone else's computer files or material derived from the Internet;

**2.1.3 theft:** any form of unauthorized procurement of academic documents, e.g., exams, student reports;

**2.1.4 falsification:** any form of illegal alteration of academic documents for any purpose including improper alteration of experimental data obtained in the laboratory;

**2.1.5 impersonation:** the act of permitting another person to substitute for oneself at an examination;

**2.1.6 obstruction:** interference with or sabotage of the work of any other person through vandalism or theft;

**2.1.7 assistance:** the act of helping another to commit fraud in any of the above-mentioned ways.

**2.2 Academic Research Misconduct is defined as a violation of scholarly conduct codes or of unethical behavior in research. In addition to forms of academic fraud, Academic Research Misconduct could be any of the following:**

**2.2.1 inaccurate listing of authorship:** the act of listing as an author or co-author those who have not made substantial contributions to the research or listing an author or co-author without their consent or the act of not naming as an author or co-author someone who is a major contributor;

**2.2.2 failure to disclose a conflict of interest:** such as failing to disclose being paid by an organization that will benefit from a research project;

**2.2.3 violation of ethical standards related to human and animal testing:** e.g., experimentation on human subjects without informed consent (All human/animal experiments must be reviewed and preapproved by NMT's Institutional Review Board);

**2.2.4 fabrication of data:** improper alteration of experimental data obtained in the laboratory or any scientific or research experiment;

**2.2.5 failure to report:** failure to report incidents of research or scientific misconduct;

**2.2.6 providing inaccurate assessment of research:** such as exaggerating or denigrating contributions by those involved in peer review.

### 2.3 Sponsored Research (Externally Funded Research)

Research Misconduct in Externally Funded Research is governed by the "Policy to Assure the Integrity of Research" which can be found at <http://www.nmt.edu/research-policies-a-forms>.

In the case of Research Misconduct in Externally Funded Research, the procedures of the above policy, the "Policy to Assure the Integrity of Research" must be followed.

The following is taken directly from page 6 of the "Policy to Assure the Integrity of Research":

All employees or individuals associated with New Mexico Tech should report observed, suspected, or apparent misconduct in science to the Vice President for Research & Economic Development. If an individual is unsure whether a suspected incident falls within the definition of scientific misconduct, he or she may call the Vice President for Research & Economic Development to discuss the suspected misconduct informally. If the circumstances described by the individual do not meet the definition of misconduct, the Vice President will refer the individual or allegation to other offices or officials with responsibility for resolving the problem.

At any time, an employee may have confidential discussions and consultations about concerns of possible research misconduct with the Vice President for Research & Economic Development and will be counseled about appropriate procedures for reporting allegations, which may be made orally and anonymously.

The following is considered "research misconduct" under the policy that governs externally funded research, and is taken directly from pages 1 and 2 of the "Policy to Assure the Integrity of Research":

1. Violation of any criminal or civil law in obtaining, analyzing or reporting data.
2. Plagiarism: The act of taking the written or oral research ideas or results from another and presenting them as one's own.
3. Intentional falsification or fabrication of data or results:
  - a. Forging Data: Inventing some or all of the reported research data, or reporting experiments never performed.
  - b. "Cooking" Data: Retaining only those results that fit the hypothesis.
  - c. "Trimming" Data: The unreasonable smoothing of irregularities to make the data look extremely accurate and precise.
4. Applying for federal funding while under federal suspension or debarment, or knowingly utilizing as a co-principal investigator, investigator, technician, or consultant a person suspended or debarred.
5. Failure to maintain a record of primary data with the intent to deceive, e.g. destroying laboratory notebooks, survey forms, microscope reference slides, computer or other machine printouts with the intent to deceive.
6. Failure to report known or suspected acts of misconduct on the part of others, including the act of knowingly withholding or destroying evidence crucial in an investigation of misconduct.
7. Abuse of confidentiality when gathering or reporting data, e.g., releasing data gathered during privileged communication.
8. Use of honorary authorships, without the person's consent, and/or with the intent to deceive.
9. Without being involved with the research in question, making a demand to be listed as an author on a researcher's publication, solely because the person making the demand is in a position of authority over the researcher.

### 3.0 Fostering Academic Honesty and Research Integrity

**3.1** The need to foster academic honesty and research integrity imposes a nexus of responsibilities on the Institute, its students and faculty.

**The Institute:** The Institute's responsibility is to publish relevant policies, ensure that all such publications are consistent with each other, and implement the policies in a consistent manner.

**Students:** Each student's responsibility is to understand for every academic assignment what is expected from him/her and what would indicate academic dishonesty.

**Faculty:** It is the responsibility of the instructor of a course to clearly articulate any special case of academic dishonesty that is relevant to that course but not covered in Section 2.0.

#### 3.2 The following recommendations are intended to help in discharging those responsibilities:

##### 3.2.1 Recommendations for the Institute

- Compile useful articles on academic honesty and plagiarism and publish them on the Web.
- Ensure that any student who is engaged in learning, in teaching, and in research receive guidance about relevant ethical issues.

##### 3.2.2 Recommendations for students

- Attend all classes; in case a class is missed, talk to the instructor and find out about assignments given and topics covered.
- Time management is crucial. When study time is planned, the possibility of last-minute panic is minimized along with the consequent temptation to take unethical shortcuts.
- Unless explicitly prohibited in a course, sharing and discussing ideas with other students is encouraged as it can facilitate learning. But make sure that you do not share what you turn in for individual assignments.
- Do not keep open books or course material in close proximity to you while you take a test unless it is explicitly allowed.
- If you are experiencing undue stress, you have many resources available on campus for help and support -- your academic advisor, your department chair, the Center for Student Success, the Counseling and Disabilities Office, the Dean of Students, and the Office of Academic Affairs. Seek help and support rather than resorting to unethical behavior.
- The Center for Graduate Studies will provide education and training in the responsible conduct of research to all students supported on research grants. Relevant websites on this subject include:
  - NMT's research policy and forms at <http://www.nmt.edu/research-policies-a-forms-research-and-econ-dev>;
  - NSF's policy at <http://www.nsf.gov/oig/resmisreg.pdf> ;
  - and NIH's policy at [http://grants.nih.gov/grants/research\\_integrity/](http://grants.nih.gov/grants/research_integrity/).
- Students should be aware that the Associate Vice President for Academic Affairs is available to all students to discuss and advise on any troublesome matter of academic concern and helps to expedite resolution of such matters.

##### 3.2.3 Recommendations for faculty

- Mention this section of the catalog in your syllabus and in your introductory lecture.
- In the syllabus you hand out in the beginning of the course, list any special policies relevant to your course. For example, you could clarify what you mean by a restricted use of a resource like the Internet; you could set guidelines for non- standard assignments like group work, field trips, and ungraded papers. Furthermore, if you could include this syllabus in a Web page for the course, it could benefit students as well as other faculty.

## **4.0 Dealing with Incidents of Academic Dishonesty or Academic Research Misconduct**

### **4.1 The Role of the Instructor in the Bringing of Charges**

If a dishonest action is discovered by, or brought to the attention of, a teaching assistant assigned to a course, he/she shall play the role of instructor as described below only if explicitly authorized by the faculty supervisor of that course; otherwise, the teaching assistant shall immediately convey the specific details to the faculty supervisor who will fill that role. The department chair or his/her designated representative shall substitute for an absent faculty supervisor.

### **4.2 Determination of the Act of Academic Dishonesty by the Instructor**

**4.2.1** When a case of academic dishonesty is detected, it is the instructor's responsibility to:

- (a) distinguish between a minor infraction and a major one, and
- (b) to take action appropriate to this judgment of severity.

For example, a missed reference in an otherwise well-cited paper should be treated as carelessness; one unattributed remark in an ungraded paper should be considered minor. On the other hand, copying a substantial part of a term paper off a document available on the Internet should be considered a major violation; falsification of laboratory work by a student engaged in research should also be considered major.

Minor infractions repeated in spite of warnings may be treated as major.

### **4.3 Classes of Action Available to Instructor**

**Four classes of actions are available to the instructor, one without a penalty, two that are Grade Penalty Actions, and one Research Penalty Action.**

Throughout this policy, Penalty Action will refer to either a Grade Penalty Action or a Research Penalty Action as appropriate.

**The instructor may:**

**4.3.1 only warn**, i.e., issue a warning to the student(s) without any penalty in grades or research.

**Or the instructor may impose one of the following Grade Penalty Actions:**

**4.3.2 only penalize the assignment in question**, e.g., decrease the student's grades for that academic work (perhaps a zero for the entire assignment or part thereof) and/or ask the student to re-do the assignment;

**4.3.3 penalize the course**, i.e., directly change the course grade, e.g., drop a letter grade or assign an 'F' for the course.

**Or in the case of academic research, the research supervisor may impose a Research Penalty Action:**

**4.3.4 terminate research involvement**, i.e., remove the student from the research project, which may include termination of employment.

### **4.4 Bringing of Charges -- Procedure by Instructor when Academic Dishonesty is Detected:**

**4.4.1 The instructor must make every effort to discuss with the student(s) the violation detected and any Penalty Action being imposed.**



#### 4.4.2 Bringing of Charges Statement

- If a Penalty Action is imposed, the instructor must write in a memo – the Bringing of Charges Statement -- to the Associate Vice President for Academic Affairs.
- If the dishonesty does not involve any course, e.g., when a student employed under an externally-funded research grant falsifies laboratory data, the faculty research supervisor must comply with the “Policy to Assure the Integrity of Research.”
- If more than one student is involved in the act of dishonesty, the instructor must submit a separate Bringing of Charges statement (memo) for each student.
- Notifications from the Instructor to the Associate Vice President for Academic Affairs must be sent within ten days of the discovery of the dishonesty.

#### The Bringing of Charges Statement must include the following information:

- the grade for the course has been affected partly or wholly by an act of academic dishonesty,
- the nature of the violation and its severity,
- details as to time, place, and persons involved,
- any available supporting evidence,
- the specific Penalty Action imposed.

#### Evidence of Act of Dishonesty Provided with Bringing of Charges Statement

The instructor should provide with the memo evidence of the violation, e.g., copies of assignments exhibiting plagiarism, a witness in case of cheating during an in-class exam, a hard copy of plagiarized Web page.

#### Further Recommendations in the Bringing of Charges Statement

Further, the instructor may recommend in the Bringing of Charges Statement that the Associate Vice President for Academic Affairs should impose an appropriate disciplinary action on the student. The term disciplinary action refers to a penalty listed in section “6.5 Academic Disciplinary Action.”

#### 4.5 Response Procedure by Associate Vice President for Academic Affairs:

- The Associate Vice President for Academic Affairs’ responsibility is to respond to the bringing of charges, to review the evidence provided by the instructor and evidence the student might provide, and to make a determination on the charges.
- In addition, the Associate Vice President for Academic Affairs’ responsibility is to decide on the imposition of disciplinary action, i.e., whether or not disciplinary action should be imposed and, if so, which specific disciplinary action penalty (listed in section 6.5) is appropriate.
- The Associate Vice President for Academic Affairs will follow the procedures described under the Associate Vice President for Academic Affairs’ Investigation (section 6.4) with the following additions and clarifications:

**4.5.1** On receiving a notification of dishonesty, the Associate Vice President for Academic Affairs shall look up the student’s record of past incidents of dishonesty.

**4.5.2** The Associate Vice President for Academic Affairs shall convey in writing to the student involved within ten days after the Bringing of Charges (see 6.3) both the specific charge made by the instructor and the Penalty Action imposed, inform the student about the provisions of this policy, and give him/her an opportunity to discuss the incident with the Associate Vice President for Academic Affairs

**4.5.3** The Associate Vice President for Academic Affairs shall consider requests from the student for additional time to gather evidence.

**4.5.4** If the current incident has been judged minor by the instructor but the student has a past record of dishonesty, the Associate Vice President for Academic Affairs shall determine whether or not this time the infraction shall be treated as major. Based on this determination, the Associate Vice President for Academic Affairs may elect to impose disciplinary action.

**4.5.5** If the current incident has been judged major by the instructor, the Associate Vice President for Academic Affairs shall decide on the imposition of the disciplinary action after considering the instructor's recommendation, the evidence presented, the student's account of the case, and any other fact the Associate Vice President for Academic Affairs finds pertinent. The absence of past incidents shall not be construed as a dilution of the seriousness of a major violation. For example, a student who has falsified research results should not be treated leniently solely because it is his/her first incident of academic dishonesty.

**4.5.6** The Associate Vice President for Academic Affairs shall notify the student and the instructor in writing of the Associate Vice President's determination of the academic dishonesty incident, the concurrence or non-concurrence with the Penalty Action and whether or not disciplinary action is being imposed within twenty days of the receipt of the Bringing of Charges statement or ten days from the end of any additional time period granted to the student.

- If the Associate Vice President for Academic Affairs concurs that the charges brought are substantiated, the Associate Vice President for Academic Affairs will also notify the student's academic advisor.
- Notifications of incidents of academic dishonesty from instructors, the correspondence from the Associate Vice President for Academic Affairs, and the outcomes of the incidents shall remain in the students' files in the Office of Academic Affairs in accordance with section "8.0 Records of Penalty Actions, Academic Disciplinary Actions and Hearings."
- Annually, early in the Fall semester, the Associate Vice President for Academic Affairs shall present to the Faculty Senate the number of instances of academic dishonesty reported along with their breakdown by cases (4.3.2, 4.3.3, 4.4.4) of instructor notifications (Bringing of Charges), Penalty Action imposed, instructor recommendations of disciplinary action, categories of infractions, disciplinary actions imposed, appeals, and their outcomes. In addition, the Associate Vice President for Academic Affairs shall communicate any observations from the President regarding conflicts of this policy with any other so that conflicts may be rectified.

## **5.0 Students' Right to Appeal a Penalty Action**

### **5.1 Requesting a Hearing to Appeal a Penalty Action**

Upon request by the student charged and subjected to a Penalty Action, the procedures of the Academic Discipline Policy described in Section 7.0 and modified in 5.2 below must be followed.

#### **The student may request a hearing before the Student Discipline Committee:**

- The request must be made in writing to the Associate Vice President for Academic Affairs;
- An undergraduate student must send a copy of the request to the president of the Student Government Association;
- The request must be made within ten days of the receipt of the notification from the Associate Vice President for Academic Affairs.

## 5.2 Hearing Procedure

The procedures listed under Hearing (Section 7.3) shall apply with the following additions and exclusions.

### Additions

- The Associate Vice President for Academic Affairs shall submit the instructor notification (Bringing of Charges memo) plus any previous records of academic dishonesty of the student as evidence before the Student Discipline Committee.
- The instructor who brought charges of dishonesty will act as a witness.
- If the committee decides that a grade penalty should be reversed, the instructor shall be required to submit a fresh grade computed by removing the penalty.

### Exclusions

- If no disciplinary action is involved, i.e., only a Penalty Action is being appealed, legal counsel will not be permitted and no recording will be made of the hearing.

## 5.3 Instructor Appeal of the Student Discipline Committee Decision on Penalty Action

The decision of the Student Discipline Committee may be appealed as described in section “7.4 Appeal of the Student Discipline Committee Decision” with the following additions and exclusions.

### Additions

- The instructor who brought charges of academic dishonesty that resulted in only a Grade Penalty Action may appeal the decision of the Student Discipline Committee only if the decision was based on a tie.
- The Vice President for Academic Affairs shall communicate the final outcome of the appeal to the student, the Associate Vice President for Academic Affairs, and the instructor who brought charges of academic dishonesty.

## 5.4 Composition of the Student Discipline Committee

The composition of the Student Discipline Committee for cases of academic dishonesty by undergraduate students shall be as described in section “7.2 Student Discipline Committee.”

# Discipline Policies for Undergraduate Students

## 6.0 Academic Discipline Policy and Procedures

6.1 New Mexico Tech’s Academic Discipline Policy has two primary purposes:

First, it is intended to ensure that the student charged with academic honesty infractions is granted due process of law consistent with the principles of the United States Constitution. Due process means a fundamentally fair procedure based upon reasonable principles impartially applied.

Second, the policy is intended to educate the student in question regarding the standards of conduct expected at New Mexico Tech and throughout society as a whole. The process is not intended to mimic a genuine adversarial court proceeding but is based upon sound judicial practices.

Students violating Academic Honesty Policy are subject, in addition to a Penalty Action, to academic disciplinary action in accordance with the procedures listed below.

## 6.2 Bringing of Charges

Charges of academic dishonesty or research misconduct must be in writing, must specify the nature of the violation, and must give details as to time, place, and persons involved (see 4.4). This statement must be given to the Associate Vice President for Academic Affairs within ten days of the discovery of the incident(s) in question.

If more than one student is involved in the violation, the instructor must submit a separate memo for each student.

## 6.3 Notification of Charges

Students charged with violations of Academic Honesty Policy must be notified in writing by email and/or campus mail by the Associate Vice President for Academic Affairs of the charge within ten days of the bringing of charges. This notice must contain the particulars specified in the written Bringing of Charges statement, as outlined in 4.4, and notification of where to find the Academic Honesty Policy in the New Mexico Tech Catalog.

## 6.4 The Associate Vice President for Academic Affairs' Investigation

The Associate Vice President for Academic Affairs will investigate the charges and may impose disciplinary penalties as stated in the section "6.5 Academic Disciplinary Action." The action taken shall constitute the Associate Vice President for Academic Affairs' decision. Regardless of the action taken by the Associate Vice President for Academic Affairs, the student has the right of hearing and appeal.

## 6.5 Academic Disciplinary Action

6.5.1 A student who is found to have violated the Academic Honesty Policy may be subject to one or more of the following disciplinary action penalties in addition to a Penalty Action:

- Academic disciplinary probation, not to exceed one calendar year (recorded in the student's file in the Office of Academic Affairs)
- Interim suspension (see "6.6 Interim Suspension")
- Academic disciplinary suspension, not to exceed one calendar year (recorded in the student's permanent file in the Office of the Registrar and noted on the student's transcript)
- Permanent dismissal (recorded in the student's permanent file in the Office of the Registrar and noted on the student's transcript).
- Other disciplinary actions deemed appropriate to the specific case

6.5.2 If none of the above penalties is deemed appropriate, a student may be given an oral or written warning or statement that no disciplinary action is warranted.

6.5.3 The decision whether or not to take action shall belong to the Associate Vice President for Academic Affairs.

## 6.6 Interim Suspension

At times, on the basis of his/her investigation into charges of violations of the Academic Honesty Policy, the Associate Vice President for Academic Affairs may conclude that it is necessary to suspend a student immediately, prior to a hearing on the matter. This may be the case when the student in question is believed to be dangerous to himself or herself, to others, or to property. Under such circumstances, the Associate Vice President for Academic Affairs or in his/her absence, the Vice President for Academic Affairs or other person designated by the Institute President, may impose an interim suspension pending written notice with a hearing to be set at a later date.

An interim suspension may not be imposed unless it is based upon facts that show that the student's continued presence on campus may constitute a danger to the student, to others, or to property.

An interim suspension may not be based upon mere suspicion of guilt. Any student suspended on an interim basis has the right to a hearing before the Student Discipline Committee. The student suspended on an interim basis must present a written request for a hearing to the Associate Vice President for Academic Affairs, within five days of the effective date of the interim suspension. The hearing must be held within five days of the suspended student's request for a hearing unless the student charged requests a delay, in which case the times specified in the following section shall apply.

The interim suspension shall terminate when the hearing is held. The Associate Vice President for Academic Affairs may impose regular disciplinary penalties at this point in the proceedings.

## **7.0 Students' Right to Appeal an Academic Disciplinary Action**

### **7.1 Upon request by the student charged and subjected to disciplinary action, the case will be heard by the Student Discipline Committee:**

- The request must be made in writing to the Associate Vice President for Academic Affairs;
- An undergraduate student must send a copy of the request to President of the Student Government Association;
- The request must be made within ten days of the receipt of the notification from the Associate Vice President for Academic Affairs.

### **7.2 Student Discipline Committee**

**7.2.1** The Student Discipline Committee shall hear cases of students charged with violations of the Academic Honesty Policy and subject to academic disciplinary penalties if requested by the student charged as outlined in section 7.1. The committee will then make its decision following a hearing on the matter.

**7.2.2** The Student Discipline Committee shall be composed of:

- Two members and one alternate of the Supreme Court of the Student Government Association (or other members of the Student Government Association if Supreme Court members are not available) as designated by the President of the Student Government Association
- One member of the Graduate Student Association and one alternate as designated by the President of the Graduate Student Association
- Three members of the Faculty Senate and two alternates (not members of the administration other than chairpersons of academic departments) elected by the Faculty Senate Student Discipline Committee

**7.2.3** Either party to the dispute may disqualify one member of the Student Discipline Committee. Members may also disqualify themselves and should do so if they are aware of any reason they would not be able to render a fair and impartial decision.

**7.2.4** The Student Discipline Committee shall establish its own procedures and shall select its own Chairperson, except that a quorum shall consist of all six members of the committee. (In the event that one or more committee members are unable to meet at times consistent with the provisions of previous sections titled Interim Suspension and Hearings, an alternate member shall serve.)

**7.2.5** The Chairperson must vote on each and every issue. In case of a tie vote on the charges, the student shall be found innocent, and in case of a tie vote on the discipline imposed, the less serious disciplinary action shall be recommended to the Associate Vice President for Academic Affairs.

### 7.3 Hearing

The hearing is not intended to be a full-fledged adversarial proceeding; it is intended to be a fair hearing with ample opportunity for both parties (the student and the Institute) to present the facts. The Institute will be represented by the Associate Vice President for Academic Affairs or his/her designated representative.

**The following procedures shall apply:**

**7.3.1** Both parties will be notified of the date of the hearing by the President of the Student Government Association at least ten days prior to the hearing (except in the case of interim suspension). In exceptional cases the Student Discipline Committee may choose to hold the hearing at an earlier time, but only with the express agreement of both parties.

**7.3.2** Both parties shall be permitted to inspect, at least 24 hours in advance of the hearing, any documentary evidence that the other party intends to submit at the hearing. Both parties shall submit the documentary evidence with a list of witnesses who will testify at the hearing to the President of the Student Government Association after receiving notification of the hearing date.

**7.3.3** The party who is charged with violating Academic Honesty Policy is responsible for presenting his or her case; advisors or support persons (including attorneys) of either party can be present but are not permitted to present arguments or evidence in the hearing.

**7.3.4** Both parties may question any witness who testifies at the hearing.

**7.3.5** A recording will be made of the hearing. A more formal record by a court reporter may be arranged by either party at their own expense.

**7.3.6** The hearing shall be private if so requested by the student charged.

**7.3.7** The student charged is not required to testify in his/her own defense and failure to testify shall not be held against the student.

**7.3.8** The Student Discipline Committee will base its findings and decision solely on the evidence presented at the hearing.

**7.3.9** The Student Discipline Committee shall give a written copy of its findings and decision to the parties within a reasonable amount of time. A copy of the findings and decision will also be kept on file in the Office of Academic Affairs.

**7.3.10** The Student Discipline Committee may affirm, reverse or modify the decision of the Associate Vice President for Academic Affairs. The decision of the Student Discipline Committee shall be final unless appealed and reversed or modified.

### 7.4 Appeal of Student Discipline Committee Decision

Either the student charged or the Associate Vice President for Academic Affairs may appeal the decision of the Student Discipline Committee. This appeal, which must be in writing, will be sent to the Vice President for Academic Affairs of the Institute within ten days of the date of the Student Discipline Committees written decision.

The Vice President for Academic Affairs' review shall typically be limited to a review of the record made before the Student Discipline Committee, including all documentary evidence, if any, admitted. However, the Vice President for

Academic Affairs may allow such additional testimony and/or documentary evidence to be presented to him/her as he/she may, at his/her sole discretion, determine necessary in order to clarify the facts and/or the respective position of the parties. The Vice President for Academic Affairs may recommend to the President of the Institute affirmation, reversal, or modification of the Student Discipline Committee's decision. The President may affirm, reverse, or modify the Student Discipline Committee's decision.

Following this, the decision of the President shall be binding. Should the President be a party to the dispute, a person selected by the Regents shall perform the duties assigned to the President. The decision on the appeal shall be returned in a timely manner.

## **8.0 Records of Penalty Actions, Academic Disciplinary Actions and Hearings**

### **8.1 Record of Penalty Actions, Academic Disciplinary Actions and Hearings will be kept as follows:**

**8.1.1** Records of violations of Academic Honesty Policy that result in a Penalty Action or academic disciplinary action taken shall be kept by the Office of Academic Affairs for 10 years after the date of action taken.

**8.1.2** A record of academic disciplinary suspension will remain in the student's permanent file in the Office of the Registrar and will be noted on the student's academic transcript.

**8.1.3** A record of permanent dismissal will remain in the student's permanent file in the Office of the Registrar and will be noted on the student's transcript.

**8.1.4** Any student may examine his or her own file and may request that records of academic dishonesty or research misconduct including any disciplinary action be removed and destroyed. Such requests will be reviewed by the Associate Vice President for Academic Affairs and must be honored if the relevant period specified in paragraph 8.1.1 above has expired.

**8.1.5** If a New Mexico Tech undergraduate student applies to a graduate program at New Mexico Tech, the student's application and graduate record will include only records of violations that are included on the student's academic transcript. This is the same access that any graduate program, undergraduate program or place of employment will have when transcripts are required.

## **9.0 New Mexico Tech's Guide to Conduct and Citizenship**

### **9.1 Statement of Policy**

New Mexico Tech's primary purpose is education, which includes teaching, research, discussion, learning, and service. An atmosphere of free and open inquiry is essential to the pursuit of education. Tech seeks to protect academic freedom and build on individual responsibility to create and maintain an academic atmosphere that is a purposeful, just, open, disciplined, and caring community.

### **9.2 Terms**

The following selected terms are defined in an effort to facilitate a more thorough understanding of New Mexico Tech's Guide to Conduct and Citizenship. This list is not intended to be a complete list of all the terms referenced in the guide that might require interpretation or clarification. The Dean of Students shall make the final determination on the definition of any term found in the New Mexico Tech's Guide to Conduct and Citizenship.

**9.2.1 Accused student** - any student accused of violating The Student Code.

**9.2.2 Administrative hearing officer** - a University staff member who is authorized to determine the appropriate resolution of an alleged violation of The Student Code, and/or to impose sanctions or affect other remedies as appropriate. Subject to the provision in this code, and administrative hearing officer is vested with the authority to, among other duties such as:

- Investigate a complaint or an alleged violation of The Student Code
- Decline to pursue a complaint
- Refer identified disputants to mediation and other appropriate resources
- Establish charges against a student
- Approve an administrative agreement developed with an accused student

- Conduct an administrative hearing
  - Impose sanctions
  - Approve sanctions recommended by another Disciplinary Committee
  - Chair and/or advise a hearing or peer board
  - Conduct and appellate review
- 9.2.3 **Appeal** – a request to review of a case to any person authorized by New Mexico Tech, or designee to conduct a review of a decision reached by the Dean of Student or his/her designee.
- 9.2.4 **Complainant or Complaining Party** - any person who submits a charge alleging that a student violated The Student Code. When a student believes that s/he has been a victim of another student’s misconduct, the student who believes s/he has been a victim will have the same rights under The Student Code as are provided to the complainant, even if another member of the University community submitted the charge itself.
- 9.2.5 **Controlled Property** - locations not owned by New Mexico Tech but which the Institute has been given authority to manage.
- 9.2.6 **Day/Days/Number of Days** - The term day/days/number of days shall mean the number of academic days within an academic semester or summer session. If the procedure of the incident occurs or continues when the final grades are due or after the end of the academic semester or academic session, the Dean of Students will determine whether to proceed on non-academic session business days of the Institute or to continue the procedure when the next semester or session begins. Concerning this, the Dean of Students will take into consideration requests by the student charged.
- 9.2.7 **Designee** - refers to a staff or faculty member who has responsibility for implementing the student conduct process or administering the student conduct system, in part or in whole.
- 9.2.8 **Dean of Students or Dean** - the person, designated by the President to be responsible for the overall coordination of the University undergraduate student conduct system, including the development of policies, procedures, and education and training programs. The Dean of Students may serve as an administrative hearing officer.
- 9.2.9 **Disciplinary Action** - reprimanding students who fail to abide by the New Mexico Tech’s performance standards, policies or rules.
- 9.2.10 **Disciplinary Committee** - one or more members of the University community authorized by the Dean of Students to determine whether a student has violated The Student Code and to impose sanctions as warranted.
- 9.2.11 **Due process** - a fundamentally fair procedure based upon reasonable principles impartially applied.
- 9.2.12 **Hearing** - is a formal meeting where a student who has been reported to violate a University policy presents testimony and arguments to the Dean of Students or designee.
- 9.2.13 **Function** - activities and events that are sponsored by one or many departments at New Mexico Tech.
- 9.2.14 **Institute** - means New Mexico Tech.
- 9.2.15 **May** - is used in the permissive sense.
- 9.2.16 **Policy** - the written regulations, standards, and student conduct expectations adopted by the University and found in, but not limited to, The Student Code; The On-Campus Housing Contract; the Policy on Alcohol and Other Drugs, graduate and undergraduate catalogs; and other publicized University notices.
- 9.2.17 **Shall and Will** - are used in the imperative sense.
- 9.2.18 **Student** - any person admitted, registered, enrolled, or attending any University course; any person admitted to the University who is on University premises or University-related premises for any purpose pertaining to his or her registration or enrollment.
- 9.2.19 **Student Conduct File** - the printed/written file which may include but is not limited to incident report(s), correspondence, academic transcript, witness statements, and student conduct history.
- 9.2.20 **Student organization** - any association or group of persons that has complied with the formal requirements for University recognition.
- 9.2.21 **Support person** - any person who accompanies an accused student, a complainant, or a victim to an administrative hearing for the limited purpose of providing support and guidance. A support person **may not** directly address the Disciplinary Committee, question witnesses, or otherwise actively participate in the hearing process.



- 9.2.22 **Unauthorized entry** - gaining entry to a controlled property without proper permission from the University.
- 9.2.23 **University** - New Mexico Tech.
- 9.2.24 **University property** - includes all land, buildings, facilities, and other property in the possession of or owned, used, or controlled by the University, either solely or in conjunction with another entity.

### 9.3 Student Code of Conduct (The Student Code)

The **Student Code of Conduct** (also called The Student Code) attempts to clarify the types of conduct that shall be considered to affect adversely New Mexico Tech's educational function.

New Mexico Tech will not allow any conduct to disrupt community living on campus or to interfere with the rights of others to pursue their education, perform their duties and responsibilities, or participate in New Mexico Tech activities. Any conduct that does interfere with, or disrupts, the general campus educational purpose is subject to disciplinary action.

## 10.0 Citizenship Misconduct/Causes for Disciplinary Measures

- 10.1 Dishonesty or knowingly furnishing false information to the Institute.
- 10.2 Forgery, alteration, or misuse of Institute documents, records, or identification.
- 10.3 Use, possession, or distribution of narcotics, drugs, or alcoholic beverages, except as expressly permitted by law. For more details about our alcohol policy please go to New Mexico Tech Undergraduate Handbook, [www.nmt.edu/nmt-student-handbook-cs-student-academics](http://www.nmt.edu/nmt-student-handbook-cs-student-academics).
- 10.4 Possession of weapons, fireworks, or other explosives on Institute property, including student housing, except as expressly permitted by law or policy and in designated areas.
- 10.5 Theft of, or damage to, Institute property, or causing injury to a member of the Institute community or a campus visitor.
- 10.6 Physical assault, mental abuse, intimidation or coercion of any person on Institute-owned or controlled property, or at Institute-sponsored or -supervised functions
- 10.7 Any conduct which threatens or endangers the health, safety, personal rights, or dignity of any person.
- 10.8 Unauthorized entry to Institute facilities or use of Institute equipment.
- 10.9 Violations of rules governing residence in Institute-owned or -controlled property.
- 10.10 Violations of Institute policies or of campus regulations, including those concerning the registration of student organizations, use of Institute facilities or time, place, and manner of public expression.
- 10.11 Obstruction or disruption of teaching, research, administration, disciplinary procedures or Institute functions, including public service functions, or of other authorized activities on Institute premises.
- 10.12 Violation of the laws of the State of New Mexico or of any other governmental body with jurisdiction.
- 10.13 Harassment of individuals (physically, sexually or emotionally) via direct contact or electronically. For more on NMT's sexual harassment policies please go to [http://www.nmt.edu/images/stories/hr/pdfs/employee\\_handbook\\_1999.pdf](http://www.nmt.edu/images/stories/hr/pdfs/employee_handbook_1999.pdf)

## 11.0 Non-Academic Discipline Policy & Procedures

11.1 The New Mexico Tech Non-Academic Discipline Policy has two primary purposes:

First, it is intended to ensure that the student charged with disciplinary infractions is granted due process of law consistent with the principles of the United States Constitution. Due process means a fundamentally fair procedure based upon reasonable principles impartially applied.

Second, the policy is intended to educate the accused student in question regarding the standards of conduct expected at Tech and throughout society as a whole. The campus judicial process is not intended to mimic a genuine adversarial court proceeding but is based upon sound judicial practices.

Students violating The Student Code of Conduct are subject to disciplinary action in accordance with the procedures listed below.

### 11.2 Bringing of Charges

Charges of violations of the The Student Code may be brought by any member of the student body or staff, including, but not limited to, members of the faculty and the administration. Charges must be in writing, must specify the nature of the violation, and must give details as to time, place, and persons involved. This statement must be given to the Dean of Students by the complainant within ten days of the incident(s) in question or the report of a violation.

### 11.3 Notification of Charges

Accused students charged with violations of The Student Code must be notified in writing via email and/or campus mail of the charge by the Dean of Students within ten days of the bringing of charges. This notice must contain the particulars specified in the written statement of charges, give the student an opportunity to discuss the incident with the Dean of Students, and provide a notification of where to find New Mexico Tech's Guide to Conduct and Citizenship and the Non-Academic Discipline Policy in the New Mexico Tech Catalog.

### 11.4 The Dean of Students' Investigation

The Dean of Students or his/her designated representative will investigate the charges. He/she may claim a student is responsible for said charges and impose disciplinary penalties as stated in the "Non-Academic Disciplinary Action" section. The action taken shall constitute the Dean of Student's decision. The Dean of Students will notify the student in writing of his/her determination within twenty days of the receipt of the Bringing of Charges statement or ten days from the end of any additional time period granted to the student.

Regardless of the action taken by the Dean of Students, the student has the right to request an appeal.

## 12.0 Non-Academic Disciplinary Action

12.1 A student who is found responsible of violating Institute policy may be subject to one or more of the following penalties:

- Costs for damage to school property
- Requirement to complete community service projects
- Suspension of the right to use Institute facilities for a period of time
- Removal and/or banishment from campus housing
- Disciplinary probation, not to exceed one calendar year (recorded in the student's file in the Dean of Students' Office)
- Interim suspension (see "12.2 Interim Suspension")
- Disciplinary suspension, not to exceed one calendar year (recorded in the student's permanent file in the Office of the Registrar and noted on the student's transcript)
- Permanent dismissal (recorded in the student's permanent file in the Office of the Registrar and noted on the student's transcript)

12.1.1 If none of the above penalties is deemed appropriate, other disciplinary action may be imposed by the Dean of Students based on the violation(s). A student may be given an oral or written warning or statement that no disciplinary action is warranted.

12.1.2 Disciplinary action may be taken in cases where students are convicted of breaking criminal or civil law off campus.

**12.1.3** The Dean may also proceed with disciplinary action against a student or students without waiting for the results of criminal proceedings.

**12.1.4** The decision whether or not to take action shall belong to the Dean.

## **12.2 Interim Suspension**

At times, on the basis of his/her investigation, the Dean of Students may conclude that it is necessary to suspend a student immediately prior to a hearing on the matter. This may be the case when the student in question is believed to be dangerous to himself or herself, to others, or to property. Under such circumstances, the Dean of Students, or, in his/her absence, a person designated by the Institute President, may impose an interim suspension with a hearing to be set at a later date.

An interim suspension may not be imposed unless it is based upon facts that show that the student's continued presence on campus may constitute a danger to the student, to others, or to property.

An interim suspension may not be based upon mere suspicion of guilt. Any student suspended on an interim basis has the right to a hearing before the Student Discipline Committee (see Section 13). The student suspended on an interim basis must present a written request for a hearing to the Dean of Students and to the President of the Student Government Association within five days of the notification of the interim suspension. The hearing must be held within five days of the suspended student's request for a hearing unless the student charged requests a delay, in which case the times specified in the following section shall apply.

The interim suspension shall terminate when the hearing is held. The Dean of Students may impose regular disciplinary penalties at this point in the proceedings.

## **13.0 Student's Right to Appeal a Non-Academic Disciplinary Action**

**13.1** Upon request by the student charged and subjected to disciplinary action, the case will be appealed to the Student Discipline Committee:

- the request must be made in writing to the Dean of Students;
- an undergraduate student must send a copy of the request to the President of the Student Government Association;
- the request must be made within ten days of the receipt of the notification from the Dean of Students.

## **13.2 Student Discipline Committee**

**13.2.1** The Student Discipline Committee shall hear appeals to cases of students charged with violations of The Student Code and subject to disciplinary penalties if requested by the student charged as outlined in section 13.0. The Committee will then make its decision following a hearing.

**13.2.2** The Student Discipline Committee shall be composed of:

- Two members and one alternate of the Supreme Court of the Student Government Association (or other members of the Student Government Association if Supreme Court members are not available) as designated by the President of the Student Government Association
- One member of the Graduate Student Association and one alternate as designated by the President of the Graduate Student Association
- Three members of the Faculty Senate and two alternates (not members of the administration other than chairpersons of academic departments) elected by the Faculty Senate Student Discipline Committee

**13.2.3** Either party to the dispute may disqualify one member of the Student Discipline Committee. Members may also disqualify themselves and should do so if they are aware of any reason they would not be able to render a fair and impartial decision.

**13.2.4** The Student Discipline Committee shall establish its own procedures and shall select its own Chairperson. A quorum shall consist of all six members of the committee. (In the event that one or more committee members are unable to meet at times consistent with the provisions of Interim Suspension and Hearings, an alternate member shall serve.)

**13.2.5** The Chairperson must vote on each and every issue. In case of a tie vote on the charges, the student shall be found innocent, and in case of a tie vote on the discipline imposed, the less serious disciplinary action shall be recommended to the Dean of Students.

### **13.3 Hearing**

The hearing is not intended to be a full-fledged adversarial proceeding; it is intended to be a fair hearing with ample opportunity for both parties (the student and the Institute) to present the facts. The Institute will be represented by the Dean of Students or his/her designated representative.

#### **The following procedures shall apply:**

- 13.3.1** Both parties will be notified of the date of the hearing by the President of the Student Government Association at least ten days prior to the hearing (except in the case of interim suspension). In exceptional cases, the Student Discipline Committee may choose to hold the hearing at an earlier time, but only with the express agreement of both parties.
- 13.3.2** Both parties shall be permitted to inspect, at least 24 hours in advance of the hearing, any documentary evidence that the other party intends to submit at the hearing. Both parties shall submit the documentary evidence with a list of witnesses who will testify at the hearing to the President of the Student Government Association after receiving notification of the hearing date.
- 13.3.3** The person or party who is charged with violating The Student Code is responsible for presenting his or her case; advisors or support person (including attorneys) of either party can be present but are not permitted to present arguments or evidence in the hearing.
- 13.3.4** Both parties may question any witness who testifies at the hearing.
- 13.3.5** A recording will be made of the hearing. A more formal record by a court reporter may be arranged by either party at their own expense.
- 13.3.6** The hearing shall be private if so requested by the student charged.
- 13.3.7** The student charged is not required to testify in his/her own defense and failure to testify shall not be held against the student.
- 13.3.8** The Student Discipline Committee will base its findings and decision solely on the evidence presented at the hearing.
- 13.3.9** The Student Discipline Committee shall give a written copy of its findings and decision to the parties within a reasonable amount of time. A copy of the findings and decision will also be kept on file in the Dean of Students' Office.
- 13.3.10** The Student Discipline Committee may affirm, reverse or modify the decision of the Dean of Students. The decision of the Student Discipline Committee shall be final unless appealed and reversed or modified.

### **13.4 Appeal of Student Discipline Committee Decision**

Either the student charged or the Dean of Students may appeal the decision of the Student Discipline Committee. This appeal, which must be in writing, will be sent to the President of the Institute within ten days of the date of the Student

Discipline Committees written decision.

The President of the Institute's review shall typically be limited to a review of the record made before the Student Discipline Committee, including all documentary evidence, if any, admitted. However, the President of the Institute may allow such additional testimony and/or documentary evidence to be presented to him/her as he/she may, at his/her sole discretion, determine necessary in order to clarify the facts and/or the respective position of the parties. The President may affirm, reverse, or modify the Student Discipline Committee's decision.

Following this, the decision of the President shall be binding. Should the President be a party to the dispute, a person selected by the Regents shall perform the duties assigned to the President. The decision on the appeal shall be returned in a timely manner.

## **14.0 Records of Disciplinary Actions and Hearings**

### **14.1 Record of Non-Academic Disciplinary Actions and Hearings will be kept as follows:**

- 14.1.1** Records of violations of the Conduct and Citizenship Policy and The Student Code that result in a disciplinary action taken shall be kept by the Dean of Students' Office for 10 years after the date of action taken.
- 14.1.2** A record of non-academic disciplinary suspension will remain in the student's permanent file in the Office of the Registrar and will be noted on the student's academic transcript.
- 14.1.3** A record of permanent dismissal will remain in the student's permanent file in the Office of the Registrar and will be noted on the student's transcript.
- 14.1.4** Any student may examine his or her own file and may request that records of non-academic disciplinary action be removed and destroyed. Such requests will be reviewed by the Dean of Students and must be honored if the relevant period specified in paragraph 14.1.1 above has expired.
- 14.1.5** If a New Mexico Tech undergraduate student applies to a graduate program at New Mexico Tech, the student's application and graduate record will include only records of violations that are included on the student's academic transcript. This is the same access that any graduate program, undergraduate program or place of employment will have when transcripts are required.

# Graduation Requirements

To graduate, a student must fulfill the following:

- 1) The student must be a regular student.
- 2) The student must declare which catalog he or she is graduating under.

If a student is continuously enrolled (excluding summer sessions), the student may choose the degree requirements to be satisfied from:

- a) the catalog in effect when the student first enrolled or
  - b) any subsequent catalog. Under special circumstances (such as being called away to active military duty), a student may use the catalog under which he or she was admitted. Each case will be dealt with individually. A readmitted student **must** choose degree requirements to be satisfied from:
    - a) the catalog in effect when the student was readmitted or
    - b) any subsequent catalog provided the student is continuously enrolled after readmission.
- 3) General Education Core Curriculum Requirements —to qualify for all bachelor's degrees, the student must complete the General Education Core Curriculum Requirements as stated on page 100 for the bachelor of science and page 124-125 for the bachelor of general studies. General degree requirements for graduate degrees can be found on page 56 and page 101.
  - 4) The student must also complete the courses specified by the major department. Some programs require that the student pass each required class with a grade of "C" or better. The minimum number of credit hours for any bachelor's degree is 130.
  - 5) New Mexico Tech's Community Education classes (designated by the letter "C" in the course number) may not be used to fulfill the General Education Core Curriculum for a Bachelor of Science degree (page 100). However, these classes may be used to fulfill elective credit for some majors. Check the specific degree requirements for your major.
  - 6) The student's cumulative grade point average (see page 9) must equal 2.0 or greater.
  - 7) The student must complete a minimum of 30 credit hours at Tech.
  - 8) A candidate for a degree, before registering for the final semester of enrollment, must announce

candidacy to the Registrar by filing an "Intent to Graduate" form. Deadlines for submitting a Declaration of Intent are June 1 for those completing their degrees in August, July 1 for those completing their degrees in December, and December 1 for those completing their degrees in May.

At that time, the Registrar must be furnished with a list of all courses the student wishes to submit in fulfillment of requirements for the degree. It is the responsibility of the candidate, in consultation with the chosen major department and the Registrar, to make sure that the courses fulfill all requirements for graduation. The final declaration must be signed by the student's major advisor, who certifies that the courses taken meet the requirements for the degree specified. Any arrangement involving a departure from the regular requirements for graduation requires the approval of the Faculty Senate.

- 9) All fees and financial obligations to NM Tech must be paid before a student will be awarded a degree.
- 10) Students must complete all degree requirements in order to participate in commencement.

## Double Majors

Whenever a student satisfies the requirements for two majors, the student shall be awarded a degree listing a double major, and both majors shall be noted on the diploma.

The degrees of Bachelor of Science in Basic Sciences and the Bachelor of General Studies are excluded from the possibility of a double major listing.

## Dual Degrees

Students who wish to be granted two undergraduate degrees not only must fulfill all the requirements specified for each individual degree, but also must earn a minimum of 30 credit hours above the requirements for the first degree.

## Major

Your major is your primary field of study. The number of credit hours required in your major varies by program. Since your choice of major determines which courses you are required to take, it is advisable to declare your major as soon as possible. You may change majors at any time, but the earlier the better.

You must declare a major and be assigned a major advisor prior to completing the coursework for the major.

## Minor

New Mexico Tech awards minors for your secondary field of study. (See page 6 for a list of minors.) The number of credits required for a minor vary from department to department. Students cannot earn a minor with either the Associate of General Studies or Bachelor of General Studies.

You must declare a minor and be assigned a minor advisor prior to completing the coursework for the minor.

## Terminal Transfer Credits

Terminal transfer credits, credits earned at another college or university in order to complete the last degree requirements at NM Tech, are not allowed except when specified by a particular degree program, or when unusual circumstances appear to justify it. In no case will more than 16 credit hours of terminal transfer credits be allowed. A student who anticipates the need for requesting terminal transfer credit should do so as soon as practical and in no event later than the time of filing the declaration of candidacy for a degree. The request should be addressed to the Vice President for Academic Affairs. It should contain a statement of the circumstances which, in the student's judgment, justify the request and a specific statement of the program proposed for obtaining the terminal credits. Approval, if granted, will be of a specific program.

## Curriculum Changes

The Faculty Senate reserves the right to make curriculum changes. Assurance is given to students that proper measures will be employed to avoid hardships that may result from such changes.

Students can generate degree audits online via BanWeb.

## Commencement

Commencement ceremonies are held each year in early May.

If you finish your degree requirements in August or December, you may participate in ceremonies held the following May. Students must complete all degree requirements in order to participate in commencement. The only exception is for the earth science major who needs to complete EARTH 480, Field Methods, during the summer immediately following commencement.

See following pages for a list of honors awarded at commencement ceremonies.

# Honors and Awards

## Honor Roll

An Honor Roll of all students who successfully completed at least 12 credit hours with a grade-point average of 3.0 or better is released at the end of each semester. At least 6 of those credit hours must have received letter grades.

## Tech Scholars

Any student having demonstrated superior scholastic competence and conduct may be named a "Tech Scholar" upon the recommendation of the advisor or major department chair and the approval of the Vice President for Academic Affairs. The student must normally have completed 30 or more letter-graded credit hours at NM Tech and achieved a cumulative GPA of 3.5 or better at Tech. A heavier than normal course load and employment hours will be taken into consideration. "Tech Scholar" status will remain in effect until the student graduates, but will be revoked if the student's cumulative GPA falls below 3.0. In recognition of scholarly competence, the NM Tech Scholar may register early at preregistration. The designation of "Tech Scholar" will also be added to the student's transcript and he or she will be recognized at their graduation.

## Commencement Awards

### Graduation with Honors

Any undergraduate student who has earned a cumulative GPA of 3.0 or higher at NM Tech graduates with honors. The minimum requirements for graduation with honors are:

- "with highest honors," GPA of 3.75
- "with high honors," GPA of 3.50
- "with honors," GPA of 3.00

Honors are calculated using the fall GPA. A student with fewer than the two final years in residence at NM Tech must have attained the required average overall, as well as at NM Tech, to qualify for graduation with honors.

### Brown Award

The Brown Award is named in honor of C. T. Brown, who was for many years a member of the NM Tech Board of Regents. The award is given to that person graduating with a Bachelor of Science degree who is judged by the faculty to be highest in scholarship, conduct, and leadership. In addition to a plaque, the award consists of a \$500 prize.

### **Cramer Award**

This award was established to honor Tom Cramer, an engineer and a member of the NM Tech Board of Regents for 26 years. It is awarded to the male and female seniors graduating in engineering who rank highest in scholarship. The awards consist of citations and \$200 prizes. The recipients are chosen by the Faculty Senate upon recommendation of the engineering faculty.

### **Founders' Award**

A Founders' Award was created to honor the persons responsible for establishing the New Mexico School of Mines in Socorro in 1889, especially J. J. Baca and Ethan Eaton. The award is presented to the recipient of an advanced degree who has made an outstanding contribution to NM Tech through scholarship, research, and involvement in campus affairs. The recipient is chosen by faculty nomination and Faculty Senate election. The award consists of a plaque and a \$400 cash prize.

### **Langmuir Award**

The Langmuir Award for Excellence in Research is given for an outstanding scientific research paper by any student or graduate of New Mexico Tech. The paper must have been submitted to or published by a recognized journal during the preceding year. The recipient is selected by the Faculty Senate's Honorary Degrees and Awards Committee. The award is named in honor of Irving Langmuir (Nobel Laureate, 1932) who conducted extensive research with NM Tech staff. The award consists of a plaque and a \$200 cash prize.

### **New Mexico Tech Student Association and Graduate Student Association Service Awards**

The New Mexico Tech Student Association and Graduate Student Association present appreciation awards to students, faculty, and staff, who have done the most for the students of NM Tech.

### **Alumni Association Distinguished Achievement Award**

This award is presented to alumni who have achieved distinction in their special fields of endeavor. Awards are presented to alumni of both the New Mexico School of Mines and New Mexico Institute of Mining and Technology. Recipients are selected by the Alumni Association Board from those nominated by other alumni, faculty and staff, or friends of New Mexico Tech.

### **Alumni Association Distinguished Service Award**

The Alumni Association Distinguished Service Award is presented to alumni or friends of New Mexico Tech who have contributed outstanding service. Recipients are selected by the Alumni Association Board from those nominated by other alumni, faculty and staff, or friends of New Mexico Tech.

### **Distinguished Teaching Award**

The Distinguished Teaching Award is presented each year to a faculty member based on recommendations and nominations from students, alumni, and other faculty.

### **Distinguished Research Award**

This award is presented each year to an outstanding researcher on the NM Tech faculty or staff nominated by their colleagues and chosen by a committee of fellow researchers.



# Department Awards

Department	Name of Award	Criteria and Description
Biology	David K. Shortess Prize	Awarded to the outstanding graduating student in biology
Chemistry	Morris F. Stubbs Award	Given in honor of Morris F. Stubbs, professor emeritus
Computer Science	Patrick Orr Memorial Award	Given to the outstanding graduate student who demonstrates excellence in scholarship and potential for service in computer science education. The award is given in memory of Patrick Orr, a former member of the Computer Science Department.
Earth and Environmental Science	Albuquerque Gem & Mineral Club Scholarship	Given to a junior or senior majoring in earth science who displays academic excellence in the field
	Anton and Anita Budding Graduate Research Scholarship	Given to a graduate student in good standing in the earth and environmental science department.
	Estwing Award	Given to a senior graduating with a degree in earth science. The award consists of a rock hammer and certificate.
	New Mexico Geological Society Lucille Pipkin Undergraduate Scholarship	Given to a junior or senior earth science student, with preference to students with interests in subsurface, sedimentary, and/or petroleum geology.
	New Mexico Geological Society Registration Award	Given to a student majoring in earth science. The award pays for registration for the New Mexico Geological Society's Fall Field Conference
	New Mexico Geological Society Grant-in-Aid	Given to a student majoring in earth science who is doing research in New Mexico. A cash award of up to \$500.
	Roswell Geological Society Award	Given to a graduate student or a graduating student who is majoring in earth science.
Environmental Engineering	Paige Ashman Memorial Prize	Given to a graduating senior who has demonstrated excellence in environmental engineering and is active in the student environmental club.
CLASS	Howard Sylvester Prize	Given to the member of the graduating class who has shown high achievement in the Humanities.
Information Technology	Addy and Ravi Bhasker Award	Given to the graduating student with the highest GPA in Information Technology.
Materials & Metallurgical Engineering	Ashman Award	Given to B.S., M.S., and Ph.D. students who have demonstrated excellence in the field and who are active in the department activities.
	Ron Roman Scholarship	Given to a student who has demonstrated excellence in materials engineering and contributed to Tech's research effort.
	Javorsky Scholarship	Given to an undergrad student showing academic excellence that shows a financial need.
	Albuquerque Journal Scholarship	Given to a junior level undergraduate based on proposed research, to be applied to their senior year.
Petroleum Engineering	John M. Kelly Fellowship	Given to an outstanding graduate student
	Langdon B. Taylor Award	Given to a student who has rendered outstanding service to the student chapter of the Society of Petroleum Engineers.
Physics	Abraham and Esther Brook Prize	Given to a student who has demonstrated excellence in physics. The \$650 prize is given at the end of the junior year.
	Leslie Fallon Award	Given to the graduate student who does the best job of teaching freshman physics laboratory.
	Marvin Wilkening Award	Given to the graduating physics student who has demonstrated excellence in experimental physics. The technical tool kit is valued between \$600 and \$700.

# Course Descriptions and Curricula

## Course Descriptions

### Course Numbers

Courses are arranged numerically by department or program. In general, courses numbered from 100 to 199 are intended primarily for first-year students (freshmen); 200 to 299 for second-year students (sophomores); 300 to 399 for third-year students (juniors); 400 to 499 for fourth-year students (seniors); and 500 to 599 for graduate students. Exceptions may be made with the approval of the major advisor and instructor. Graduate students may be allowed credit for courses numbered 300 and above.

### Credit Hours

Following the course title, you will find the number of credit hours (cr) you will receive for completing the course. Credit hours are measured in class hours (cl hrs), lab hours (lab hrs), and recitation/discussion hours (recitation hr).

“1 cl hr” and “1 recitation hr” correspond roughly to one hour spent in class each week and is equivalent to one (1) credit hour. “3 lab hrs” equals about three hours per week in the laboratory and is also equivalent to one (1) credit hour.

In addition to class and lab time, you can expect to spend about two to three hours of study and preparation for each credit hour of class.

Most one-semester classes average three credit hours. To graduate with a bachelor’s degree, you will need a minimum of 130 credit hours, depending on your chosen major.

### Prerequisites and Corequisites

Some courses have prerequisites or courses you must successfully complete before enrolling in that course. Exceptions can be made with the instructor’s approval. If you enroll in a course in which you do not have the prerequisites without the instructor’s permission, you may be disenrolled. Corequisites are courses taken during the same semester.

Prerequisites and corequisites are not determined by the student’s individual catalog, but rather by the catalog in effect at the time that the course is offered.

### Semester Offered

Not all courses are offered every semester. The first semester of a two-semester-sequence course (such as ACCT 201/202, ES 110/111, and EARTH 101/102) is usually offered in the fall semester. The second semester is usually offered in the spring semester. Courses that are offered only one semester (“Offered fall semesters”) or alternate years (“Offered Spring Semesters and alternate years”) are so noted. “Offered on demand” implies that the course is offered only when a sufficient number of students want to enroll in the course.

### Description

The course description contains a short list of topics to be covered during the semester. This list is not meant to be exhaustive.

### Cross-listing

Sometimes courses fulfill the requirements for two different degrees and are listed under both programs. In such cases, the course description will end with the cross-listing “(Same as BCS 283).”

### Electives

Electives are courses taken in addition to the specific courses required by your major. Electives bring your credit hours up to the required number for graduation. Some majors allow students to choose many electives; others, few.

New Mexico Tech’s community education classes (designated by the letter “C” in the course number) may not be used to fulfill the General Education Core Curriculum Requirements for a Bachelor of Science degree (listed on page 100). However, these classes may be used to fulfill elective credit for some programs.

## Degree Requirements

In order to graduate, every student enrolled in a Bachelor of Science program must complete NM Tech’s General Education Core Curriculum Requirements, which are listed on page 100. This core set of requirements contains courses in humanities, mathematics, and basic science or engineering.

Graduate students must also complete a set of general requirements (see pages 56 and 101).

In addition, each program has its own set of courses you must complete to earn the degree, as well as the minimum number of credit hours needed to graduate.

## Sample Curricula

Most programs provide sample curricula to help you set your schedule. While you will graduate at the end of four years if you follow the sample curriculum faithfully, *these curricula are meant to be guides only. Talk with your advisor to chart your individual curriculum and select electives to round out your degree program.*

## New Mexico Common Course Numbering System (NMCCNS)

A common course numbering system has been devised by New Mexico colleges and universities in compliance with the New Mexico Post-Secondary Education Articulation Act. The purpose of the system is to assist New Mexico students who are transferring between institutions within the state. The system provides a neutral state wide course identifier for those courses that are similar in nature and considered to be equal in transfer. Students will find in the course description section of the catalog the state wide course identifier and the area of the General Education Common Core in brackets following the New Mexico Tech course for which the course can meet general education requirements. (See Page 38.)

# General Education Core Curriculum Requirements

## Requirements for a Bachelor of Science Degree

To fulfill the general education core curriculum requirements for the Bachelor of Science degree from New Mexico Tech, each student must complete the courses listed in this section. Where there are options, the student should consult with his or her appointed advisor.

## Requirements for a Bachelor of General Studies Degree

The General Education Core Curriculum requirements for a Bachelor of General Studies are found on page 124-125.

## Purpose of the General Education Core Curriculum Requirements

New Mexico Tech views its general education core curriculum requirements as the foundation for a broad and meaningful educational experience for all its undergraduates. The New Mexico Tech general education core curriculum requirements prepare students to communicate and reason well, evaluate and apply information, understand human societies and cultures, deepen their sense of values and ethics, and enrich their personal lives. Additionally, the general

education core curriculum requirements equip students with the analytical, language, science, and mathematics skills necessary for the specific degree requirements of their majors. The courses and their sequence in the general education core curriculum requirements are designed specifically to achieve these objectives and to prepare students for success in subsequent courses.

## New Mexico Higher Education General Education Core Competencies

New Mexico Tech teaches and assesses in compliance with the New Mexico Higher Education General Education Core Competencies established for Area 1: Communications; Area 2: Mathematics; Area 3: Basic Laboratory Sciences; Area 4: Social Sciences; and Area 5: Humanities.

## Transfer Students

Transfer students are expected to meet these general requirements in principle but are not required to present the exact duplicates of these courses. Their transcripts will be evaluated by the Registrar.

Changes in the educational program are made from time to time by action of the Faculty Senate. Students in continuous residence are assured that care will be taken to avoid unnecessary hardship caused by such changes.

## GPA Requirements

Some department require that their students achieve a minimum GPA in required courses. This information is listed by individual department. Student should consult their advisors for specific criteria.

# General Education Core Curriculum Requirements for a Bachelor of Science Degree

## Area 1– Communications (9 credit hours)

**ENGL 111 (3)** - ENGL 111 is waived for students who have a high enough ACT or SAT score (see pg 36). These students must take another course to replace the three credit hours; however, that course does not have to be an English course.

**ENGL 112 (3)** - Must meet prerequisites to enroll, see page 128

**ENGL 341 (3)** - Must meet prerequisites to enroll, see page 128

## Area 2 - Mathematics (8 credit hours)

**MATH 131 (4)** - Must meet prerequisites to enroll, see page 187

**MATH 132 (4)** - Must meet prerequisites to enroll, see page 187

## Area 3 - Basic Laboratory Sciences (26 credit hours)

### PHYS 121 & 121L (5)

Physics majors must take PHYS 221 & 221L. Other students may substitute this sequence with permission of the Physics Department.

### PHYS 122 & 122L (5)

Physics majors must take PHYS 222 & 222L. Other students may substitute this sequence with permission of the Physics Department.

### CHEM 121 & 121L (4)

CHEM 121 & 121L may be replaced by CHEM 151 & 151L

### CHEM 122 & 122L (4)

CHEM 122 & 122L may be replaced by CHEM 152 & 152L

## Eight (8) credit hours with associated laboratories from the disciplines of:

Biology (BIOL)

Earth Science (ERTH)

Engineering (ChE, CE, EE, ENVE, MATE, METE, ES, MENG, ME, PETR)

Computer Science Engineering (CSE)

*Note: Students majoring in biology, computer science, earth science, environmental science, psychology, and any engineering discipline fulfill this portion of the general education core curriculum requirements while fulfilling their major requirements.*

## Area 4 - Social Sciences (6 credit hours)

Economics (ECON)

Political Science (PS)

Psychology (PSY)

Anthropology (ANTH)

Women's and Gender Studies (WGS)

## Area 5 - Humanities (6 credit hours)

English (ENGL), except ENGL 103, 111, 112, 341

Art History (ART)

Music (MUS), except for performance ensembles

History (HIST)

Philosophy (PHIL)

Humanities (HUMA)

Technical Communication (TC) except TC 321, 420, 422

Theater (THEA)

Foreign Languages (SPAN, FREN, GERM)

Other languages may be counted only if they are listed or approved by the Communication, Liberal Arts, Social Sciences Department

## Area 6 - Additional Courses from Area 4 or 5 (6 credit hours)

## General Degree Requirements for a Master of Science Degree

The general requirements common to all M.S. degree curricula in the sciences and engineering fields are listed below. Additional requirements for specific curricula are listed under the appropriate department.

It is required that a student preparing for the M.S. degree:

1. Have competence in the subject matter of the standard introductory college courses in chemistry, physics, and one natural science,
2. Have a working knowledge of calculus and the content of one additional course in mathematics beyond calculus,
3. Have a minimum of six credit hours of approved upper-division or graduate course work from another department,
4. Declare a major with at least 12 credit hours of course work above the 500-level, exclusive of research credits, and
5. Complete a research project culminating in a thesis or independent study paper.

Note: These general requirements do not apply to students in the Master of Science for Teachers (MST) program. MST requirements are listed on page 212.

## General Degree Requirements for a Doctor of Philosophy Degree

The degree of Doctor of Philosophy requires a high level of competence in a recognized field of learning, and only those students showing unusual promise are accepted. A dissertation that contributes to the general field of knowledge must be written and defended before a committee of the faculty.

In addition to dissertation credits, course requirements for each specialty are listed under the programs and courses of instruction for each department.

# Arts & Sciences

# Air Force ROTC (AFROTC)

*Professor Garcia*

*Assistant Professors Bradley, McMahon*

AFROTC Detachment 510  
(Aerospace Studies Building 159)  
MSC02 1650 / 1901 Las Lomas NE  
1 University of New Mexico  
Albuquerque, NM 87131-0001  
(505)277-4502  
Www.afrotc.com  
Www.unm.edu/~rotcweb

The mission of the Air Force ROTC is to provide instruction and experience to all cadets in a diversified college or university environment, so they can graduate with the knowledge, character, and motivation essential to becoming leaders in the United States Air Force. The Air Force ROTC approach to education encourage inquiry, analysis, critical thinking, imagination, judgment, and individual participation on the part of each student.

The Air Force ROTC commissioning program is open to qualified students in all academic majors. The program is divided into a general military course (GMC) and a professional officer course (POC). The latter is the final commissioning phase for those students who qualify and desire a commission in the USAF. Both the GMC and POC programs require students to enroll in an Aerospace Science Leadership Laboratory each semester.

## Program Requirements

Qualified students may enroll in aerospace studies classes during normal college registration procedures. The student enrolls in the General Military Course (GMC) for the first two years. Prior to enrolling the last two years of the program, the Professional Officer Course (POC), the student must meet Air Force ROTC qualification standards and requirements. In addition, all Air Force ROTC participants must complete a four-week summer field training course prior to entering the POC, normally between the sophomore and junior years. It is possible to compress the two GMC years to one through dual enrollment into the academic courses. The POC portion must last two years.

## Financial Opportunities

The Air Force provides uniforms and textbooks for Air Force ROTC courses. Participants receive approximately \$600.00 for the four-week summer training period (in addition to travel pay and an airline ticket). After successful completion of the training and entrance into the POC, participants will receive up to \$500 a month (tax-free) subsistence for approximately 20 months (until graduation). Students who qualify may receive an AFROTC scholarship which will pay tuition and fees, up to \$900 per year for books and up to \$550.00 per month (tax-free) subsistence throughout the academic period that the scholarship is in effect. Scholarships are available for four, three and one-half, three, two and one-half, and two year periods. An additional year of scholarship benefits is available for most technical majors. Students who qualify for the POC and are not on AFROTC scholarships receive up to \$500.00 per month. To retain this scholarship, the student must continue to meet retention standards.

This department is administered by personnel of the United States Air Force under rules promulgated by the Department of the Air Force and New Mexico Tech.

Following successful completion of the Air Force ROTC program, each individual is commissioned as a second lieutenant in the United States. Full pay and benefits begin upon initial assignment to active duty.

Students may enter Air Force ROTC from any high school, college or university. Transfer students with a ROTC background can receive credit for previous ROTC experience.

## Three Phases of the AFROTC Program General Military Course (GMC)

The GMC is an introduction to the U.S. military forces and to the development of air and space power. The course of study is designed to prepare cadets for entry into the studies normally offered to freshmen and sophomores. The GMC total approximately 180 course hours, consisting of 60 course hours of academics and 120 course hours of leadership laboratory over two years. Four courses are required to complete the GMC: First year, AFAS 120 (fall semester), AFAS 121 (spring semester), second year; AFAS 250 (fall semester), AFAS 250 (spring semester). Sophomores may dual enroll in AFAS 120/121 and AFAS 250/251 to accomplish these requirements in two semesters instead of four.

## Field Training

Field Training is a four week encampment at Maxwell AFB in Montgomery, AL, which is designed to evaluate the student while challenging them both mentally and physically. Upon successful completion of Field Training, the student is allowed to enter POC.

## Professional Officer Course (POC)

POC subject matter includes theoretical and applied leadership, management, communication skills and national security and defense policy. The POC prepares cadets for active duty as commissioned officers in their junior and senior years. The POC totals approximately 300 hours, with 180 hours of academics and 120 hours of leadership laboratory over two years.

NOTE: Leadership laboratory is a co requisite each semester throughout the four-year program. Leadership laboratory provides a variety of practical leadership experiences by rotating cadet corps positions and responsibilities among students enrolled in the GMC and POC

## General Military Courses

### AFAS 120, The Foundation of the United States Air Force I, 1 cr

A survey course designed to introduce students to the United States Air Force and provide an overview of the basic characteristics, missions and organization of the Air Force.

### AFAS 120L, Leadership Laboratory, 1 cr

*Corequisite: AFAS 120*

Development of personal leadership and managerial abilities. Examination and demonstration of Air Force customs and courtesies, drill and ceremonies and standards of discipline and conduct. Graded S/U.

### AFAS 121 The Foundation of the United States Air Force II, 1 cr

A survey course designed to introduce students to the United States Air Force and provide an overview of the basic characteristics, missions and organization of the Air Force.

### AFAS 121L, Leadership Laboratory

*Corequisite: AFAS 121*

Continuation of AFAS 120L. Graded S/U.

### AFAS 250, The Evolution of USAF Air and Space Power I, 1 cr

Introduces topics on Air Force heritage and leaders, introduction to air and space power through examination of competencies, functions and continued application of communication skills.

### AFAS 250L, Leadership Laboratory

*Corequisite: AFAS 250*

Application of elements of personal leadership. Demonstration of command, effective communications, individual leadership instruction, physical fitness training and knowledge of Air Force requirements. Graded S/U.

### AFAS 251, The Evolution of USAF Air and Space Power II, 1-2 credits

Introduces topics on Air Force heritage and leaders, introduction to air and space power through examination of competencies, functions, and continued application of communication skills.

### AFAS 251L, Leadership Laboratory, 1-2 cr

*Corequisite: AFAS 251*

Continuation of AFAS 250L. Graded S/U.

### AFAS 300, Air Force Leadership Studies, 3 cr

Teaches cadets advanced skills and knowledge in management and leadership. Emphasis placed on enhancing leadership skills. Cadets have an opportunity to try out the leadership/management techniques in a supervised environment as juniors and seniors.

### AFAS 300L, Air Force Leadership Laboratory

*Corequisite: AFAS 300*

Application of leadership and management theories and concerns through participation in advanced leadership experiences; weight and fitness training. Graded S/U.

### AFAS 301, Air Force Leadership Studies, 3 cr

Teaches cadets advanced skills and knowledge in management and leadership. Emphasis placed on enhancing leadership skills. Cadets have an opportunity to try out the leadership/management techniques in a supervised environment as juniors and seniors.



**AFAS 301L, Air Force Leadership Laboratory, 1 cr***Corequisite: AFAS 301*

Continuation of AFAS 300L. Graded S/U.

**AFAS 400, Natl Security Affairs/Prep for Active Duty, 3cr**

A foundation for seniors to understand their role as military officers in American society. An overview of the complex social and political issues facing the military profession.

**AFAS 400L, Air Force Leadership Laboratory, 1cr***Corequisite: AFAS 400*

Application of leadership and management theories and concerns through participation in advanced leadership experiences; weight and fitness training.

**AFAS 401, Natl Security Affairs/ Prep for Active Duty, 3cr**

A foundation for seniors to understand their role as military officers in American society. An overview of the complex social and political issues facing the military profession.

**AFAS 401L, Air Force Leadership Laboratory, 1 cr***Corequisite: AFAS 401*

Continuation of AFAS 400L. Graded S/U

These courses are taught through a special cross-enrollment agreement with the University of New Mexico and its Department of Aerospace Studies. Items required for the courses are provided by the AFROTC program.

Courses are taught on the main campus of UNM; students wishing to take these courses should contact the Aerospace Studies Department at 505.277.4502.

## Atmospheric Sciences Interdepartmental Graduate Program

A number of departments at NM Tech offer coursework and research opportunities in the atmospheric sciences. This program was developed to:

- 1) make it easier for students to discern what is available at NM Tech in the atmospheric sciences and
- 2) facilitate cross-departmental course and research work by students.

The actual degrees awarded are those offered by each department; there is no separate degree in the atmospheric sciences. The student must satisfy all the requirements in his or her department to earn a degree. Each student shall have an academic advisor from the student's home department. However, the student's research advisor can be a faculty member from any of the participating departments.

### Current Specialties

Atmospheric and environmental chemistry: Kyle, Wingenter

Cloud physics, cloud dynamics, and atmospheric electricity: Eack, Krehbiel, Raymond, Rison, Winn

Hydroclimatology: Hendrickx

Upper-atmosphere physics: Minschwaner, Thomas

### Applicable Courses

#### Chemistry

CHEM 422, Environmental Geochemistry

CHEM 531, Chemistry of Aquatic Systems

CHEM 532, Atmospheric Chemistry

#### Earth and Environmental Science

ERTH 422, Environmental Geochemistry

GEOC 507, Hydrogeochemistry

HYD 503, Groundwater Hydrology

HYD 507, Hydrogeochemistry

HYD 512, Surface Water Hydrology

HYD 513, Hydroclimatology

HYD 517, Vadose Zone Hydrology

## Environmental Engineering

ENVE 413, Fundamentals of Air Pollution Engineering  
 ENVE 416, Design of Air Pollution Engineering Systems  
 ENVE 535, Transport and Fate of Air Pollutants

## Physics

PHYS 331, Physics of Weather and Climate I  
 PHYS 332, Physics of Weather and Climate II  
 PHYS 432, Atmospheric Remote Sensing  
 PHYS 443, Atomic and Nuclear Physics  
 PHYS 526, Fluid Dynamics  
 PHYS 533, Advanced Topics in Atmospheric Physics

## Participating Departments and Faculty

### Chemistry

Wingenter—Atmospheric Chemistry

### Earth and Environmental Science

Hendrickx—Vadose Zone Hydrology  
 Kyle—Igneous Geochemistry, Antarctic Geology, Volcanology

### Electrical Engineering

Rison—Atmospheric Electricity, Instrumentation  
 Thomas—Upper Atmospheric Physics, Instrumentation

### Environmental Engineering

Cal—Air Quality Engineering and Science

### Materials and Metallurgical Engineering

G. Bond—Carbon Dioxide Remediation

### Physics

Eack—Atmospheric Physics, Atmospheric Electricity  
 Krehbiel—Lightning Studies, Radar Meteorology, Thunderstorm Electrification  
 Minschwaner—Radiative Transfer and Climate, Physics of the Upper Atmosphere  
 Raymond—Geophysical Fluid Dynamics, Cloud Physics, Clouds and Climate  
 Winn—Atmospheric Physics, Electrical Discharges in Gases, Instrumentation

## Basic Sciences Program (Interdepartmental)

*Administrative Committee for Basic Sciences:  
 Professor Cormack (Chair)*

### Degrees Offered: B.S. in Basic Sciences

The degree Bachelor of Science in Basic Sciences is intended for the student who desires a Bachelor of Science degree but wishes more latitude in the selection of courses than is available otherwise. It is well adapted to the needs of a student who may wish to complete preparation for secondary school teaching in science or mathematics. For this purpose, however, proper selection of courses is necessary, and the advice of the Department of Education should be sought.

To qualify for the degree Bachelor of Science in Basic Sciences, a student must satisfy the general education core curriculum requirements for the Bachelor of Science degree (page 100).

- Of the minimum 130 credit hours required for this degree, at least 65 must be in science and mathematics. These can include biology, chemistry, computer science, earth and environmental science, mathematics, engineering courses (numbered above 200), physics, and psychology.
- At least 30 of these credit hours must be in courses numbered 201 or above. In order that a reasonable depth of study is attained in at least two fields, the 30 credit hours must include at least nine credit hours in each of two fields.
- The foreign language requirement is six credit hours in a single language.
- Of the total credit hours required, at least 42 must be in courses numbered 300 or above.

# Biology

*Professors Kieft, Rogelj (Chair of the Department)*

*Associate Professors Kirk, Reiss*

*Assistant Professors Naik, Shors*

*Adjunct Faculty: Bhasker, Boston, Gonzales, Markwell,*

*Tartis, D. Wilkinson, P. Wilkinson*

*Emeritus Faculty: Shortess, Smoake*

**Degrees Offered: B.S. in Biology, Biology with Environmental Science Option, and Biology with Medical Technology Option; M.S. in Biology and M.S. in Microbiology**

**Program Offered: 5 year BS/MS Program**

The mission of the Biology Department is to provide students with a relevant education for biomedical and biotechnological careers, to lead in molecular biological research, and to serve the university and the scientific community. The Biology program prepares undergraduate students for graduate education in the medically allied professions and in the specialized fields of the biological sciences. (Students who are interested in pre-medical, pre-dental, and pre-veterinary science programs should see page 208) A wide variety of career opportunities is currently available for those individuals possessing advanced knowledge and skills, particularly in the areas of biochemistry, molecular biology, microbiology, ecology, genetics, endocrinology, and immunology. Market demand in these areas will likely remain strong for the foreseeable future.

Undergraduate majors typically have diverse career goals and objectives. To accommodate these differences, the undergraduate program is very flexible; only a minimal number of technical core courses is required. Through the selection of appropriate technical electives, each student customizes their education based on personal academic needs and career objectives.

The main approach in the classroom is to stress the highly quantitative and analytical nature of modern biological inquiry, which utilizes sophisticated biochemical and biophysical techniques to answer fundamental questions about living organisms. Undergraduates are encouraged to undertake research through various directed study and special topics offerings and are often employed as technicians in the research laboratories of the faculty.

## Program Educational Objectives:

Our graduates will be able to use basic principles of science to analyze, to explain, and to apply biological information and concepts.

Our graduates will be able to design and implement biological research and report findings orally and in writing.

## Undergraduate Program

### Bachelor of Science in Biology

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum*

*Requirements (page 100), the following courses are required:*

- BIOL 111 (3), 111L (1), 112 (3), 112L (1), 311 (3), 311L (1), 331 (3), 333 (3) & 333L (1) or 341 (3) & 341L, and BIOL 471 (1)
- At least 6 additional credit hours from: BIOL 341 (3) & 341L (1) or 333(3) & 333L (1), 351 (3), 352 (3), 353L (2), 354L (2), 355 (2), 355L (1), 356 (2), 356L (1), 431 (3), 437 (3)
- At least 6 additional credit hours from: BIOL 343 (3), 343L (1), 344 (3), 344L (1), 444 (3), 446 (3), 455 (3)
- Additional Biology (12). CHEM 441 and 442 (Biochemistry I and II) may be applied to biology electives.
- CHEM 333 (3); plus 6 additional hours of the following: CHEM 311 (3–4), 331 (3–4), 333L (1), 334 (3), 334L (1), 441 (3–4)
- Computer Science or Mathematics: CSE 113 (4) or MATH 283 (3)
- Electives to complete 130 hours

Biology laboratory classes are required for biology lecture courses that offer an associated laboratory if credit for the lecture course is used to meet the required number of biology credits for a degree in biology. Students pursuing a B.S. in Biology must take Biology and Chemistry courses for a letter grade, except for BIOL 101 and BIOL 102. Prerequisites for a particular course may be waived only with the written permission of the course instructor and chair of the department.

### Sample Curriculum for the Bachelor of Science in Biology

#### *Semester 1*

- 4 BIOL 111 & 111L (intro)
- 4 CHEM 121 & 121L (general)
- 3 ENGL 111 (college English)
- 4 MATH 131 (calculus)
- 1 Physical Recreation
- 16 Total Credit Hours

#### *Semester 2*

- 4 BIOL 112 & 112L (intro)
- 4 CHEM 122 & 122L (general)
- 3 ENGL 112 (college English)
- 4 MATH 132 (calculus)
- 1 Physical Recreation
- 16 Total Credit hours

*Semester 3*

- 4 BIOL 311 & 311L (genetics)
- 3 BIOL 331 (cell)
- 3 Social Science
- 5 PHYS 121 & 121L (general)
- 3 CHEM 333 (organic)
- 18 Total credit hours

*Semester 4*

- 4 BIOL 333 & 333L (molecular)
- 3 Social Science
- 3 Humanities
- 5 PHYS 122 & 122L (general)
- 3 Chemistry Elective
- 18 Total credit hours

*Semester 5*

- 4 Biology Elective
- 3 Biology Elective
- 3 Chemistry Elective
- 3 Social Science
- 3 ENGL 341 (technical writing)
- 16 Total credit hours

*Semester 6*

- 4 Biology Elective
- 3 Biology Elective
- 3–4 CSE 113 (computer science) or  
MATH 283 (statistics)
- 3 Humanities
- 3 Electives
- 16-17 Total credit hours

*Semester 7*

- 4 Biology Elective
- 3 Biology Elective
- 1 BIOL 471 (seminar)
- 8 Electives
- 16 Total credit hours

*Semester 8*

- 4 Biology Elective
- 3 Biology Elective
- 3 Humanities/Social Science
- 6 Electives
- 16 Total credit hours

**Bachelor of Science in Biology with Environmental Science Option**

*Minimum credit hours required—130*

*In addition to the General Degree Requirements (page 100), the following courses are required:*

- BIOL 111 & 111L (4), 112 & 112L (4), 311 & 311L (4), 331 (3), 333 & 333L (4), or BIOL 343 & 343L, and BIOL 471 (1)
- At least 12 additional credit hours from: BIOL 343 (3), 343L (1), 344 (3), 344L (1), 444 (3), 446 (3), 455(3), 493 (4); CHEM 422 (3), 422L (1), EARTH 340 (3), 390 (3), 422 (3), 440 (3)
- Additional Biology (12) CHEM 441 and 442 (Biochemistry I and II) may be applied to biology electives.
- CHEM 333 (3); plus 6 additional hours of the following: CHEM 311 (3–4), 331 (3–4), 333L (1), 334 (3), 334L (1), 422 (3–4), 441 (3–4)
- Computer Science or Mathematics: CS 111 (4) or MATH 283 (3)
- Electives to complete 130 hours

Biology laboratory classes are required for biology lecture courses that offer an associated laboratory if credit for the lecture course is used to meet the required number of biology credits for a degree in biology. Students pursuing a B.S. in Biology must take Biology and Chemistry courses for a letter grade, except for BIOL 101 and BIOL 102. Prerequisites for a particular course may be waived only with the written permission of the course instructor and chair of the department.

**Bachelor of Science in Biology with Medical Technology Option**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

- BIOL 111 & 111L (4), 112 & 112L (4), 341 & 341L (4), 437 (3); and one of the following options:
  1. BIOL 311 & 311L (4)
  2. BIOL 331 (3) and 333 (3)
  3. BIOL 351 (3) and 352 (3)
- CHEM 311 & 311L (4), 333 & 333L (4)
- MATH 283 (3)
- Internship (30) at an approved school of medical technology

**Minor in Biology**

*Minimum credit hours required—18*

*The following courses are required:*

- BIOL 111 & 111L (4)
- BIOL 112 & 112L (4)
- BIOL 331 (3)
- BIOL 344 & 344L (4)
- Additional biology course numbered 300 or above (3)

*Biology classes required for a minor in biology may not be taken on an S/U basis.*

## Graduate Program

### Master of Science in Biology

The master's candidate must demonstrate competence in mathematics, chemistry, and physics comparable to New Mexico Tech's Bachelor of Science in Biology. Requirements for the Master of Science degree in Biology follow the M.S. with Thesis option (page 54). Additional requirements are the following:

- Completion of at least six credit hours of 500-level biology coursework other than thesis, directed study, or seminar.
- Completion of at least six credit hours of 500-level coursework other than thesis, directed study, or seminar in one or more disciplines outside of biology.
- Completion of two credit hours of BIOL 501, Graduate Seminar.

### Five Year Program: Biology B.S./Biology M.S.

Exceptionally well motivated students may earn both BS and MS degrees in Biology in five years. The student fulfills the requirements for a BS degree in four years and for an MS degree the following year. A minimum of 160 credit hours are required to complete both degrees. The MS degree requires the completion of a thesis based on the student's own research.

Students may apply for the BS/MS program at the end of their 4th semester. Admission is contingent on their having a GPA of at least 3.0, and on the acceptability of their proposed course of study. Students with upper division standing may also apply, with the same requirements for admission.

Students in the five-year program must apply for graduate standing, normally in their 6th semester. Once admitted to the graduate program, the student spends his or her 8th semester as a dually registered student. During their senior year, the student must select a graduate advisory committee and formalize his or her graduate research topic. Once admitted to the graduate program, a student may apply for financial support via research assistant or teaching assistant positions.

### Biology Courses:

#### BIOL 101, Issues in Biological Science, 1 cr, 1 cl hr

*Graded S/U*

Introduction to modern topics in biotechnology, biodiversity, and biocomplexity. Discussion of career options in the biological sciences.

#### BIOL 111, 111L, General Biology, 4 cr, 3 cl hrs, 2 lab hrs

*Corequisite: CHEM 109 or CHEM 121*

A survey of life functions and associated structures at the cellular level. Energy fixation and utilization, growth and development through cell division, and gene action. [NMCCNS BIOL 1214: General Education Area III]

#### BIOL 112, 112L, General Biology II, 3-4 cr, 3 cl hrs, 3 lab hrs

*Prerequisite: BIOL 111*

Introduction to evolution, ecology, physiology, and development. Laboratory is a phylogenetic survey of the kingdoms of life. [NMCCNS BIOL 1224: General Education Area III]

#### BIOL 311, 311L, Genetics, 3-4 cr, 3 cl hrs, 3 lab hrs

*Prerequisites: BIOL 111 & 111L; concurrent enrollment in 311R highly recommended.*

An overview of the storage, transmission and expression of biological information. The lab emphasizes Mendelian analysis in model organisms and fluorescent analysis of human DNA.

#### BIOL 311R, Genetics Recitation, 1 cr, 1cl hrs

*Corequisite: Biol 311*

#### BIOL 331, Cell Biology, 3 cr, 3 cl hrs

*Prerequisites: BIOL 111; CHEM 121*

Studies of life at the cellular level. The structure and functions of eukaryotic cells and their organelles. The molecular basis for energy transfers, growth and development, and their regulation.

#### BIOL 333, 333L, Molecular Biology, 3-4 cr, 3 cl hr, 3 lab hrs

*Prerequisites: BIOL 331; CHEM 121*

Principles of modern molecular biology. Laboratory emphasizes enzyme purification and recombinant DNA techniques, organized as a gene cloning project. BIOL 333 and BIOL 333L must be taken concurrently.

#### BIOL 341, 341L, Introductory Microbiology, 3-4 cr, 3 cl hrs, 3 lab hrs

*Prerequisite: CHEM 122*

*Corequisite: BIOL 331*

A comparative study of reproduction, growth, and metabolism of bacteria, rickettsia, and viruses, with emphasis on the bacteria and their relation to man and their environment.

**BIOL 343, 343L, Environmental Microbiology, 3–4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite:* BIOL 111

*Corequisite for Biology majors:* BIOL 331; BIOL 331 recommended for other majors

A study of the relationship between microorganisms and water and soil environments with emphasis on biogeochemical cycles.

**BIOL 344, 344L, Introductory Ecology, 3–4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites:* BIOL 112; MATH 131

A study of the principles which govern the interactions between biological populations and the environment.

**BIOL 351, Physiology I, 3 cr, 3 cl hrs**

*Prerequisite:* BIOL 112; 331

Principles and mechanisms of vertebrate function, emphasizing mammalian systems. Includes homeostasis, membranes, receptors, muscle and nerve function, sensory system and the regulation and function of hormones.

**BIOL 352, Physiology II, 3 cr, 3 cl hrs**

*Prerequisite:* BIOL 351

Continuation of BIOL 351. Includes cardiovascular, respiratory, water and ion homeostasis, gastrointestinal, and reproductive physiology.

**BIOL 353L, Experimental Physiology I, 2 cr, 1 cl hr, 3 lab hrs**

*Prerequisite:* BIOL 351

Students will quantify and interpret physiologic responses in humans. Experiments will involve the nervous, sensory, and muscular systems. A portion of this course will include gross anatomy.

**BIOL 354L, Experimental Physiology II, 2 cr, 1 cl hr, 3 lab hrs**

*Prerequisite:* BIOL 351, 353L

*Corequisite:* BIOL 352

Continuation of BIOL 353L. Students will quantify and interpret physiologic responses in humans. Experiments will involve the cardiovascular, renal, and respiratory systems. A portion of this course will include gross anatomy.

**BIOL 362, Animal Behavior, 3 cr, 3 cl hrs**

*Prerequisites:* PSY 121; BIOL 112; or consent of instructor

General overview of ethological and physiological approaches to the study of animal behavior. (Same as PSY 362)

**BIOL 411, Advanced Genetics, 3 cr, 3 cl hrs**

*Prerequisites:* BIOL 311 and 333

A study of current topics in genetics, including the molecular basis of gene structure and action in eukaryotes and prokaryotes.

**BIOL 431, Virology, 3–4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite:* BIOL 331

*Corequisite:* BIOL 311

Molecular biology of viral infection, replication, and pathogenesis. Animal viruses emphasized.

**BIOL 435, Bioinformatics, 3 cr, 3 cl hrs**

*Prerequisite:* BIOL 311 or consent of instructor

Computer analysis of biological sequence data used to perform in silico experiments. Students will design and perform experiments using public domain software and databases.

**BIOL 437, Infection and Immunity, 3 cr, 3 cl hrs**

*Prerequisite:* BIOL 341

Study of human infectious disease and the immune system. Pathogenic microorganisms and mechanisms of pathogenicity. Innate and acquired immune responses. Immunochemistry, cellular immunity, and immunopathology.

**BIOL 444, Evolutionary Biology, 3 cr, 3 cl hrs,**

*Prerequisite:* BIOL 311, BIOL 344

The mechanisms and implications of biological evolution. Topics include population genetics, adaptation and natural selection, fossil evidence, and evolutionary medicine.

**BIOL 446, Environmental Toxicology, 3 cr, 3 cl hrs**

*Prerequisite:* CHEM 333

The fate and behavior of toxic pollutants in terrestrial and aquatic environments, from an ecosystem perspective.

**BIOL 449 Astrobiology, 3 cr, 3 cl hours**

*Prerequisites:* CHEM 121, 122, PHYSICS 121, 122, plus one other science course and consent of instructor. Offered on demand.

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. (Same as EARTH 449.)

**BIOL 455, Molecular Ecology, 3 cr, 3 cl hrs**

*Prerequisites: BIOL 311 and 344, or consent of instructor*

Application of molecular biological techniques to ecological and environmental problems. Current research projects at Tech are emphasized.

**BIOL 471, Life Sciences Seminar, 1 cr, 1 cl hr**

*Prerequisite: Upper-class standing in biology or consent of instructor*

Review, discussion, and student presentations of the current literature on a single topic in biology. Topics are chosen with the aim of integrating multiple levels of biological organization and research approaches.

**BIOL 486, Cytogenetics, 3 cr, 3 cl hrs**

*Prerequisites: BIOL 311 and 333*

Principles of chromosome structure and function with an emphasis on medical diagnostics. Course includes a field trip to a cytogenetics diagnostic laboratory.

**BIOL 487, 487L Advanced Virology, 3-4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite: BIOL 431 or 531*

An in-depth study of one or two viruses, viral vectors for gene therapy, and herpes or hemorrhagic fever viruses. The laboratory section of the course will include viral propagation in tissue culture and methods to investigate the molecular biology of viral infection.

**BIOL 488, Biology of Cancer, 3 cr, 3 cl hrs**

*Prerequisites: BIOL 331 and 333*

Principles and molecular mechanisms of carcinogenesis. Involves elements of cell biology, genetics, molecular biology, immunology, biochemistry, virology, pharmacology, physiology, developmental biology, and pathology.

**BIOL 489, Special Topics in Biology, cr and hrs to be arranged**

*Prerequisites: Two semesters of advanced courses and consent of instructor*

Special readings or course in biology.

**BIOL 491, Special Problems, cr and hrs to be arranged**

*Prerequisites: Two semesters of advanced courses and consent of instructor*

An introduction to methods of research. Problems are chosen from the fields of biology and may be small independent investigations or part of a research program being directed by the advisor.

**BIOL 493, Directed Study in Environmental Biology, cr and hrs to be arranged**

*Prerequisites: Senior student majoring in Biology—Environmental Science Option, and consent of instructor*

A student-designed study of local problems and processes occurring during interaction between biological systems and their physico-chemical environment including literature review, field and laboratory research, and result presentation by written report and seminar.

**BIOL 500, Directed Research, cr to be arranged**

This course may not be used to fulfill graduate degree requirements. Research under the guidance of a faculty member.

**BIOL 501, Graduate Seminar, 1 cr, 1 cl hr**

*Prerequisite: Graduate-level standing or consent of instructor*

Special topics in biology. Readings, student presentations, and discussions will focus on a single topic within biology, with a different topic to be selected by the Biology faculty each semester.

**BIOL 511, Advanced Genetics, 3 cr, 3 cl hrs**

*Prerequisites: BIOL 311 and 333*

A study of current topics in genetics, including the molecular basis of gene structure and action in eukaryotes and prokaryotes. Shares lecture with BIOL 411, but is graded separately and additional graduate-level work is required.

**BIOL 531, Virology, 3 cr, 3 cl hrs**

*Prerequisite: BIOL 331*

*Corequisite: BIOL 311*

Molecular biology of viral infection, replication, and pathogenesis. Animal viruses emphasized. Shares lecture with BIOL 431, but is graded separately and additional graduate-level work is required.

**BIOL 535 Bioinformatics 3 cr, 3 cl hrs**

*Prerequisite: BIOL 311 or consent of instructor*

Computer analysis of biological sequence data used to perform in silico experiments. Students will design and perform experiments using public domain software and databases. Shares lecture with BIOL 435, but is graded separately and additional graduate-level work is required.

**BIOL 537, Infection and Immunity, 3 cr, 3 cl hrs**

*Prerequisite: BIOL 341*

Study of human infectious disease and the immune system. Pathogenic microorganisms and mechanisms of pathogenicity. Innate and acquired immune responses. Immunochemistry, cellular immunity, and immunopathology. Shares lecture with BIOL 437, but is graded separately and additional graduate-level work is required.

**BIOL 542, Advanced Microbiology, 3 cr, 3 cl hrs**

*Prerequisite: BIOL 341 or consent of instructor*

A study of the current topics in structure, function, genetics, and biochemistry of microorganisms, with emphasis on recent scientific literature. Medical and environmental topics will be covered.

**BIOL 544, Evolutionary Biology, 3 cr, 3 cl hrs**

*Prerequisite: BIOL 311, BIOL 344; graduate standing or consent of instructor.*

The mechanisms and implications of biological evolution. Topics include population genetics, adaptation and natural selection, fossil evidence, and evolutionary medicine. Shares lecture with BIOL 444, but is graded separately and additional graduate-level work is required.

**BIOL 549 Astrobiology, 3 cr, 3 cl hours**

*Prerequisites: Graduate status or consent of instructor. Offered on demand.*

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Shares lecture with BIOL 449, but is graded separately and additional graduate-level work is required. (Same as GEOL 549.)

**BIOL 560, Population and Community Ecology, 3 cr, 3 cl hrs**

*Prerequisites: BIOL 344; graduate standing or consent of instructor*

Advanced study of demography, population dynamics, species interactions, and community structure.

**BIOL 564, Molecular Ecology, 3 cr, 3 cl hrs**

*Prerequisite: BIOL 333 or consent of instructor*

Molecular ecology is the application of molecular genetics to ecological and environmental issues. The current literature in the field is reviewed. Participants choose a topic to research and develop a research proposal as the final project. Graduate students present a public seminar.

**BIOL 581, Directed Study, cr to be arranged**

Study under the guidance of a member of the biology staff. In general, subject matter will supplement that available in other graduate offerings in biology.

**BIOL 586 Cytogenetics, 3 cr, 3 cl hrs**

*Prerequisites: BIOL 311 and 333*

Principles of chromosome structure and function with an emphasis on medical diagnostics. Course includes a field trip to a cytogenetics diagnostic laboratory. Shares lecture with BIOL 486, but is graded separately and additional graduate-level work is required.

**BIOL 587, 587L Advanced Virology, 3–4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite: BIOL 431 or 531*

An in-depth study of one or two viruses, viral vectors for gene therapy; and herpes or hemorrhagic fever viruses. The laboratory section of the course will include viral propagation in tissue culture and methods to investigate the molecular biology of viral infection. Shares lecture and lab with BIOL 487, 487 L, but is graded separately and additional graduate-level work is required.

**BIOL 588, Biology of Cancer, 3 cr, 3 cl hrs**

*Prerequisites: BIOL 331 and 333*

Principles and molecular mechanisms of carcinogenesis. Involves elements of cell biology, genetics, molecular biology, immunology, biochemistry, virology, pharmacology, physiology, developmental biology, and pathology. Graduate students are required to write a grant proposal.

**BIOL 591, Thesis (master's program), cr to be arranged****Faculty Research Interests**

Bhasker—Medical Professions

Boston - Geomicrobiology

Gonzales—Veterinary Professions

Kieft—Microbiology, Environmental Biology

Kirk—Biology of Aging, Evolutionary Ecology

Markwell—Medical Professions

Reiss—Molecular Genetics, Evolution

Rogelj—Cell Biology, Pathogen Detection, Drug Discovery

Tartis—Chemical Engineering of Drug Delivery Systems

Dean Wilkinson—Veterinary Professions

Pepita Wilkinson—Veterinary Professions

Smooke—Animal Physiology, Endocrinology



# Chemistry

*Professor Heagy (Associate Chair)*

*Associate Professors Pullin (Chair of the Department),*

*Wingenter*

*Assistant Professors Altig (Lab Director), Pias*

*Adjunct Faculty: Kalugin, Elliott, Clewitt*

*Research Faculty Magedov*

*Teaching Faculty Kombarakkaran, Hahn, Frolova*

*Emeritus Professors: Brandvold, Brower, Hatch, C. Popp*

**Degrees Offered: B.S. in Chemistry, Chemistry with Environmental Option, Chemistry with Biochemistry Option, and Chemistry with Pre-Medicine or Pre-Veterinary Program; M.S. in Chemistry and M.S. in Chemistry with Biochemistry Option; Ph.D. in Chemistry and Geochemistry (see Earth and Environmental Science)**

The fundamental mission of the Department of Chemistry is to provide students with: (1) the skills necessary for critical and analytical thinking; (2) an understanding of the basic concepts of chemistry; (3) an appreciation of chemistry and its central place among the sciences; (4) a feeling for the joys and frustrations of original research; and (5) the ability to communicate observations and discoveries.

The Department of Chemistry offers a balance between pure and applied chemistry and presents science as part of a liberal education. The faculty is qualified in the major divisions of chemistry—inorganic, organic, analytical, physical, and biochemical. The undergraduate program emphasizes development of a strong foundation in the fundamental areas of chemistry in order to prepare students for the diverse career opportunities available to chemists. Laboratory facilities support research in all major areas of chemistry, as well as atmospheric, environmental, explosives, and medicinal chemistry. Interdisciplinary work is encouraged. The department maintains a full complement of modern analytical instrumentation. Most undergraduate students participate in departmental research. Career possibilities range from industrial process control through scientific research in academic and government laboratories. More than 60 percent of Tech chemistry graduates continue their education in graduate school. Many have become teachers, medical doctors, or research scientists. The student has freedom to select courses to meet individual interests and objectives, such as preparation for graduate school or industry, or simply a superior education. Graduates receive a bachelor of science degree accredited by the American Chemical Society.

## Undergraduate Program

### Bachelor of Science in Chemistry

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum*

*Requirements (page 100), the following courses are required:*

- MATH 231 (4)
- CHEM 311 (3), 311L (1), 331 (3), 331L (1), 332 (3), 332L (1), 333 (3), 333L (1), 334 (3), 334L (1), 411 (3), 411L (1), 441 (3), 443 (3), 443L (1), 493 (1), 494 (2);
- Advanced Chemistry courses: Any three chosen from CHEM 422 (3), 427 (3), 442 (3), 445 (3), 446 (3)
- Advanced Chemistry labs: Any two chosen from CHEM 422L (1), 441L (1), 442L (1), 445L (2)

This leaves a minimum of 20 credit hours of electives. The Chemistry Department promotes a diverse set of electives for a well-founded education. Recommended electives include CSE 113, MATH 254, MATH 335, ES 110, ChE 326, MATE 202, and EARTH 211. The probable sequence of electives should be discussed with the student's advisor during the freshman year.

### Sample Curriculum for the Bachelor of Science in Chemistry

This curriculum assumes a reasonably strong high school background. Where possible, CHEM 311, 333, and 334 should be completed by the end of the sophomore year. This is only a sample curriculum. Students should consult their advisor to design programs that fit their individual backgrounds and interests.

#### Semester 1

- 4 CHEM 121 & 121L (general)
- 1 CHEM 121R
- 3 ENGL 111 (college English)
- 4 MATH 131 (calculus)
- 4 BIOL 111 or EARTH 101 (general)
- 1-2 Electives
- 17-18 Total credit hours

#### Semester 2

- 4 CHEM 122 & 122L (general)
- 1 CHEM 122R
- 3 ENGL 112 (college English)
- 4 MATH 132 (calculus)
- 5 PHYS 121 & 121L (general)
- 17 Total credit hours

*Semester 3*

- 4 CHEM 311 & 311L (quantitative analysis)
  - 4 CHEM 333 & 333L (organic)
  - 4 MATH 231 (calculus)
  - 5 PHYS 122 & 122L
- 17 Total credit hours

*Semester 4*

- 4 CHEM 334 & 334L (organic)
  - 4 CSE 113 (programming)
  - 3 Humanities
  - 3 Social Science
  - 3 Electives
- 17 Total credit hours

*Semester 5*

- 4 CHEM 331 & 331L (physical)
  - 4 BIOL 102/ERTH 102 (general)
  - 3 Humanities
  - 3 Social Science
  - 3 Electives
- 17 Total credit hours

*Semester 6*

- 4 CHEM 332 & 332L (physical)
  - 3 ENGL 341 (technical writing)
  - 3 Social Science
  - 6 Electives
- 16 Total credit hours

*Semester 7*

- 4 CHEM 411 & 411L (instrumental)
  - 3 CHEM 441 (biochemistry)
  - 4 Advanced Chemistry
  - 1 CHEM 493 (senior thesis)
  - 3 Humanities/Social Science
  - 3 Electives or Advanced Chemistry
- 18 Total credit hours

*Semester 8*

- 4 CHEM 443 & 443L (inorganic)
  - 4 Advanced Chemistry
  - 2 CHEM 494 (senior thesis)
  - 6 Electives or Advanced Chemistry
- 16 Total credit hours

### **Bachelor of Science in Chemistry with Environmental Science Option**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum Requirements (page 100), requirements include the courses listed for the Bachelor of Science in Chemistry and the following courses:*

- 12 credit hours from the following: CHEM 422; BIOL 343, 344, 446, or 447; EARTH 412; Special Problems in Environmental Chemistry.

### **Bachelor of Science in Chemistry with Biochemistry Option**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum Requirements (page 100), requirements include the courses listed for the Bachelor of Science in Chemistry and the following courses:*

- CHEM 441L (1), 442 (3), 442L (1)
- Six credit hours of upper-division biology courses

### **Bachelor of Science in Chemistry with Pre Medicine or Pre-Veterinary Program**

Chemistry students may receive excellent preparation for medical or veterinary school by selecting most of their electives from the following:

- BIOL 111 and 204 (general requirements), 331, 341, 351, 355, 411, and 453.
- Upper-division chemistry course requirements should be filled by CHEM 441 and 442.

Students interested in such a program should consult their advisor and the pre-medical advisor.

### **Minor in Chemistry**

*Minimum credit hours required—19*

*The following courses are required:*

- Chemistry 311 (3) & 311L (1)
- Three of the following courses with the associated labs:
  - Chemistry 331 (3) & 331L (1)
  - Chemistry 332 (3) & 332L (1)
  - Chemistry 333 (3) & 333L (1)
  - Chemistry 334 (3) & 334L (1)
- One chemistry course numbered 400 or above (3-4)

### **Graduate Program**

Students entering any chemistry graduate program must take entrance examinations within a week after their first registration. If deficiencies are determined, appropriate undergraduate coursework will be suggested. The student's course of study must be approved by the student's advisory committee and must fulfill the general degree requirements for their respective advanced degree.

### **Master of Science in Chemistry**

M.S. students must meet the general degree requirements for the Master of Science degree at New Mexico Tech. In addition, a minimum of 12 credit hours of 500-level chemistry course is required. CHEM 529 and 530 do not count towards this requirement. Additionally

students must take 6 credit hours at the 300, 400, or 500-level and above from other departments. The student should consult with their committee and advisor when developing a course plan.

M.S. students are required to take CHEM 529 and 530 for credit for at least two semester and to register as auditor for other semesters.

### Master of Science in Chemistry with Biochemistry Option

Students earning a Master of Science degree in chemistry can receive a Biochemistry Option through cooperation with the Biology Department. The requirements for the biochemistry option are the same as those for a Master of Science in Chemistry, except that:

- Six (6) credit hours of the 12 credit hours minimum of 500-level chemistry classes must be from CHEM 521 and 547.
- A maximum of three (3) credit hours of CHEM 581 or BIOL 581 (directed study) may be used toward the degree.
- A minimum of six (6) credit hours of upper-division/500-level courses in biology, selected from the following, must be completed: BIOL 331, 333, 351, 352, 356, 488, 501, 552, 588.
- Students interested in such a program should consult their advisor and the pre-medical advisor.

### Doctor of Philosophy in Chemistry

Students of exceptional ability may pursue a program leading to the doctoral degree. The prospective doctoral candidate will develop a broad background in chemistry and related fields and prove his ability to do independent research. An early assessment of the student's ability is achieved in the candidacy examination to be completed by the end of the second year. Research fields appropriate for the Ph.D. candidate are all major areas of chemistry. Current specializations include analytical, climate change environmental, medicinal, pharmaceutical, theoretical, and green chemistry, as well as spectroscopic techniques and nanomaterials. Interdisciplinary programs with other science departments, such as physics, biology, or earth and environmental science can be pursued. Ph.D. students must meet the general degree requirements for the Doctor of Philosophy degree at New Mexico Tech.

### No Prior Master's Degree

A minimum of 50 credit hours is required. These hours are distributed as follows:

500-level chemistry courses 21 cr hrs minimum

CHEM 529, 530 (Seminar)	2 cr hrs
CHEM 554, 555 (Proposal Writing)	3 cr hrs
CHEM 595 (Dissertation)	24 cr hrs

Students may substitute up to 6 credit hours of courses at the 300-level and above from other departments. Additional 500-level courses from other departments may be used in place of 500-level chemistry courses, upon approval of student's advisory committee.

### Prior Master's Degree in Chemistry

A minimum of 38 credit hours is required. These hours are distributed as follows:

500-level chemistry courses minimum	9 cr hrs
CHEM 529, 530 (Seminar)	2 cr hrs
CHEM 554, 555 (Proposal Writing)	3 cr hrs
CHEM 595 (Dissertation)	24 cr hrs

Students may substitute up to 3 credit hours of courses at the 300-level and above from other departments. Additional 500-level courses from other departments may be used in place of 500-level chemistry courses, upon approval of student's advisory committee.

## Chemistry Courses:

### CHEM 109, Introduction to Chemistry, 3 cr, 2 cl hrs, 4 lab hrs

*Prerequisite: MATH 101*

An overview of the fundamental concepts in chemistry. Topics will include a discussion of the classification of matter, the fundamental laws of chemical combination, the atomic theory and chemical bonding. The stoichiometry of chemical reactions will be presented. Several types of chemical reactions will be discussed, including precipitation reactions, oxidation-reduction reactions and acid-base reactions. Topics in organic and biochemistry will also be considered. Lectures will include numerous examples and demonstrations of chemical principles. Extensive laboratory exercises will further illustrate concepts discussed during the lecture hours.

### CHEM 121, General Chemistry I, 3 cr, 3 cl hrs

*Prerequisite: MATH 103 (or equivalent, passed with grade C or better)*

*Corequisite: CHEM 121L*

*Offered fall and spring semesters*

Basic descriptive and quantitative principles of chemistry associated with the concepts of the mole, concentration, heat, atomic and molecular structure, periodicity, bonding, physical states, stoichiometry, and reactions. [NMCCNS CHEM 1214: General Education Area III]

**CHEM 121L, General Chemistry Laboratory I, 1 cr, 3 lab hrs**

*Corequisite: CHEM 121; a lab usage fee is charged*

*Offered fall and spring semesters*

Laboratory experiments and techniques emphasizing principles from CHEM 121. [NMCCNS CHEM 1214: General Education Area III]

**CHEM 121R, General Chemistry I Recitation, 1 cr, 1 cl hr**

*Corequisite: CHEM 121; Graded S/U*

*Offered fall and spring semesters*

Recommended for all students enrolled in Chem 121. Reinforce concepts studied in class. Practice problem solving skills in chemistry.

**CHEM 122, General Chemistry II, 3 cr, 3 cl hrs**

*Prerequisites: CHEM 121 and 121L*

*Corequisites: CHEM 122L and MATH 131 or equivalent*

*Offered fall and spring semesters*

Continuation of CHEM 121. Emphasizes basic kinetics, thermodynamics, equilibria, electrochemistry, reactions of inorganic compounds, and an introduction to organic chemistry. [NMCCNS CHEM 1224: General Education Area III]

**CHEM 122L, General Chemistry Laboratory II, 1 cr, 3 lab hrs**

*Corequisite: CHEM 122; a lab usage fee is charged*

*Offered fall and spring semesters*

Laboratory experiments and techniques emphasizing principles from CHEM 122. [NMCCNS CHEM 1224: General Education Area III]

**CHEM 122R, General Chemistry II Recitation, 1 cr, 1 cl hr**

*Corequisite: CHEM 122; Graded S/U*

*Offered fall and spring semesters*

Recommended for all students enrolled in Chem 122. Reinforce concepts studied in class. Practice problem solving skills in chemistry.

**CHEM 151, General Chemistry I, 3 cr, 3 cl hrs**

*Prerequisite: MATH 103 (or equivalent, passed with grade C or better)*

*Corequisite: CHEM 151L*

*Recommended corequisite: CHEM 151R, MATH 131*

*Offered fall semester*

Topic coverage parallels CHEM 121 with emphasis on critical thinking and active, collaborative and problem-based learning. Small class size, limited enrollment. Admission to this course involves a selection process. Contact the Chemistry Department (chem@nmt.edu) for details. Recommended for Chemistry majors; other majors are welcome. (The CHEM 151/152 sequence is equivalent to CHEM 121/122.)

**CHEM 151L, General Chemistry I, 1 cr, 3 lab hrs**

*Corequisite: CHEM 151, a lab usage fee is charged*

*Offered fall semester*

Laboratory experiments emphasizing principles from CHEM 151.

**CHEM 151R, General Chemistry I Recitation, 1 cr, 1 cl hr**

*Corequisite: CHEM 151*

*Offered fall semesters; Graded S/U*

Practice problem solving skills in chemistry.

Recommended for all students enrolled in Chem 151.

**CHEM 152, General Chemistry II, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 151 and 151L*

*Corequisites: CHEM 152 L and MATH 131 or equivalent*

*Recommended corequisite: CHEM 152 R*

*Offered spring semester*

Continuation of CHEM 151. Topic coverage parallels CHEM 122 with emphasis on critical thinking and active, collaborative and problem-based learning. Small class size, limited enrollment. Admission to this course involves a selection process. Contact the Chemistry Department (chem@nmt.edu) for details. Recommended for Chemistry majors; other majors are welcome. The CHEM 151/152 sequence is equivalent to CHEM 121/122.)

**CHEM 152L, General Chemistry Laboratory II, 1 cr, 3 lab hrs**

*Corequisite: CHEM 152, a lab usage fee is charged*

*Offered spring semester*

Laboratory experiments emphasizing principles from CHEM 152.

**CHEM 152R, General Chemistry II Recitation, 1 cr, 1 cl hr**

*Corequisite: CHEM 152*

*Offered fall semester; Graded S/U*

Practice problem solving skills in chemistry.

Recommended for all students enrolled in Chem 152.

**CHEM 311, Quantitative Analysis, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 122 passed with grade C- or better*

*Offered fall semester; offered spring semester if sufficient demand*

Fundamental theory and techniques in traditional chemical analysis. Emphasizes sampling and separation methods, measurement, statistics, volumetric and gravimetric analysis, equilibrium and pH studies, basic electrochemical techniques, and introduction to instrumentation.

**CHEM 311L, Quantitative Analysis Laboratory, 1 cr, 3 lab hrs**

*Corequisite: CHEM 311; a lab usage fee is charged.*

*Offered fall semester; offered spring semester if sufficient demand*

Laboratory experiments and techniques emphasizing the principles from CHEM 311.

**CHEM 331, Physical Chemistry I, 3 cr, 3 cl hrs**

*Prerequisites: CHEM 122 passed with grade C- or better; MATH 132; PHYS 122*

*Offered fall semester; offered spring semester if sufficient demand*

Study of the fundamental principles of thermodynamics applied to equilibria, physical states, electromotive force, solution phenomena, and reaction kinetics. Study of physical state properties.

**CHEM 331L, Physical Chemistry Laboratory I, 1 cr, 3 lab hrs**

*Corequisite: CHEM 331; a lab usage fee is charged*

*Offered fall semester; offered spring semester if sufficient demand*

Laboratory experiments and techniques emphasizing principles from CHEM 331.

**CHEM 332, Physical Chemistry II, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 331*

*Offered spring semester*

Atomic and molecular quantum theory, group theory, spectroscopy, and statistical mechanics.

**CHEM 332L, Physical Chemistry Laboratory II, 1 cr, 3 lab hrs**

*Corequisite: CHEM 332; a lab usage fee is charged*

*Offered spring semester*

Laboratory experiments and techniques emphasizing principles from CHEM 332.

**CHEM 333, Organic Chemistry I, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 122 passed with grade C- or better*

*Offered fall semester; offered spring semester if sufficient demand*

Nomenclature, properties, structure, reactions, and synthesis of carbon compounds.

**CHEM 333L, Organic Chemistry Laboratory I, 1 cr, 3 lab hrs**

*Corequisite: CHEM 333; a lab usage fee is charged*

*Offered fall semester; offered spring semester if sufficient demand*

**CHEM 334, Organic Chemistry II, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 333*

*Offered spring semester*

Continuation of CHEM 333.

**CHEM 334L, Organic Chemistry Laboratory II, 1 cr, 3 lab hrs**

*Prerequisite: CHEM 333L*

*Corequisite: CHEM 334; a lab usage fee is charged*

*Offered spring semester*

**CHEM 411, Advanced Instrumental Methods, 3 cr, 3 cl hrs**

*Prerequisites: CHEM 311 and 332 or consent of instructor*

*Corequisite: CHEM 411L*

*Offered fall semester*

Instrumental design, operation and advanced techniques of chemical analysis. Emphasizes gas chromatography; atomic absorption; ultraviolet, visible, and infrared spectroscopy; specific ion electrodes; nuclear magnetic resonance spectroscopy; mass spectroscopy, etc.

**CHEM 411L, Advanced Instrumental Laboratory, 1 cr, 3 lab hrs**

*Corequisite: CHEM 411; a lab usage fee is charged*

*Offered fall semester*

Laboratory experiments and instrumental techniques emphasizing principles from CHEM 411.

**CHEM 412, Advanced Topics in Analytical Chemistry, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 311, 411, or consent of instructor*

*Offered on sufficient demand*

Study of special topics not otherwise treated in analytical chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 512.)

**CHEM 413, Separation Science, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 331, 411, or consent of instructor*

*Offered on sufficient demand*

Theory and practice of separation science. Topics include selective mass transport, extraction, chromatography, and electrophoresis. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 513.)

**CHEM 422, Environmental Chemistry, 3 cr, 3 cl hrs**

*Prerequisites: Any two of the following: CHEM 311, 331, or 333*

*Offered on sufficient demand*

Application of chemical principles to the study of the environment. Includes natural processes and pollution problems related to water, air, and soil. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 522 and EARTH 422.)

**CHEM 422L, Environmental Chemistry Laboratory, 1 cr, 3 lab hrs**

*Corequisite: CHEM 422/522; a lab usage fee is charged*  
*Offered on sufficient demand*

Laboratory experiments related to the principles in CHEM 422/522. The graduate and undergraduate versions of the course will differ in the assignments and exams. (Same as CHEM 522L.)

**CHEM 423, Applied Spectroscopy, 3 cr, 3 cl hrs**

Discussions of mass spectrometry, fluorescence, Nuclear Magnetic Resonance (NMR), X-ray (XPS, X-ray diffraction, solid state spectroscopy), Infrared (IR), Ultraviolet/Visible spectroscopic methods and techniques, as applied to chemical and biological problems, including structure elucidation, medical diagnostics, molecular sensors. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 523.)

**CHEM 425, Molecular Quantum Mechanics, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 331, 332, or consent of instructor*  
*Offered on sufficient demand*

Molecular structure; theories of the chemical bond; perturbation and variation methods; electronic and magnetic properties of molecules. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 525.)

**CHEM 426, Chemical Spectroscopy, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 331, 332, or consent of instructor*  
*Offered on sufficient demand*

Principles and applications of electronic, molecular, and spin spectroscopies, laser spectroscopy; transitions; elements of group theory; quantitative correlations and analytical chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 526.)

**CHEM 427, Molecular Reaction Dynamics, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 331, 332, or consent of instructor*  
*Offered on sufficient demand*

Techniques in studies of chemical reaction rates. Topics commonly include: rate laws, collision theory, mechanistic studies, transition state theory, fast reactions, chemical oscillations, transport theory, and transport coefficients. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 527.)

**CHEM 428, Advanced Topics in Physical Chemistry**

Study of special topics not otherwise covered in physical chemistry. (Same as CHEM 528.)

**CHEM 431, Chemistry of Aquatic Systems, 3 cr, 3 cl hrs**

The thermodynamics and aqueous chemistry of natural waters, with emphasis on groundwater. Chemical equilibrium concepts, surface chemistry, redox reactions, and biochemistry. The interaction of water with the atmosphere and geologic materials. Basic concepts applied to problems of groundwater quality evolution, water use, and groundwater contamination. (Same as CHEM 531.)

**CHEM 432, Atmospheric Chemistry, 3 cr, 3 cl hrs**

Chemistry of the atmosphere. Important chemical reactions and their effects on surface and ground water. Effects of anthropogenic inputs on the atmosphere, climate change. Distribution of chemical species in the atmosphere, etc. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 532.)

**CHEM 433, Global Biogeochemical Cycles, 3 cr, 3 cl hrs**

Human activity is increasing the rate of addition of materials to the environment, resulting in changes to the earth's climate. The transformation and movement of natural and anthropogenic sources of chemical substances between reservoirs in a global context. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 533.)

**CHEM 441, Biochemistry I, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 331 and 334; or consent of instructor*  
*Corequisite: CHEM 441L*  
*Offered fall semester*

Overview of basic biochemistry. Emphasizes structure, nomenclature, and reactions of biologically active compounds such as carbohydrates, lipids, proteins, nucleic acids, and enzymes. Introduction to metabolic pathways.

**CHEM 441L, Biochemistry Laboratory I, 1 cr, 3 lab hrs**

*Corequisite: CHEM 441; a lab usage fee is charged*  
*Offered fall semester*

Experiments related to CHEM 441.

**CHEM 442, Biochemistry II, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 441*  
*Corequisite: CHEM 442L*  
*Offered spring semester*

Continuation of CHEM 441. Emphasizes vertebrate biochemistry and the study of vitamins, hormones, biochemical genetics, and nutrition. Introduction to photosynthesis.

**CHEM 442L, Biochemistry Laboratory II, 1 cr, 3 lab hrs**

*Corequisite: CHEM 442; a lab usage fee is charged*

*Offered spring semester*

Topics related to CHEM 442. Emphasis on bioanalytical techniques.

**CHEM 443, Intermediate Inorganic Chemistry, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 332*

*Corequisite: CHEM 443L*

*Offered spring semester*

Atomic and molecular structure with relationships based on the periodic system; bonding theories; elements of group theory; chemistry in nonaqueous solvents; chemistry of the elements; coordination chemistry; ligand field theory.

**CHEM 443L, Intermediate Inorganic Chemistry Laboratory, 1 cr, 3 lab hrs**

*Corequisite: CHEM 443; a lab usage fee is charged*

*Offered spring semester*

**CHEM 444, Advanced Topics in Organic Chemistry**

*Prerequisite: CHEM 333, 334, or consent of instructor*

*Offered on sufficient demand*

Study of special topics not otherwise covered in organic chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 544.)

**CHEM 445, Intermediate Organic Chemistry, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 334*

*Corequisite: CHEM 445L*

*Offered fall semester, odd years, or on sufficient demand*

The determination of the structure of organic compounds by chemical and physical means.

**CHEM 445L, Intermediate Organic Chemistry Laboratory, 2 cr, 6 lab hrs**

*Corequisite: CHEM 445; a lab usage fee is charged*

*Offered spring semester, odd years, or on sufficient demand*

**CHEM 446, Polymer Chemistry, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 332, 334 or consent of instructor*

*Offered on sufficient demand*

Study of the preparation, properties, and uses of macromolecules. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 546.)

**CHEM 447, Medicinal Chemistry, 3 cr, 3 cl hrs**

Molecular-level mechanisms of drug action and rational drug design. Material is drawn from the recent primary literature. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 547.)

**CHEM 449, Organometallic Chemistry, 3 cr, 3 cl hrs**

Organometallic chemistry of the main group and transition elements. Ligand classification and molecular orbital description of bonding in organometallic complexes. Structure, bonding, synthesis, and properties of transition metal compounds and their derivatives. Organometallic complexes as catalysts. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 549.)

**CHEM 450, Physical Organic Chemistry, 3 cr, 3 cl hrs**

Physical aspects of organic chemistry. Emphasizes reaction mechanisms, reaction kinetics, and electronic theories. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 550.)

**CHEM 491, Special Problems, 1–3 cr****CHEM 493, Senior Research and Thesis, 1 cr**

*Offered fall semester*

Problem-oriented research under the direction of a faculty member. Research topics must be approved and started so as to allow two semesters for completion. Projects will consist of and be graded on three criteria: the research work itself, a write-up in thesis form, and two oral presentations of the project.

**CHEM 494, Senior Research and Thesis, 2 cr**

*Prerequisite: CHEM 493*

*Offered spring semester*

Continuation of research begun in CHEM 493.

*All courses numbered 500 and above require the consent of the instructor.*

**CHEM 500, Directed Research**

*This course may not be used to fulfill graduate degree requirements.*

**CHEM 501 Applied Molecular Quantum Mechanics, 3 cr, 3 cl hrs**

*Offered fall semester*

*Prerequisites: CHEM 332, 334, and 443 or equivalent*

Review of bonding, structure and symmetry.

Application of molecular theory to contemporary problems in organic chemistry (e.g. EHMO, frontier orbital theory), inorganic chemistry (e.g. ligand field theory, Jahn-Teller effect) and analytical chemistry (e.g. photo physicochemical processes).

**CHEM 512, Advanced Topics in Analytical Chemistry, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 311, 411, or consent of instructor*

*Offered on sufficient demand*

Study of special topics not otherwise treated in analytical chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 412.)

**CHEM 513, Separation Science, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 331, 411, or consent of instructor*

*Offered on sufficient demand*

Theory and practice of separation science. Topics include selective mass transport, extraction, chromatography, and electrophoresis. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 413.)

**CHEM 521, Advanced Topics in Biochemistry, 3 cr, 3 cl hrs**

Topics may include biomolecules and cancer, drug action, cell culture, cytotoxicity and cytostaticity, clinical trials.

**CHEM 522, Environmental Chemistry, 3 cr, 3 cl hrs**

*Prerequisites: Any two of the following: CHEM 311, 331, or 333*

*Offered on sufficient demand*

Application of chemical principles to the study of the environment. Includes natural processes and pollution problems related to water, air, and soil. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 422.)

**CHEM 522L, Environmental Chemistry Laboratory, 1 cr, 3 lab hrs**

*Corequisite: CHEM 422/522; a lab usage fee is charged*

*Offered on sufficient demand*

Laboratory experiments related to the principles in CHEM 422/522. The graduate and undergraduate versions of the course will differ in the assignments and exams. (Same as CHEM 422L.)

**CHEM 523, Applied Spectroscopy, 3 cr, 3 cl hrs**

Discussions of mass spectrometry, fluorescence, Nuclear Magnetic Resonance (NMR), X-ray (XPS, X-ray diffraction, solid state spectroscopy), Infrared (IR), Ultraviolet/Visible spectroscopic methods and techniques, as applied to chemical and biological problems, including structure elucidation, medical diagnostics, molecular sensors. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 423.)

**CHEM 524 Statistical Thermodynamics, 3 cr, 3 cl hrs**

*Offered alternate years*

Entropy, randomness, the Boltzmann distribution, and the chemical potential. Translational, rotational, vibrational, and electronic contributions to the partition function. Calculation of mean energies, heat capacities, and equilibrium constants. Stability. The influence of wave function symmetry: Bose-Einstein and Fermi-Dirac statistics. The quantum statistical operator. Coherence and the Pauli principle. (Same as Phys 508)

**CHEM 525, Molecular Quantum Mechanics, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 331, 332, or consent of instructor*

*Offered on sufficient demand*

Molecular structure; theories of the chemical bond; perturbation and variation methods; electronic and magnetic properties of molecules. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 425.)

**CHEM 526, Chemical Spectroscopy, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 331, 332, or consent of instructor*

*Offered on sufficient demand*

Principles and applications of electronic, molecular, and spin spectroscopies, laser spectroscopy; transitions; elements of group theory; quantitative correlations and analytical chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 426.)

**CHEM 527, Molecular Reaction Dynamics, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 331, 332, or consent of instructor*

*Offered on sufficient demand*

Techniques in studies of chemical reaction rates. Topics commonly include: rate laws, collision theory, mechanistic studies, transition state theory, fast reactions, chemical oscillations, transport theory, and transport coefficients. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 427.)



**CHEM 528, Advanced Topics in Physical Chemistry**

Study of special topics not otherwise covered in physical chemistry. (Same as CHEM 428.)

**CHEM 529 (Fall), 530 (Spring), Graduate Seminar, 1 cr each semester****CHEM 531, Chemistry of Aquatic Systems, 3 cr, 3 cl hrs**

The thermodynamics and aqueous chemistry of natural waters, with emphasis on groundwater. Chemical equilibrium concepts, surface chemistry, redox reactions, and biochemistry. The interaction of water with the atmosphere and geologic materials. Basic concepts applied to problems of groundwater quality evolution, water use, and groundwater contamination. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 431, GEOC 507 and HYD 507)

**CHEM 532, Atmospheric Chemistry, 3 cr, 3 cl hrs**

Chemistry of the atmosphere. Important chemical reactions and their effects on surface and ground water. Effects of anthropogenic inputs on the atmosphere, climate change. Distribution of chemical species in the atmosphere, etc. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 432.)

**CHEM 533, Global Biogeochemical Cycles, 3 cr, 3 cl hrs**

Human activity is increasing the rate of addition of materials to the environment, resulting in changes to the earth's climate. The transformation and movement of natural and anthropogenic sources of chemical substances between reservoirs in a global context. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 433.)

**CHEM 540, The Chemistry of Energetic Materials, 3 cr, 3 cl hrs**

The chemistry of propellants, pyrotechnics, and explosives. Material to be covered will include history, oxidation/reduction reactivity, kinetics of decomposition, analytical characterization techniques, performance evaluation, hazards analysis, safety testing, and structure property relationships.

**CHEM 542, Organometallic Chemistry, 3 cr, 3 cl hrs**

Organometallic chemistry of the main group and transition elements. Ligand classification and molecular orbital description of bonding in organometallic complexes. Structure, bonding, synthesis, and properties of transition metal compounds and their derivatives. Organometallic complexes as catalysts.

**CHEM 543, Advanced Topics in Inorganic Chemistry, 3 cr, 3 cl hrs**

Study of special topics otherwise not covered in inorganic chemistry.

**CHEM 544, Advanced Topics in Organic Chemistry**

*Prerequisite: CHEM 333, 334, or consent of instructor*  
*Offered on sufficient demand*

Study of special topics not otherwise covered in organic chemistry. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 444.)

**CHEM 545, Advanced Organic Synthesis, 3 cr, 3 cl hrs**

Principles and practices of organic synthesis.

**CHEM 546, Polymer Chemistry, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 332, 334 or consent of instructor*  
*Offered on sufficient demand*

Study of the preparation, properties, and uses of macromolecules. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 446.)

**CHEM 547, Medicinal Chemistry, 3 cr, 3 cl hrs**

Molecular-level mechanisms of drug action and rational drug design. Material is drawn from the recent primary literature. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 447.)

**CHEM 548, Experimental NMR Spectroscopy**

*A lab usage fee is charged*

Introduction to NMR instrumentation, data-acquisition, and processing.

**CHEM 549, Organometallic Chemistry, 3 cr, 3 cl hrs**

Organometallic chemistry of the main group and transition elements. Ligand classification and molecular orbital description of bonding in organometallic complexes. Structure, bonding, synthesis, and properties of transition metal compounds and their derivatives. Organometallic complexes as catalysts. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 449.)

**CHEM 550, Physical Organic Chemistry, 3 cr, 3 cl hrs**

Physical aspects of organic chemistry. Emphasizes reaction mechanisms, reaction kinetics, and electronic theories. The graduate and undergraduate versions of the course will differ in the assignments and exams, while sharing the same lectures. (Same as CHEM 450.)

**CHEM 554/555, Research Proposal Writing, 3 cr, 3 cl hrs (1 cr 1<sup>st</sup> semester, 2 cr 2<sup>nd</sup> semester)**

Students will choose a research topic, survey related literature and write an original research proposal in the first semester. In the second semester, the student will present a public seminar on the written proposal. Following the seminar, the student will defend the proposal to his or her dissertation or thesis committee. Both CHEM 554/555 will be offered concurrently in Fall and Spring semesters.

**CHEM 581, Directed Study, cr to be arranged**

Study under the guidance of a member of the faculty. A topic and schedule of meetings is arranged between instructor and student early in the semester.

**CHEM 591, Thesis (master's program), cr to be arranged****CHEM 595, Dissertation (doctoral degree program), cr to be arranged**

Pre-Requisites: Successful completion of PhD Candidacy Exam and Academic Advisor recommendation for Candidacy

**Faculty Research Interests**

Altig—Computational Chemistry  
 Heagy—Organic Chemistry, Organic Synthesis, Physical Organic Chemistry  
 Pias—Computational Chemistry and Biochemistry  
 Pullin—Environmental and Analytical Chemistry, Geochemistry  
 Wingenter—Atmospheric and Ocean Chemistry, Climate Change  
 Magedov—Organic Chemistry, Medicinal Chemistry

**Adjunct Faculty Research Interests**

Kalugin—Nanoscience, Optical and Electron Transport, Semiconductors, Optical and Infrared Spectroscopy  
 Elliott—Marine Biogeochemistry in Earth System Models  
 Clewitt—Nuclear Magnetic Resonance

**Emeritus Faculty Research Interests**

Brandvold—Biophysical Chemistry, Enzyme Mechanisms, Environmental Chemistry, Atmospheric Chemistry  
 Brower—Physical Organic Chemistry, Explosives Chemistry  
 Hatch—Organic Chemistry, Polymer Chemistry  
 Popp—Environmental Chemistry, Geochemistry

# Communication, Liberal Arts, Social Sciences (CLASS)

*Professors Dezember, D. Dunston, Lara-Martínez*  
*Associate Professors Bonnekessen (Chair of the Department), S. Dunston, Ford, Newmark, Prusin*  
*Assistant Professor Simpson, Kramer-Simpson, Durão*  
*Instructors Griffin, Stewart-Langley*  
*Adjunct Faculty López, Price*  
*Emeritus Professors Campbell, Corey, Deming, Olsen, Wilson, Yee*

**Degree Offered:** *B.S. in Technical Communication, B.G.S., A.G.S.*

**Minors Offered:** *Hispanic Studies, History, Literature, Philosophy, Technical Communication*

The multidisciplinary Department of Communication, Liberal Arts, and Social Sciences develops students' ability to learn, reason, and communicate in diverse fields of study and areas of human experience. The CLASS Department's mission is threefold: to help students write well, think critically, and read widely; to provide an intellectual experience that increases students' awareness of human history, human cultures, and human values; and to encourage the lifelong study of human experience.

The Department provides virtually all courses in three of the five areas of the General Education Core Curriculum required by the New Mexico Higher Education Department for the comprehensive education of undergraduates enrolled in New Mexico state institutions of higher education.

These areas are:

Area 1 — Communications (College Writing and Public Speaking);

Area 4 — Social Sciences (Cultural Anthropology, Political Science, Women's and Gender Studies);

Area 5 — Humanities/Liberal Arts (Art History, Communication, Creative Writing, Hispanic History, Languages, Literature, Media Studies, Music, Philosophy, Popular Culture, Technical Communication, Visual Art).

The Department offers three degrees: an industry-endorsed Bachelor of Science in Technical Communication, a Bachelor of General Studies, an Associate of General Studies, and several minors, allowing students to enrich their studies at Tech to become successful professionals and knowledgeable members of society.

## Degrees and Curricula:

### Bachelor of Science in Technical Communication

The Technical Communication curriculum combines courses from three fields of study to prepare students for technical communication positions upon graduation:

- The TC courses introduce students to document design, graphics, and computer documentation, created online and for multimedia. The TC courses also develop students' writing, speaking, and editing abilities.
- The humanities and social science courses improve students' understanding and appreciation of history, literature, philosophy, psychology, and the arts.
- The science and technology courses provide students a background in one specific science or engineering discipline.

*Minimum credit hours required—132*

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

- Technical Communication—32 credit hours of technical communication courses including TC 100 (1), 101 (1), 151 (3), 202 (3), 211 (3), 321 (3), 411 (3), 420 (3), 421 (3), 422 (3), and six credit hours of technical communication electives. All technical communication courses must be completed with grade C or better. Students may use these TC courses to fulfill Area 5 of the General Education Core Curriculum Requirements (page 100) with the exception of TC 321, TC 421, and TC 422.
- Humanities: 12 credit hours in excess of the General Education Core Curriculum Requirements and excluding TC courses.
- MGT 330 (3)
- Foreign Language: Six credit hours of one language
- Science or Engineering: 12 credit hours in a single discipline in excess of general degree requirements
- Electives to complete 132 hours

### Sample Curriculum for the Bachelor of Science in Technical Communication

*Semester 1*

- 1 TC 101 (orientation)
- 3 ENGL 111 (college English)
- 4 MATH 131 (calculus)
- 4 CHEM 121 & 121L (general)
- 3 Foreign Language
- 15 Total credit hours

*Semester 2*

3	TC 151 (visual communication)
3	ENGL 112 (college English)
4	MATH 132 (calculus)
4	CHEM 122 & 122L (general)
<u>3</u>	Foreign Language
17	Total credit hours

*Semester 3*

3	TC 202 (elements of editing)
5	PHYS 121 & 121L (general)
4	Biology/Earth Science/Engineering with lab
3	Humanities
<u>3</u>	Social Science
18	Total credit hours

*Semester 4*

3	TC 211 (media studies)
5	PHYS 122 & 122L (general)
4	Biology/Earth Science/Engineering with lab
3	Humanities
<u>3</u>	Social Science
18	Total credit hours

*Semester 5*

1	TC 100 (community service)
3	ENGL 341 (technical writing)
6	Humanities
3	Humanities/Social Science
<u>3</u>	Science or Engineering
16	Total credit hours

*Semester 6*

3	TC 421 (professional writing workshop)
3	Technical Communication Elective
6	Humanities
3	Social Science
<u>3</u>	Science or Engineering
18	Total credit hours

*Semester 7*

3	TC 321 (internship)
3	TC 411 (persuasive writing)
3	TC 420 (senior seminar)
3	MGT 330 (management & organizational behavior)
<u>3</u>	Science or Engineering
15	Total credit hours

*Semester 8*

3	Technical Communication Elective
3	TC 422 (senior thesis)
3	Science or Engineering
<u>6</u>	Electives
15	Total credit hours

**Bachelor of General Studies***Minimum credit hours required—130*

This degree allows a student to plan a program of courses according to individual educational goals and career plans. The Bachelor of General Studies degree will be awarded after completion of 130 credit hours with a grade-point average of 2.0 or more. Other requirements for this degree include the following:

- Completion of the General Education Core Curriculum listed below.
- 42 credit hours in courses numbered 300 or above.
- Completion of the BGS Academic Career Plan with a stated Emphasis area or areas.
- Fulfillment of the Institution's residence credit requirement (30 credit hours).
- To be admitted into the program for this degree, the candidate must meet with the CLASS department chair and the BGS academic advisor, who will be assigned by the CLASS department chair, to create a BGS Academic Career Plan that will be on file with the Registrar. Any changes to the BGS Academic Career Plan must be approved by the CLASS department chair and the student's BGS academic advisor. These changes will be on file with the Registrar and must be met, along with the above-stated requirements, before the degree will be awarded.

**General Education Core Curriculum for the Bachelor of General Studies (BGS)****Area 1: Communications (9 credit hours)**

- ENGL 111 — ENGL 111 is waived for students who scored 27 or higher on the ACT English Test or 610 or higher on the SAT Critical Reading Test. These students must take ENGL 112, ENGL 242 and ENGL 341 to fulfill the 9 credit hours in this area.
- ENGL 112
- COMM 242 or ENGL 341

**Area 2: Mathematics (3 credit hours)**

- MATH 101
- MATH 103
- MATH 104
- MATH 105
- MATH 131

Area 3: Laboratory Sciences (8 credit hours with associated labs)

- BIOL 111 & Lab
- BIOL 112 & Lab
- CHEM 109
- CHEM 121 & Lab
- CHEM 122 & Lab
- PHYS 121 & Lab
- PHYS 122 & Lab
- ES 110 & Lab
- ES 111 & Lab
- CSE 113
- Engineering with lab (ChE, CE, EE, ENVE, MATE, METE, ES, MENG, ME, PETR)

Area 4: Social Sciences (6 credit hours)

- Anthropology (ANTH)
- Economics (ECON)
- Political Science (PS)
- Psychology (PSY)
- Social Sciences (SS)
- Women's and Gender Studies (WGS)

Area 5: Humanities (6 credit hours)

- English (ENGL), except 103, 111, 112, 341. If ENGL 242 is used to fulfill credits in Area 1, it cannot also count in Area 5.
- Art History (ART)
- History (HIST)
- Humanities (HUMA)
- Music (MUS) except for performance ensembles
- Technical Communication (TC) except TC 321, 420, 422
- Foreign Languages (SPAN, FREN, GERM). Other languages may be counted only if they are listed or approved by the CLASS Department.

Area 6: Additional Courses from Area 4 or Area 5 (6 credit hours)

NOTE: Students who plan to pursue a career or graduate studies that require a Bachelor of Science degree are advised to pursue another degree program at New Mexico Tech.

## Associate of General Studies

*Minimum credit hours required—65*

A two-year certificate, Associate of General Studies, may be awarded after completion of 65 credit hours of course work approved by the CLASS department chair and the student's AGS academic advisor with a grade-point average of 2.0 or above. Fulfillment of the Institution's residence requirement (30 credit hours) must also be met.

- To be admitted into the program for this degree, the candidate must meet with the CLASS department chair and the AGS academic advisor, who will be assigned by the CLASS department chair, to create a AGS Academic Career Plan that will be on file with the Registrar.
- Any changes to the AGS Academic Career Plan must be approved by the CLASS department chair and the student's AGS academic advisor. These changes will be on file with the Registrar. The certificate will be awarded only after completion of the above requirements and completion of the AGS academic Career Plan and after petition to the Vice President for Academic Affairs.
- Completion of the General Education Core Curriculum listed below.

### General Education Core Curriculum for the Associate of General Studies (AGS)

Area 1: Communications (9 credit hours)

- ENGL 111 — ENGL 111 is waived for students who scored 27 or higher on the ACT English Test or 610 or higher on the SAT Critical Reading Test. These students must take ENGL 112, ENGL 242 and ENGL 341 to fulfill the 9 credit hours in this area.
- ENGL 112
- COMM 242 or ENGL 341

Area 2: Mathematics (3 credit hours)

- MATH 101
- MATH 103
- MATH 104
- MATH 105
- MATH 131

Area 3: Laboratory Sciences (8 credit hours with associated labs)

- BIOL 111 & Lab
- BIOL 112 & Lab
- CHEM 109
- CHEM 121 & Lab
- CHEM 122 & Lab
- PHYS 121 & Lab
- PHYS 122 & Lab
- ES 110 & Lab
- ES 111 & Lab
- CSE 113
- Engineering with lab (ChE, CE, EE, ENVE, MATE, METE, ES, MENG, ME, PETR)

**Area 4: Social Sciences (6 credit hours)**

- Anthropology (ANTH)
- Economics (ECON)
- Political Science (PS)
- Psychology (PSY)
- Social Sciences (SS)
- Women's and Gender Studies (WGS)

**Area 5: Humanities (6 credit hours)**

- English (ENGL), except 103, 111, 112, 341. If ENGL 242 is used to fulfill credits in Area 1, it cannot also count in Area 5.
- Art History (ART)
- History (HIST)
- Humanities (HUMA)
- Music (MUS) except for performance ensembles
- Technical Communication (TC) except TC 321, 420, 422
- Foreign Languages (SPAN, FREN, GERM). Other languages may be counted only if they are listed or approved by the CLASS Department.

Area 6: Additional Courses from Area 4 or Area 5 (6 credit hours)

**Minors**

The CLASS Department offers several minors to explore a field of study in more detail.

**All Minors**

- *Minimum credit hours required—18*
- *Restriction: If a student takes more than one minor in the CLASS Department, only six (6) credit hours of one minor may be applied towards another minor.*
- *Additional requirements as listed under each minor.*

**Minor in Hispanic Studies**

*The following courses are required:*

- One of the following sequences (6)
  - SPAN 113 and 114, Elementary Spanish I and II
  - SPAN 113N and 114N, Spanish for Native Speakers
- An additional 12 credit hours in any topic relevant to Hispanic Studies with the consent of the minor advisor

**Minor in History**

*The following courses are required:*

- A 100-level history course sequence (6)
- Twelve (12) additional credit hours in history courses. Of these 12 credit hours, six (6) credit hours may be taken in art history or music surveys

- Students taking the history minor are strongly encouraged to take the 12 additional credit hours from as wide a variety of topics as possible.

**Minor in Literature**

*The following courses are required:*

- 18 credit hours in ENGL literature courses

**Minor in Philosophy**

*The following courses are required:*

- PHIL 231, Comparative Introduction to Western Philosophy
- Fifteen (15) additional credit hours in philosophy courses.
- With the consent of the minor advisor, of these 15 credit hours, six (6) credit hours may be taken in upper-division courses that have a substantial philosophical focus and content.

**Minor in Technical Communication**

*The following courses are required:*

- TC 151 (3)
- TC 202 (3)
- TC 211 (3)
- Nine (9) additional credit hours of TC courses

## General Education Core Curriculum Information

The courses offered through the CLASS Department fulfill four areas (Area 1, 4, 5, and 6) required for the Bachelor of Science. Additional Social Sciences are offered through the Psychology Department (PSY courses) and the Management Department (ECON courses).

<b>Area 1 - Communications</b>	ENGL 103, 111, 112, 341
<b>Area 4 - Social Sciences</b>	ANTH Anthropology PS Political Science SS Social Science WGS Women's and Gender Studies
<b>Area 5 - Humanities</b>	ART Art History COMM Communication ENGL English (except ENGL 103, 111, 112, 341) FREN French GERM German HIST History HUMA Humanities MUS Music (except Performance Ensembles) PHIL Philosophy SPAN Spanish TC Technical Communication (except TC 321, 420, 422)
<b>Area 6</b>	Additional Courses from Area 4 or 5

### Anthropology Courses:

*The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 100).*

#### **ANTH 101, Introduction to Cultural Anthropology, 3 cr, 3 cl hr**

An introduction to the science of cultural Anthropology, its terminology, theory practice and subject matter. Students are encouraged to engage with other cultures to find similarities and connections, not differences and separation. Studies human beings, their social and cultural institutions, beliefs, and practices around the world and next door, creating a medley of adaptations to common problems.

#### **ANTH 120, Social Thought, 3 cr, 3 cl hr**

From Machiavelli and Marx to Steinem and Foucault, this course explores some of the major historical and contemporary theoretical works and authors in selected social sciences. The focus is on the cultural framework in which these thoughts emerged and the impact they had on society. (Same as WGS 120 and SS 120)

#### **ANTH 302, Food and Culture, 3 cr, 3 cl hr**

Food is more than just nutrition; in every culture, past and present, food is central to building and maintaining economic and political systems, social relationships among family members and between friends and enemies, religious taboos, ethnic identities, and gender norms. The trade in food stuffs is at the heart of colonization and globalization; the lack of food is at the heart of labor migrations and horrors of malnutrition and starvations; and the science of food causes biogenetic engineering to choose between creating profit for some or life for many. This class examines these issues, ranging from seemingly universal meals to mass-produced hamburgers, and counting the human, animal, and environmental costs of each.

#### **ANTH 303, Race and Ethnic Relations, 3 cr, 3 cl hrs**

An overview of most "racial" and ethnic groups of Americans. Provides a theoretical framework to explore their histories and critical current issues and a space to enjoy the advantages of a multicultural philosophy. Focuses on the heterogeneous character of all ethnic groups, especially in regard to gender and class; attempts to define common issues that can only be solved in unison.

#### **ANTH 320, Anthropology of Sex and Gender, 3 cr, 3 cl hrs**

A survey of the varieties of sex and gender definitions and roles in historical and contemporary human cultures. The study of sex assignment, gender definitions and roles in their association to stratified or equitable access to economic, political, and ideological resources and monopolies. Exploration of the parallels and differences between gender, race, and class. Topics include: gendered division of labor, female and male socialization, violence against women as male entertainment and female punishment, gender universals and generalities. (Same as WGS 320.)

**ANTH 370, Nahuat Mythology & Anthropology, 3 cr, 3 cl hr**

A study of Native language, literature, and mythology of Central America. The class explores a specific native literature in its own language and discusses an "American" worldview. Topics include the concept of a fragmented self and of multiple souls, of political community and redistribution, a quintesimal (5) and vigesimal (20) system of counting, sexuality, and the foundation of a Native philosophy. (Same as SPAN 370)

**ANTH 381, Qualitative Methods, 3 cr, 3 cl hr**

An introduction to the primary methods used in long-term qualitative data gathering, such as participant observation and deep ethnography, and in short-term applied data collection, such as focus groups and life histories. A major focus is research conducted with organizations and their culture. Students will design and execute their own research projects. (Same as WGS 381 and TC 381)

**Art History Courses:**

*The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

**ART 272, Art History, 3 cr, 3 cl hrs**

Survey of art of the western hemisphere from prehistory to the 21st century. May incorporate an interdisciplinary approach. [NMCCNS ARTS 2113: General Education Area V]

**ART 372, Issues in Art History, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Issues, topics, or specific periods in the visual arts. May incorporate an interdisciplinary approach. Topics may include, among others, Visual and Other Arts; Modern Art; Art and Science; Literature inspired by Art; Modern Art, Sci Fi, and Film.

**Communication Courses:**

*The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

**COMM 242, Public Speaking, 3 cr, 3 cl hrs**

A study of the principles of speech; practice in the preparation and delivery of various types of speeches, classified according to function; practice in the basic skills of oral communication; the development of poise and self-confidence. [NMCCNS COMM 1113: General Education Area I]

**COMM 360, Advanced Public Speaking, 3 cr, 3 cl hrs**

*Prerequisites: COMM 242 or consent of instructor*

Theory and practice of ethical and professional speech communication. Researching, writing and presenting professional presentations. Designing and using effective visuals, including posters and electronic presentation aids. Conducting group presentations and discussions about ethical and cross-curriculum issues in historical, cultural and workplace context.

**COMM 560, Professional Public Speaking, 3 cr, 3 cl hrs**

*Prerequisites: Consent of instructor*

Theory and practice of ethical and professional speech communication. Research, writing and presenting professional presentations. Designing and using effective visuals, including posters and electronic presentation aids. Conducting group presentations and discussions about ethical and cross-curriculum issues in historical, cultural and workplace context. Design, schedule and present a formal research colloquium.

**English Courses:**

*The following courses (except ENGL 103, 111, 112, 341) may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

**Writing Program Courses:****ENGL 103, Pre-College English, 3 cr, 3 cl hrs**

The basics of writing: sentence types, structure, and construction; topic sentences, paragraph development and coherence; the complete essay; grammar, usage, and punctuation. Prepares students for ENGL 111. *(Does not fulfill the English portion of the General Education Core Curriculum, page 89.)*

**ENGL 111, College Writing: Exposition, 3 cr, 3 cl hrs**

The essentials of academic prose; techniques and mechanics of writing well; rhetorical strategies. [NMCCNS ENGL 1113: General Education Area I]

**ENGL 112, College Writing: Argument and Analysis, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 111 or equivalent course passed with a C or better*

A continuation of ENGL 111 with critical reading and writing; writing arguments; library research paper. [NMCCNS ENGL 1123: General Education Area I]



**ENGL 341, Technical Writing, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 111 and 112 or the equivalent passed with a grade C or better and at least junior standing*

This course emphasizes clear, accurate, and precise communication and scientific and technical information to a variety of audiences, for a variety of purposes. Students will be taught how to effectively analyze the components of writing situations and appropriately conduct research, write content in a professional, yet accessible style, incorporate visuals, organize and format documents. The course culminates with a substantial technical research report and oral presentation. In addition, students work on writing documents including memos, proposals, short reports, and instructions.

**ENGL 501, Graduate Writing Seminar, 3 cr, 3 cl hrs**

*Prerequisite: Proficiency in written and spoken English, Graduate standing or consent of instructor*

Intensive practice in academic writing for graduate students. Focuses on writing and revision. Reviews the history and development of science writing and surveys the professional environments in which scientists are expected to publish. Students should come with a draft of a substantial piece of work—such as an article, chapter, or grant proposal.

**ENGL 511, Graduate Creative Writing, 3 cr, 3 cl hrs**

*Prerequisite: Consent of instructor*

Professional-level writing in fiction, poetry, creative non-fiction or plays. Focuses on the genre of the student's choice. Students write often, revise frequently, learn and apply methods of Creative Writing instruction.

**Literature Courses:****ENGL 120, Introduction to Literature, 3 cr, 3 cl hrs**

Survey of major works of poetry, short fiction, and drama in English and in translation. [NMCCNS ENGL 1013: General Education Area V]

**ENGL 311, Creative Writing, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

The study and writing of one genre or a combination of the following genres: poetry, fiction, creative nonfiction, playwriting and screenwriting. Emphasis on reading and analyzing literature.

**ENGL 312, Short Fiction, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Concentrated study of major works of short fiction written in English and in translation.

**ENGL 321, American Literature, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

An historical survey of 17th, 18th, and 19th century writing, covering the Colonial, Enlightenment, and Romantic periods. Among the authors studied are Anne Bradstreet, Benjamin Franklin, Edgar Allan Poe, Nathaniel Hawthorne, and Emily Dickinson. [NMCCNS ENGL 2513: General Education Area V]

**ENGL 322, American Literature, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

An historical survey of 19th and 20th century writing, covering Realism and Naturalism and the Modern period. Among the authors studied are Mark Twain, Willa Cather, Robert Frost, Eugene O'Neill, Ernest Hemingway, William Faulkner, Katherine Anne Porter, and James Baldwin. [NMCCNS ENGL 2523: General Education Area V]

**ENGL 323, American Nature Writing, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Survey of American nature Writers, such as Lewis and Clark, Thoreau, Edward Abbey, and Leslie Marmon Silko, with literary and philosophical analysis of their observational, documentary, rhetorical, inter-disciplinary, and self-reflective strategies to develop students' own skills in these areas and to produce their own nature writing. (Same as PHIL 323)

**ENGL 325, World Literature, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Literature of the West from the Classics through the Renaissance. [NMCCNS ENGL 2613: General Education Area V]

**ENGL 326, World Literature, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Literature of the West from Neoclassicism to Contemporary. [NMCCNS ENGL 2623: General Education Area V]

**ENGL 331, British Literature, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

A survey of British literature from its origin through the Age of Enlightenment. Major authors studied include the Beowulf poet, Chaucer, Shakespeare, and Milton. [NMCCNS ENGL 2413: General Education Area V]

**ENGL 332, British Literature, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

A continuation of ENGL 331, this course surveys British literature of the nineteenth and twentieth centuries. Emphasis is upon the major literary movements of Romanticism and Realism. [NMCCNS ENGL 2423: General Education Area V]

**ENGL 352, Contemporary Latin American Novel, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or equivalent*

Survey of the 20th century Latin American regional novel. How contemporary writers have portrayed the Latin American continent: social-realism, surrealism, the boom, neo-baroque, magical realism, mestizaje, social-protest, negrismo, etc. Focus on reading classical works such as Arguedas, Asturias, Castellanos, Fuentes, Roa Bastos, Rulfo. (Same as Spanish 352)

**ENGL 355, Latin American Fiction & the Arts, 3 cr, 3 cl hrs**

A historical journey of a multi-cultural continent. Politics, economic disparity, military dictatorship, oppression and revolutionary resistance are studied through the lens of arts and literature. The most varied styles—social-realism, surrealism, fantasy, magical-realism, etc.—complement factual history to offer an accurate picture of a cruel social reality. (Same as SPAN 355)

**ENGL 357, Latin American Literature, 3 cr, 3 cl hrs**

A review of Latin American literary production with examples of its cultural and artistic diversity. The class examines the most important writers from Mexico, the Caribbean, Central America, the Andean region and the Southern cone, and relates their poetic legacy to the social sciences and philosophy. (Same as SPAN 357)

**ENGL 431, Literary Genres, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

The study of a particular type of literature, its origins, characteristics, subtypes, and some of its major writers and works. Possible genres are poetry, drama, short stories, science fiction, novels, and nonfiction writing. May be repeated for credit with different genres.

**ENGL 435, Major Writers, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Intensive study of the writing of a major world author or authors, such as Willa Cather, Nathaniel Hawthorne, Herman Melville, William Shakespeare, Mark Twain. May be repeated for credit with different writers.

**ENGL 436, Issues and Themes in Literature, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Concentrated study of issues, ideas, and themes as they affect or are embodied in literature. Possible topics include, among others, Environment, Gender, Ethnicity, Travel, and Place. May be repeated for credit with different issues.

**ENGL 440, Philosophical Novels, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 and one PHIL course*

Exploration of the use and articulation of philosophy in novels. (Same as Phil 440)

**ENGL 491, Directed Studies, hrs and cr to be arranged**

*Prerequisite: ENGL 112 or consent of instructor*

**French Courses:**

*The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

**FREN 113, Elementary French I, 3 cr, 3 cl hrs**

Elements of French, with particular emphasis on pronunciation, through conversational materials. Stress is placed on the fundamentals of French grammar, spelling, and written expression. Supplementary readings reinforce comprehension and give additional sources for spontaneous oral expression in class discussion. [NMCCNS FREN 1113: General Education Area V]

**FREN 114, Elementary French II, 3 cr, 3 cl hrs**

*Prerequisite: FREN 113 or equivalent*

Continuation of FREN 113. [NMCCNS FREN 1123: General Education Area V]

**FREN 215, Intermediate French I, 3 cr, 3 cl hrs**

*Prerequisite: FREN 114 or equivalent*

Introduction to literary passages of easy comprehension. Translation and practice of composition, with emphasis on oral performance in class. Review of grammar through exercises.

**FREN 216, Intermediate French II, 3 cr, 3 cl hrs**

*Prerequisite: FREN 215 or equivalent*

Continuation of FREN 215.

**German Courses:**

*The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

**GERM 113, Elementary German I, 3 cr, 3 cl hrs**

Elements of German, with emphasis on the spoken language. Grammar and composition are introduced in connection with the subjects of oral practice.

**GERM 114, Elementary German II, 3 cr, 3 cl hrs**

*Prerequisite: GERM 113 or equivalent*

Continuation of GERM 113.

**GERM 211, Intermediate German I, 3 cr, 3 cl hrs**

*Prerequisite: GERM 114 or equivalent*

Expansion of skills in German language through readings in German culture, conversation, and writing. Review of German grammar.

**GERM 212, Intermediate German II, 3 cr, 3 cl hrs**

*Prerequisite: GERM 211 or equivalent*

Continuation of GERM 211.

**History Courses:**

*The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

**HIST 131, Western Civilization I 5000BC—1500 AD, 3 cr, 3 cl hrs**

Examines pivotal events in the history of the western world (primarily the European continent) from the early civilizations to the Renaissance. Explores the political, socio-economic, and cultural developments in the Fertile Crescent, ancient Greece and Rome, and medieval Europe. The course is organized in chronological and topical units, each within the framework of political geography, economy, religion, and culture.

**HIST 132, Western Civilization II, 1500 AD—2000, 3 cr, 3 cl hrs**

Examines the political, social, economic, and cultural developments from the Reformation to the European Union. Explores the watersheds in European history that continue to shape modern politics and societies.

**HIST 141, American History to 1865, 3 cr, 3 cl hrs**

A survey of American history from pre-contact North America to the end of the Civil War. The social, cultural, intellectual, and political history of the American people. [NMCCNS HIST 1113: General Education Area V]

**HIST 142, American History since 1865, 3 cr, 3 cl hrs**

A continuation of HIST 141, with attention given to the rise of the United States as a world power, urbanization and industrialization, the role of the state, and civil rights movements. [NMCCNS HIST 1123: General Education Area V]

**HIST 151, World History I, 3 cr, 3 cl hrs**

The evolution of the major Eurasian civilizations from the beginning of historical times to the beginning of the 16th century, with special reference to social, political, and cultural developments.

**HIST 152, World History II, 3 cr, 3 cl hrs**

A continuation of HIST 151, emphasizing social, political, and cultural developments in Eurasian civilization from 1500 to the present.

**HIST 161, Europe in the 19th Century, 1815-1914, 3 cr, 3 cl hrs**

An introduction to the major developments and themes in nineteenth century European history, including major international developments such as the Congress System, the Revolutions of 1848, the advance of modern ideologies and major trends in arts and sciences, and the causes of World War I.

**HIST 162, Europe in the 20th Century, 1914-2000, 3 cr, 3 cl hrs**

Explores the great watersheds of the last century in Europe, from World War I to the fall of the USSR and the rise of the European Union. Several case-studies help students understand the legacy of the 20<sup>th</sup> century and the problems we face today.

**HIST 334, The American West, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

The history of the American West up to the present. Exploration and conquest, the movement of peoples, the role of the federal government, rural and urban development, resource use, issues of race and ethnicity, gender and class, as well as the “idea” of the West.

**HIST 342, American Popular Culture, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

The history of American popular culture, with primary focus on the twentieth century. Examines such subjects as film, television, music, and print media.

**HIST 343, Atomic America: The Cultural History of Nuclear Technology in the United States, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

The history of nuclear technology in the United States. Explores the cultural, social, political, and economic dimensions of atomic energy, with particular emphasis given to changing images in popular culture. May include guest speakers and field trips to the Trinity Site and the National Atomic Museum.

**HIST 345, The Rise and Fall of the Soviet Union, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

The Bolshevik Revolution, the development of Stalinist totalitarianism, reform under Khrushchev, the “stagnation” era of Brezhnev, and the end of the “great experiment” with Gorbachev.

**HIST 348, War and Society, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

The political, economic, social, and ideological implications of warfare.

**HIST 376, Mass Violence through the Ages, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

This course examines the nature and dynamics of mass violence and aggression, and their impact on politics and societies. Through lectures and readings the students explore and compare political, sociological and psychological dimensions of genocides, state terror, and ethnic cleansing.

**HIST 380, Technology in America, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 112 or consent of instructor*

The role technology has played in American history since colonial times, focusing on the relationship of technology to American culture and the changing role of technologies and technological systems in a modern industrial society.

**HIST 385, Latin American Cultural History, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Overview of the cultural history of the Iberian world on both sides of the Atlantic from the earliest cultural expression to the current Hispanic presence in the United States. Multicultural creations of Hispanic societies. Cultural productions, i.e., fiestas, tango, music, painting, literature, graffiti—in their political, economic, and historical background. (Same as SPAN 385)

**HIST 386, Introduction to The Middle East, 3 cr, 3 cl hrs**

*Prerequisite: At least one 100-level history course or equivalent; ENGL 112*

The course is a general introduction to the history of the area known as the Fertile Crescent, with a focus on the political, ethnic, religious, and socio-economic policies of the principal states of the region.

**HIST 387, Eastern Europe In The 20th Century, 3 cr, 3 cl hrs**

*Prerequisite: At least one 100-level history course or equivalent; ENGL 112*

The course explores major political, socio-economic, and cultural developments in the “Lands Between” - the Baltic States, Poland, Hungary, Czechoslovakia, Romania, Bulgaria, Yugoslavia, and Albania—with particular attention to politics, economics, and culture.

**HIST 421, The Age of Radical Ideologies, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 112 or consent of instructor*

The theory and practice of nationalism, anarchism, communism, and fascism in the 19th and 20th centuries.

**HIST 448, The Cold War, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 112 or consent of instructor*

Senior-level seminar examining the history of the Cold War.

**HIST 466, Historical Fiction, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 112 or consent of instructor*

This seminar explores the genre of historical fiction, examining several historical fiction novels and shorter works.

**HIST 467, Film Genres, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 112 or consent of instructor*

Writing intensive senior-level seminar. Examines a selected film genre (e.g. film noir, westerns, science fiction) in depth.

**HIST 472, Special Topics, 3 cr, 3 cl hrs****HIST 491, Directed Studies, hrs and cr to be arranged**

*Prerequisite: Senior standing or consent of instructor*

**Humanities Courses:**

*The following course may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

**HUMA 301, Practical Creativity, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 112 or consent of instructor.*

*May be applied by philosophy minors toward the requirement for 18 credit hours in philosophy.*

An investigation of factors impacting creativity (discipline, time-pressure, constraints), conceptions of creativity (play, inspiration, complex adaptive systems), and applications of creativity (problem solving, negotiation, art).

**HUMA 311, Shakespeare and Music, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 112 or consent of instructor.*

An interdisciplinary study of selected works of Shakespeare through a musical lens. Shakespeare's plays were written to be spoken and heard, and this course explores the parallel issues of choice and constraint in the acts of speaking and hearing Shakespeare's words, applying tools commonly used to facilitate the performance and reception of music.

**HUMA 481, Capstone Seminar, 3 cr, 3 cl hrs**

*Prerequisites: Senior standing and must have completed at least 12 credit hours in Humanities/Social Science courses.*

Topic varies. An interdisciplinary, team-taught, upper-division seminar. Students will examine the topic from a wide variety of perspectives and consider how it relates to their chosen field of study/profession. May include a final project that will be reviewed by an advisor from the student's major department.

## Music & Music Performance Courses:

*The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

### **MUS 105, Fundamentals of Music, 3 cr, 3 cl hrs**

An introduction to the basic materials of music: tones, rhythm, notation, singing, and composition. [NMCCNS MUSI 1113: General Education Area V]

### **MUS 110, Music Appreciation, 3 cr, 3 cl hrs**

A listening-intensive study of rhythm, melody, and musical structure in Western and other music from antiquity to the present. [NMCCNS MUSI 1113: General Education V]

### **MUS 201, Comprehensive Musicianship I, 3 cr, 3 cl hrs, 1 lab hr**

*Prerequisite: MUS 105 or consent of instructor*

A detailed study of notation, keys, scales, intervals, chords, clefs, and transpositions. Practical application to keyboard, instruments, and voice.

### **MUS 301, Composition, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112*

An introduction to the structural principles of music composition. Students will use software tools to study patterns in existing compositions and then create several computer-based compositions within specific design constraints. Final project compositions will be presented in public performance. Prior music background not required.

### **MUS 311, Opera, 3 cr, 3 cl hrs**

*Prerequisite: MUS 105, or consent of instructor*

A musical and socio-historical exploration of selected great operatic works.

### **MUS 401, Interconnections of Music and Science, 3 cr, 3 cl hrs**

*Prerequisite: MUS 105, or consent of instructor*

A discussion of elements connecting music and science in theory and practice. Readings will be selected from a variety of contemporary musicological, scientific, and philosophical sources.

## Music Performance Courses:

*These courses are "offered on demand," i.e. when a sufficient number of students want to enroll, and they may be taken for elective credit only. These courses can be repeated for credit as determined by the instructor. These courses may NOT be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

**MUS 171, 172, Beginning Group Voice, 1 cr, 2 cl hrs**  
Basic techniques of correct singing.

**MUS 273, 274, Intermediate Group Voice, 1 cr, 1 cl hr**  
*Prerequisite: MUS 171, 172, or consent of instructor*  
Development of personal vocal technique, musicianship, diction.

**MUS 331–332, Chamber Choir, 1 cr, 2 cl hrs**  
*Prerequisite: Consent of instructor*

**MUS 333–334, Concert Chorus, 1 cr, 2 cl hrs**  
The Concert Chorus performs large-scale choral works independently and together with the Chamber Orchestra. Interested students without prior singing experience are encouraged to participate.

**MUS 341–342, Jazz Ensemble, 1 cr, 2 cl hrs**  
*Prerequisite: Consent of instructor*

**MUS 351–352, Chamber Orchestra, 1 cr, 2 cl hrs**  
*Prerequisite: Consent of instructor*

**MUS 361–362, Chamber Music, 1 cr, 1 cl hr**  
*Prerequisite: Consent of instructor*

**MUS 377, 378, Vocal Performance, 1 cr, 1 cl hr**  
*Prerequisite: MUS 273, 274, or consent of instructor*  
Practical and theoretical aspects of solo vocal performance.

## Philosophy Courses:

*The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

### **PHIL 120, Freshman Seminar in Philosophy, 3 cr, 3 cl hrs**

An exploration of major issues and approaches in the history and practice of philosophy, including questions of value, knowledge, reality, and problems that arise in social and political philosophy. A fundamental aim of the course is to improve skills in critical thinking, problem-solving, and evaluating.

### **PHIL 231, Western Philosophy, 3 cr, 3 cl hrs**

Introduction to Western philosophical methods, metaphysics, epistemology, ethics, and major philosophers in comparison to one major Asian philosophy text such as the Tao Te Ching. [NMCCNS PHIL 1113: General Education Area V]

**PHIL 323, American Nature Writing, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

A survey of American nature Writers, such as Lewis and Clark, Thoreau, Edward Abbey, and Leslie Marmon Silko, with literary and philosophical analysis of their observational, documentary, rhetorical, inter-disciplinary, and self-reflective strategies to develop students' own skills in these areas and to produce their own nature writing. (Same as ENGL 323)

**PHIL 300, Philosophy of Science, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

An introduction to the philosophical bases and problems of the formal and empirical sciences. Includes the nature of scientific methods, problems and paradoxes of induction, logic of explanation, concepts of causality, determinism and probability, measurement theory, and special philosophical issues in physical, biological, and behavioral sciences.

**PHIL 315, Philosophy of Digital Communication, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

A philosophical and historical overview of the shift to digital modes of communication; explores the impact of this digital shift on culture, identity, communication, education, art, medicine, ethics, community, and the production of knowledge. (Same as TC 315.)

**PHIL 321, Professional Ethics, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Ethical theories and their applications in business, research, and engineering.

**PHIL 342, Philosophy of Bioethics, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Exploration of ethical issues embedded in medicine and related activities; focuses on broad areas including: the physician/patient relationship, the media's influence on medicine, the role of the pharmaceutical industry, gene therapy, cloning and stem cell research, organ transplantation, human and animal research, reproductive technologies, and the global allocation of resources.

**PHIL 351, World Religions, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Survey of the theologies of Christianity, Judaism, Islam, Hinduism, Buddhism, and other religions. [NMCCNS PHIL 1113: General Education Area V]

**PHIL 352, Asian Philosophy, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Survey of the philosophical traditions of China (Confucianism and Taoism), India (Hinduism and Islam), and Japan (Buddhism).

**PHIL 421, Periods or Figures in Philosophy, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Study of a single philosopher's work or a philosophical school.

**PHIL 440, Philosophical Novels, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 and one PHIL course*

Exploration of the use and articulation of philosophy in novels. (Same as ENGL 440)

**PHIL 451, American Philosophy, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

Survey of American philosophy, including pragmatism from its roots in American Romantic writers such as Emerson to contemporary figures such as Richard Rorty and Stanley Fish, nature philosophers such as Thoreau and Ed Abbey, feminist philosophy, and Native-American philosophy.

**Political Science Courses:**

*The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 100).*

**PS 151, Introduction to Political Science, 3 cr, 3 cl hrs**

An introduction to political ideas, events and institutions. Explores the relationships between politics and society; examines the interdependence of citizenship and community life; investigates the complex interaction between values, issues and political behavior.

**PS 171, American Government, 3 cr, 3 cl hrs**

An examination of American democracy as a creative, evolving, and fluid process; how citizens and political institutions interact to create power, establish rights, and pursue interests. [NMCCNS GOVT 1113: General Education Area IV]

**PS 361, Issues in International Relations, 3 cr, 3 cl hrs**

Considers current international issues in light of the transforming structure of world politics; examines the changing status of America as a world power; and investigates the roles of culture, economic power, and technology in the process of global change.

**PS 370, Public Policymaking, 3 cr, 3 cl hrs**

An analytical examination of the policymaking process within the American political system, with special attention to who is involved in the process, how decisions are made, and what the consequences are of alternative policy choices.

## Social Science Courses:

*The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 100).*

### SS 120, Social Thought, 3 cr, 3 cl hrs

From Machiavelli and Marx to Steinem and Foucault, this course explores some of the major historical and contemporary theoretical works and authors in selected social sciences. The focus is on the cultural framework in which these thoughts emerged and the impact they had on society. (Same as ANTH 120 and WGS 120)

### SS 301, Interdisciplinary Problem Solving, 3 cr, 3 cl hrs

*Prerequisites: ENGL 112 or consent of instructor*

An introduction to the Theory of Inventive Problem Solving (TRIZ), including techniques for problem definition, functional modeling, and concept generation. Emphasis on qualitative, interdisciplinary approaches to technical problems.

### SS 501, Interdisciplinary Problem Solving, 3 cr, 3 cl hrs

*Prerequisites: Graduate Standing or consent of instructor*

An introduction to the Theory of Inventive Problem Solving (TRIZ), including techniques for problem definition, functional modeling, and concept generation. Emphasis on qualitative, interdisciplinary approaches to technical problems. Application of TRIZ skills to graduate student peers' design and/or experimental problems.

## Spanish Courses:

*The following courses may be used to fulfill Area 5: Humanities of the General Education Core Curriculum (page 100).*

### SPAN 113, Elementary Spanish I, 3 cr, 3 cl hrs

Elements of Spanish, with emphasis on the spoken language. Grammar and writing are introduced in connection with the subjects of oral practice. [NMCCNS SPAN 1113: General Education Area V]

### SPAN 113N, Spanish for Native Speakers, 3 cr, 3 cl hrs

Elements of Spanish, with emphasis on the spoken and written language. Grammar and writing are introduced in connection with the subjects of oral practice.

### SPAN 114, Elementary Spanish II, 3 cr, 3 cl hrs

*Prerequisite: SPAN 113 or equivalent*

Continuation of SPAN 113. [NMCCNS SPAN 1123: General Education Area V]

### SPAN 215, Intermediate Spanish I, 3 cr, 3 cl hrs

*Prerequisite: SPAN 114 or equivalent*

Expansion of vocabulary through conversation. Stress is placed on the correction of vocabulary and speech for native speakers. Extensive readings from literary models provide materials for emphasis on the principles of composition. Review of grammar.

### SPAN 216, Intermediate Spanish II, 3 cr, 3 cl hrs

*Prerequisite: SPAN 215 or equivalent*

Continuation of SPAN 215; readings in Spanish literature.

### SPAN 352, Contemporary Latin American Novel, 3 cr, 3 cl hrs

*Prerequisite: SPAN 215 or equivalent*

Survey of the 20th century Latin American regional novel. How contemporary writers have portrayed the Latin American continent: social-realism, surrealism, the boom, neo-baroque, magical realism, mestizaje, social-protest, negrismo, etc. Focus on reading classical works such as Arguedas, Asturias, Castellanos, Fuentes, Roa Bastos, Rulfo. All readings and reports to be in Spanish. (Same as ENGL 352)

### SPAN 355, Latin American Fiction & the Arts, 3 cr, 3 cl hrs

A historical journey of a multi-cultural continent. Politics, economic disparity, military dictatorship, oppression and revolutionary resistance are studied through the lens of arts and literature. The most varied styles—social-realism, surrealism, fantasy, magical-realism, etc.—complement factual history to offer an accurate picture of a cruel social reality. (Same as ENGL 355)

### SPAN 357, Latin American Literature, 3 cr, 3 cl hrs

A review of Latin American literary production with examples of its cultural and artistic diversity. The class examines the most important writers from Mexico, the Caribbean, Central America, the Andean region and the Southern cone, and relates their poetic legacy to the social sciences and philosophy. (Same as ENGL 357)

### SPAN 370, Nahuatl Mythology & Anthropology, 3 cr, 3 cl hr

A study of Native language, literature, and mythology of Central America. The class explores a specific native literature in its own language and discusses an "American" worldview. Topics include the concept of a fragmented self and of multiple souls, of political community and redistribution, a quintesimal (5) and vigesimal (20) system of counting, sexuality, and the foundation of a Native philosophy. (Same as ANTH 370)

**SPAN 385, Latin American Cultural History, 3 cr, 3 cl hrs**

*Prerequisite: SPAN 215 or equivalent*

Overview of the cultural history of the Iberian world on both sides of the Atlantic from the earliest cultural expression to the current Hispanic presence in the United States. Multicultural creations of Hispanic societies. Cultural productions, i.e., fiestas, toreo, music, painting, literature, graffiti—in their political, economic, and historical background. All readings and reports to be in Spanish. (Same as HIST 385)

**SPAN 520, Advanced Spanish Reading & Comprehension, 1 cr, 1 cl hr**

Creative writing in Spanish. The class explores the poetic and musical legacy of the Spanish speaking countries, and writes poems, short stories, or a small literary piece in Spanish.

**Technical Communication Courses:****TC 100, Community Service, 1 cr, 1 cl hr**

Proposing and then reporting in writing on a semester-long community service activity with any nonprofit organization. To be graded S/U. May be repeated for credit.

**TC 101, Orientation to Technical Communication, 1 cr, 1 cl hr**

Guest speakers introduce students to the myriad activities and career paths of technical communicators.

**TC 151, Visual Communication, 3 cr, 3 cl hrs**

Students are introduced to the significance of visual symbols in human communication. They learn fundamental graphic and document design principles, develop a vocabulary for analyzing the rhetoric, ethics, and politics of images, and apply this knowledge to the production of effective technical visuals.

**TC 202, Elements of Editing, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 112; TC 151*

Grammar review. Description of types and levels of editing. Responsibilities of editors. Use of editing and proofreading symbols, usage guides, style guides, and style sheets. Production aspects of editing. Practice in online and hardcopy editing of short manuscripts.

**TC 211, Media Studies, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 112*

Survey of media of mass communication, including print, television, film, and internet. Emphasis on social impact of media and on developing tools to examine media messages. Students will form research groups to present on and analyze selected media events.

**TC 302, Article Writing for Mass Media, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112*

Researching, writing, and marketing publishable articles on scientific or technical subjects for general audiences. Practical, legal, and ethical aspects of professional writing.

**TC 315, Philosophy of Digital Communication, 3 cr, 3 cl hrs**

*Prerequisite: ENGL 112 or consent of instructor*

A philosophical and historical overview of the shift to digital modes of communication; explores the impact of this digital shift on culture, identity, communication, education, art, medicine, ethics, community, and the production of knowledge. (Same as PHIL 315.)

**TC 321, Internship, 3 cr**

*Prerequisites: TC 202 and 211; ENGL 341; and consent of TC faculty*

Work during a school term or the summer in a technical communication or media field, such as writing, gathering data, or production work, for an on- or off-campus publications agency. To receive credit, students must have their internships approved in advance by the TC faculty. Students produce a report about their internship program.

**TC 351, Web Design, 3 cr, 3 cl hrs**

*Prerequisites: TC 151*

This course introduces students to the fundamentals of web design, including principles of usability, aesthetics, and interactivity. Students will learn and apply current web design theories and relevant technology tools to practical course projects.

**TC 371, Publications Management, 3 cr, 3 cl hrs**

*Prerequisites: TC 202 and 211 or consent of instructor*

Theory and practice of meeting managerial responsibilities. Topics include communication in organizations, management and supervision, project management, technology and professional communication, legal and ethical issues, and contract employment. Includes a collaborative research project using ethnographic methods.

**TC 381, Studying Organizational Cultures, 3 cr, 3 cl hrs**

*Prerequisites: TC 202 and 211 or consent of instructor*

Learning the practice and process of participant observations within the cultures of organizations. Exploring the differences within cultures and writing those observations as narratives.



**TC 402, Comprehensive Technical Editing, 3 cr, 3 cl hrs**

*Prerequisites: TC 202 and ENGL 341*

Working with full-length drafts, the course applies theory to problems in evaluating, revising, and designing documents, working with authors in different organizational settings, and writing and designing for international audiences. Course includes a research project and presentation.

**TC 411, Persuasive Communication, 3 cr, 3 cl hrs**

*Prerequisites: TC 202 and 211, or consent of instructor*

Theory and practice of producing proposals, sales literature, application letters, résumés, and other documents and media that promote the interest of individuals or organizations in industry and government. Topics in psychology, rhetoric, and advertising may be considered. Students gain practical experience in design, writing, and illustrating promotional texts, particularly technical proposals.

**TC 420, Senior Seminar, 3 cr, 3 cl hrs**

*Prerequisites: TC 211 and senior standing in the Technical Communication program*

Readings in professional journals and discussion of current issues in technical and professional communication. Taught as a seminar with students presenting papers. Research leading to proposal for TC 422, Senior Thesis.

**TC 421, Professional Writing Workshop, 3 cr, 3 cl hrs**

*Prerequisites: TC 202 and 211, or consent of instructor*

Emphasis on the development and writing processes of professional communication documents, which might include computer/software documentation, websites, videos, policy and procedural manuals. Students gain practical experience working on an in-depth documentation project with clients and developing materials for users.

**TC 422, Senior Thesis, 3 cr, 3 cl hrs**

*Prerequisite: TC 420*

Initiation, production, and presentation (oral and written) of an original research project in technical communication.

**TC 461, Digital Media Design, 3 cr, 3 cl hrs**

*Prerequisites: TC 351 or consent of TC faculty*

This course builds on the skills students learn in Web Design, providing the necessary tools and experience to build large-scale complex websites and applications. Through the course text, lectures, hands-on projects, and self-paced tutorials, students will explore and learn how to appropriately select from the many technological options available for designing large-scale digital projects.

**TC 491, Directed Studies, 1–3 cr, as arranged**

*Prerequisites: TC 202 and 211, or consent of instructor*

**TC 511, Persuasive Communication, 3 cr, 3 cl hrs**

*Prerequisites: Consent of instructor*

Instruction in theories and practices of effective persuasive communication. Course content will include extensive audience analysis and planning, drafting, and revising persuasive documents, with a heavy emphasis on funding and research proposals, for targeted audiences.

## Women's and Gender Studies Courses:

*The following courses may be used to fulfill Area 4: Social Sciences of the General Education Core Curriculum (page 100).*

**WGS 101, Introduction to Gender Studies, 3 cr, 3 cl hrs**

This chronologically organized course follows the changes in defining women and men as gendered beings in the U.S. We explore such cultural areas as the economy, politics, sexualities, medicine, religions, and more, tracing how ideas of femininity and masculinity are created and enforced in various areas of American culture.

**WGS 120, Social Thought, 3 cr, 3 cl hrs**

From Machiavelli and Marx to Steinem and Foucault, this course explores some of the major historical and contemporary theoretical works and authors in selected social sciences. The focus is on the cultural framework in which these thoughts emerged and the impact they had on society. (Same as ANTH 120 and SS 120)

**WGS 301, Introduction to Women's Studies, 3 cr, 3 cl hrs**

This thematically organized course introduces issues important to women and men as gendered beings. Explorations of such cultural areas as the economy, politics, sexualities, medicine, religions, and more, both in their American context as well as in comparison to other cultures.

**WGS 320, Anthropology of Sex and Gender, 3 cr, 3 cl hrs**

A survey of the varieties of sex and gender definitions and roles in historical and contemporary human cultures. The study of sex assignment, gender definitions and roles in their association to stratified or equitable access to economic, political, and ideological resources and monopolies. Exploration of the parallels and differences between gender, race, and class. Topics include: gendered division of labor, female and male socialization, violence against women as male entertainment and female punishment, gender universals and generalities. (Same as ANTH 320.)

**WGS 381, Qualitative Methods, 3 cr, 3 cl hrs**

An introduction to the primary methods used in long-term qualitative data gathering, such as participant observation and deep ethnography, and in short-term applied data collection, such as focus groups and life histories. A major focus is research conducted with organizations and their culture. Students will design and execute their own research projects. (Same as ANTH 381 and TC 381)

**Graduate Courses Offered:**

*The following courses are offered for graduate credit:*

**COMM 560, Professional Public Speaking, 3 cr, 3 cl hrs**

*Prerequisites: Consent of instructor*

Theory and practice of ethical and professional speech communication. Research, writing and presenting professional presentations. Designing and using effective visuals, including posters and electronic presentation aids. Conducting group presentations and discussions about ethical and cross-curriculum issues in historical, cultural and workplace context. Design, schedule and present a formal research colloquium.

**ENGL 501, Graduate Writing Seminar, 3 cr, 3 cl hrs**

*Prerequisite: Proficiency in written and spoken English, Graduate standing or consent of instructor*

Intensive practice in academic writing for graduate students. Focuses on writing and revision. Reviews the history and development of science writing and surveys the professional environments in which scientists are expected to publish. Students should come with a draft of a substantial piece of work—such as an article, chapter, or grant proposal.

**ENGL 511, Graduate Creative Writing, 3 cr, 3 cl hrs**

*Prerequisite: Consent of instructor*

Professional-level writing in fiction, poetry, creative non-fiction or plays. Focuses on the genre of the student's choice. Students write often, revise frequently, learn and apply methods of Creative Writing instruction.

**SS 501, Interdisciplinary Problem Solving, 3 cr, 3 cl hrs**

*Prerequisites: Graduate Standing or consent of instructor*

An introduction to the Theory of Inventive Problem Solving (TRIZ), including techniques for problem definition, functional modeling, and concept generation. Emphasis on qualitative, interdisciplinary approaches to technical problems. Application of TRIZ skills to graduate student peers' design and/or experimental problems.

**SPAN 520, Advanced Spanish Reading & Comprehension, 1 cr, 1 cl hr**

Creative writing in Spanish. The class explores the poetic and musical legacy of the Spanish speaking countries, and writes poems, short stories, or a small literary piece in Spanish.

**TC 511, Persuasive Communication, 3 cr, 3 cl hrs**

*Prerequisites: Consent of instructor*

Instruction in theories and practices of effective persuasive communication. Course content will include extensive audience analysis and planning, drafting, and revising persuasive documents, with a heavy emphasis on funding and research proposals, for targeted audiences.

## Faculty Research Interests

- Bonnekessen – Gender and STEM education; Rightwing and Fundamentalist Women’s Organizations
- Dezember – Poetry, the Visual Arts and Poetry, American Literature
- Durão – Information design, International professional communication
- D. Dunston – Conducting, Music and Science, Creativity and Innovation
- S. Dunston – American Literature, Philosophy,
- Ford – Technical Communication Pedagogy, Knowledge Transfer, Writing within Engineering, and Organizational Communication
- Lanier – Interface Design, Web Design, International Professional Communication, Editing, Computer Program Composition
- Lara-Martínez – Latin American Cultural History, Psychoanalysis
- Kramer-Simpson – Feedback, Transitioning from college to the workforce, Students developing research interests.
- Newmark – American and Multiethnic American Literature, Writing Across the Curriculum, Composition/Rhetoric.
- Prusin – Russia, Eastern Europe, Nationalism, Genocide
- Simpson – ESL Writing, Graduate Student Writing, Technical and Scientific Communication

# Earth and Environmental Science

The Department of Earth and Environmental Science administers four closely related disciplines in the Earth sciences—geology, geophysics, geochemistry, and hydrology—as well as the various options leading to a Bachelor of Science degree in Environmental Science. By its very nature, Environmental Science is an interdisciplinary program, incorporating expertise from biology, chemistry, Earth science, physics, and environmental engineering.

## Earth Science

*Professors Aster (Associate Chair of the Department), Boston, Campbell, Condie, Hendrickx, Kyle, Mozley, Person, Phillips, Wilson*

*Associate Professors Axen (Chair of the Department), Bilek, Harrison, McIntosh, Spinelli*

*Assistant Professors J. Johnson*

*Research Professors Murray, Reusch, Ulmer-Scholle*

*Emeritus Professors Budding, Gross, D. Johnson, Lattman, Sanford, Schlue*

*Adjunct Faculty Bauer, Blamey, Broadhead, Buckley, Cather, Chamberlin, Chapin, Connell, Creech-Eakman, Dunbar, Hawley, Heizler, Kelley, Kieft, Land, Love, McCord, McLemore, Pullin, Reiter, Rowe, Scholle, Stephens, Tidwell, Timmons, Vivoni*

**Degrees Offered: B.S. in Earth Science with options in Geology, Geochemistry, Environmental Geology, Geophysics, Hydrology, Petroleum Geology, and Volcanology; M.S. in Geochemistry, Geology, Geophysics (Solid Earth), and Hydrology; Ph.D. in Earth and Environmental Science with Dissertation in Geochemistry, Geology, Geophysics, or Hydrology**

Undergraduate degrees in Earth science require a broad-based background in mathematics, chemistry, and physics, as well as basic training in the Earth sciences. The curriculum emphasizes fundamentals and thus provides the background for entry into a number of Earth science professions or graduate schools.

The graduate program provides specialized training and research opportunities in theoretical or applied aspects of Earth science. Areas of particular expertise in the department include: ore genesis, origins of magmas, volcanology, tectonic history of the continents, geothermal and hydrocarbon exploration, recharge, flow, and water quality in groundwater basins and at hazardous waste sites, modern and ancient depositional processes and environments; landscape and soil evolution, atmospheric

and land surface controls on regional energy and water budgets, earthquake seismology, seismic imaging, infrasound studies, geodesy, faults and fluid flow, marine geophysics; radiometric dating, geobiology, and cave and karst studies. Staff members of the on-campus New Mexico Bureau of Geology and Mineral Resources participate in the graduate program by offering courses and supervising research work for theses and dissertations.

Earth science is a highly interdisciplinary field with many critical environmental, science, and resource connections to society. Graduates commonly enter professional careers in water resources, in the science, monitoring and management of geologic hazards and water quality, and in the exploration for and stewardship of energy and other natural resources.

## Undergraduate Program

### Bachelor of Science in Earth Science

*Minimum credit hours required—130*

Courses taken to fulfill mathematics and basic science requirements of the General Degree Requirements, and courses in Earth Science, taken to fulfill departmental requirements must be taken for a letter grade.

All degree options in the Bachelor of Science in Earth Science program share the following common core curriculum. Students may therefore immediately begin coursework for the major before choosing a specific option track.

### Earth Science Core Curriculum

ERTH 200 (3), ERTH 201 (4), ERTH 202 (4), ERTH 203 (3), ERTH 204 (4), ERTH 205 (1), ERTH 390 (3), ERTH 325 (3), ERTH 340 (3), ERTH 468 (3), ERTH 483 (2)

### Bachelor of Science in Earth Science with Geology Option

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum*

*Requirements (page 100), the following courses are required:*

A 100-level ERTH course and associated lab (4)  
ERTH 200 (3), ERTH 201 (4), ERTH 202 (4), ERTH 203 (3),  
ERTH 204 (4), ERTH 205 (1), ERTH 390 (3), ERTH  
325 (3), ERTH 340 (3), ERTH 468 (3), ERTH 483 (2)  
ERTH 380 (4), ERTH 385 (3), ERTH 434 (3) or GEOL 512  
(3), ERTH 453 (4), ERTH 484 (2), ERTH 485 (2)  
Earth science electives, minimum 9 credit hours in  
courses numbered 300 and above  
MATH 283 or 382 (3)

Total of 3 credit hours 200-level or above from chemistry,

mathematics, or physics

Technical electives, minimum 6 credit hours from courses numbered 300 or above from the following fields:  
mathematics, biology, computer science, physics, chemistry, and engineering.

Electives to complete 130 credit hours

### **Bachelor of Science in Earth Science with Environmental Geology Option**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum*

*Requirements (page 100), the following courses are required:*

A 100-level EARTH course and associated lab (4)  
ERTH 200 (3), EARTH 201 (4), EARTH 202 (4), EARTH 203 (3),  
ERTH 204 (4), EARTH 205 (1), EARTH 390 (3), EARTH 325 (3),  
ERTH 340 (3), EARTH 468 (3), EARTH 483 (2)  
ERTH 380 (4), EARTH 385 (3), EARTH 434 (3), EARTH 405 (3),  
ERTH 440 (3) and 440L (1), EARTH 484 (2), EARTH 485 (2)

Chem 311 (3)

Chem 333 (3) or Chem 422 (3)

Earth science electives, minimum 6 credit hours in courses numbered 300 and above

MATH 283 or 382 (3)

Technical electives, minimum 3 credit hours from courses numbered 300 or above from the following fields:  
mathematics, biology, computer science, physics, chemistry, and engineering.

Electives to complete 130 credit hours

### **Bachelor of Science in Earth Science with Geochemistry Option**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum*

*Requirements (page 100), the following courses are required:*

A 100-level EARTH course and associated lab (4)  
ERTH 200 (3), EARTH 201 (4), EARTH 202 (4), EARTH 203 (3),  
ERTH 204 (4), EARTH 205 (1), EARTH 390 (3), EARTH 325 (3),  
ERTH 340 (3), EARTH 468 (3), EARTH 483 (2)

ERTH 380 (4), EARTH 385 (3), EARTH 484 (2), EARTH 485 (2)

Two of the following: EARTH 411 (3), EARTH 422 (3), EARTH 431 (3), EARTH 444 (3), EARTH 462 (3), any GEOC (3).

Earth science electives, minimum 6 credit hours in courses numbered 300 and above

MATH 283 or 382 (3)

CHEM 311 & 311L (4), CHEM 331(3), CHEM 333 (3) or CHEM 422 (3)

Technical electives, minimum 3 credit hours from courses numbered 300 or above from the following fields:  
mathematics, biology, computer science, physics, chemistry, and engineering.

Electives to complete 130 credit hours

### **Bachelor of Science in Earth Science with Geophysics Option**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum*

*Requirements (page 100), the following courses are required:*

A 100-level EARTH course and associated lab (4)  
ERTH 200 (3), EARTH 201 (4), EARTH 202 (4), EARTH 203 (3),  
ERTH 204 (4), EARTH 205 (1), EARTH 390 (3), EARTH 325 (3),  
ERTH 340 (3), EARTH 468 (3), EARTH 483 (2)

ERTH 380 (4) or 385 (3), EARTH 448 (3),

One of the following: EARTH 370 (3), EARTH 434 (3), EARTH 445 (3), EARTH 453 (3), any GEOP (3),

MATH 231 (4), MATH 254 (3), MATH 332 (3), MATH 335 (3),  
MATH 283 or 382 (3)

PHYS 242 (4), PHYS 333 (3)

Approved geophysics field experience (2)

Technical electives, minimum 3 credit hours from courses numbered 300 or above from the following fields:  
mathematics, biology, computer science, physics, chemistry, and engineering.

Earth science elective in courses numbered 300 and above (3)

Electives to reach 130 credit hours

### **Bachelor of Science in Earth Science with Hydrology Option**

*Minimum credit hours required: 130*

*In addition to the General Education Core Curriculum*

*Requirements, (page 100) the following courses are required:*

- A 100-level EARTH course and associated lab (4)
- EARTH 200 (3), EARTH 201 (4), EARTH 202 (4), EARTH 203 (3),  
ERTH 204 (4), EARTH 205 (1), EARTH 390 (3), EARTH 325 (3),  
ERTH 390 (3), EARTH 340 (3), EARTH 468 (3), EARTH 483 (2)
- EARTH 384 (1), EARTH 440 (3) and 440L (1), EARTH 441 (1),  
ERTH 442 (1), EARTH 443 (1), EARTH 484 (2), EARTH 485 (2)
- Math 231 (4), Math 283 (3), Math 335 (3)
- Earth science electives, minimum 6 credit hours in courses numbered 300 and above
- CHEM 311 & 311L (4), ENV 412 (3), CSE 113 & 113L (4)
- Electives to complete 130 credit hours

### **Bachelor of Science in Earth Science with Petroleum Geology Option**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum*

*Requirements (page 100), the following courses are required:*

A 100-level EARTH course and associated lab (4)  
ERTH 200 (3), EARTH 201 (4), EARTH 202 (4), EARTH 203 (3),  
ERTH 204 (4), EARTH 205 (1), EARTH 390 (3), EARTH 325 (3),  
ERTH 330 (3), EARTH 468 (3), EARTH 483 (2)

PETR 101 (1), EARTH 370 (3), EARTH 385 (3), EARTH 440 (3) and 440L (1), EARTH 445 (3), EARTH 447 (3), EARTH 453 (3), EARTH 460 (3), EARTH 484 (2), EARTH 485 (2)

Any two of the following classes: EARTH 424 (3), EARTH 425 (3), EARTH 446 (3), EARTH 457 (3), EARTH 470 (3)

MATH 283 (3) or 382 (3)

Electives to complete 130 hours

### **Bachelor of Science in Earth Science with Volcanology Option**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum*

*Requirements (page 100), the following courses are required:*

A 100-level EARTH course and associated lab (4)

ERTH 200 (3), EARTH 201 (4), EARTH 202 (4), EARTH 203 (3), EARTH 204 (4), EARTH 205 (1), EARTH 384 (1), EARTH 325 (3), EARTH 340 (3), EARTH 390 (3), EARTH 468 (3), EARTH 483 (2)

ERTH 380 (4), EARTH 444 (3)

ERTH 356 (3), EARTH 457 (3),

A total of 3 credit hours from either EARTH 454 (3) or EARTH 456 (3)

A total of 4 credit hours from EARTH 484, EARTH 485, EARTH 437 (Volcanology Field Trip), and/or EARTH 455 (Volcano Geophysical Field Methods). At least 2 of the 4 credit hours must be satisfied through EARTH 437 or EARTH 455

One of the following: EARTH 491 (3), EARTH 492 (3)

Earth science electives, minimum 4 credit hours in courses numbered 300 and above

MATH 283 (3) or 382 (3), CHEM 331 (3)

Technical electives, minimum 3 credit hours from courses numbered 300 or above from the following fields: mathematics, biology, computer science, physics, chemistry, and engineering.

Electives (3) to complete 130 credit hours

### **Bachelor of Science in Earth Science with CO<sup>2</sup> Sequestration Option**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum*

*Requirements, (page 100) the following courses are required:*

A 100-level EARTH course and associated lab (4)

ERTH 200 (3), EARTH 201 (4), EARTH 202 (4), EARTH 203 (3), EARTH 204 (4), EARTH 205 (1), EARTH 390 (3), EARTH 325 (3), EARTH 330 (3), EARTH 468 (3), EARTH 483 (2)

PETR 101 (1), EARTH 370 (3), EARTH 427 (3), EARTH 440 (3) EARTH 447 (3), EARTH 460 (3), EARTH 484 (2), EARTH 485 (2)

At least one of the following: EARTH 424 (3), EARTH 445 (3), HYD 507 (Hydrogeochemistry)

CHEM 311 & 311L

MATH 283 (3) or 382 (3)

Electives to complete 130 hours

### **Minor in Earth Science**

*Minimum credit hours required — 18*

*The following courses are required:*

- One 100-level EARTH class and associated lab (4 hrs)
- Two classes from the following list: EARTH 201, 202, 203, or 204 (8 hrs)
- At least six hours 200 or above EARTH, GEOL, GEOP, GEOC, or HYD

### **Earth Science Courses:**

#### **ERTH 101, Earth Processes, 3 cr, 3 cl hrs**

*Offered fall semester*

A study of the physical processes that operate on and within the Earth and determine its evolution through geologic time. Students are encouraged to enroll concurrently in EARTH 101L or EARTH 103L. [NMCCNS GEOL 1114: General Education Area III]

#### **ERTH 101L, Earth Processes Laboratory, 1 cr, 3 lab hrs**

*Corequisite: EARTH 101*

For students majoring in Earth sciences. Identification of rocks and minerals, maps and map reading, and measurement and interpretation of geologic features. Field trips. [NMCNNS GEOL 1114: General Education Area III]

#### **ERTH 103L, Earth Processes Laboratory for Non-Majors, 1 cr, 3 lab hrs**

*Corequisite: EARTH 101*

Laboratory to accompany EARTH 101 for students not majoring in the Earth sciences. Identification of rocks and minerals, maps and map reading, and measurement and interpretation of geologic features.

#### **ERTH 120, Introductory Oceanography, 3 cr, 3 cl hrs**

*Offered spring semester, odd-numbered years*

An introduction to the oceans, including aspects of physical, geological, and biological oceanography. Focus is on presentation of science in a social context. Topics include: origin and evolution of ocean basins and marine sediments; ocean currents, waves, tides, and sea level; beaches, shorelines, and coastal processes; marine life; climate; marine resources, pollution, and human impacts on the ocean.

#### **ERTH 120L, Oceanography Laboratory, 1 credit, 3 lab hours**

*Corequisite: EARTH 120*

Hands-on laboratory exercises in oceanographic processes, including mapping of ocean basins and bathymetry, sediments and deposition, waves, salinity and thermohaline processes, tides, and marine ecosystems.

**ERTH 130, Spaceship Earth, 3cr, 3 cl hrs**

*Offered fall semester, even-numbered years*

Study of Earth as an immense system composed of a gigantic rocky mass, a planet-dominating ocean, an active atmosphere, and an abundance of life. Consideration of subsystems interacting across time and space. Discussion of possible mechanisms that may control this megasystem including controversial topics, e.g. co-evolution, homeostatic feedback mechanisms, and the Gaia Hypothesis.

**ERTH 130L, Spaceship Earth Laboratory, 1cr, 3 lab hrs**

Laboratory and field demonstrations of principles of global biogeochemical cycles and the interaction of life with its planetary home.

**ERTH 140 Water in the Rise and Fall of Civilizations, 3 cr, 3 cl hrs**

*Offered fall semester, odd-numbered years*

A survey of how water resources have nurtured the rise of civilizations and how changes in, or misuse of, these resources have led to their demise. The impact of hydrologic extremes such as floods and droughts on social sustainability will also be examined. Case studies from the ancient to the modern world will be considered in the context of the underlying hydrological processes and their environmental and social ramifications.

**ERTH 140L, Water in the Rise and Fall of Civilizations Laboratory, 1 cr, 3 lab hrs**

*Corequisite: EARTH 140*

Laboratory and field exercises in hydrologic processes including flood forecasting, erosion, salinization, and groundwater overdraft.

**ERTH 150, The Catastrophic Earth: An Introduction to Natural Hazards, 3 cr, 3 cl hrs**

*Offered spring semester, even-numbered years*

A survey of natural hazards—such as earthquakes, volcanoes, slope failures, severe weather, asteroid impacts, and fire—and their societal implications. Scientific principles such as plate tectonics, volcanology, weather, space science, and statistics of hazard occurrences, as well as topical discussions of natural hazards in the news.

**ERTH 150L, Catastrophic Earth Laboratory, 1 cr, 3 lab hrs**

*Corequisite: EARTH 150*

Laboratory exercises dealing with natural hazards, including locating recent earthquakes using seismograms, combining maps of earthquake and volcanic hazards with statistical hazard information, estimating flood recurrence for rivers, and tracking hurricanes using meteorological data.

**ERTH 200, Introduction to Mineralogy. 3 cr, (2 cls hrs, 3 lab hrs).**

*Prerequisite: a 100-level EARTH course and associated lab*  
*Offered spring semester.*

An introduction to minerals, including identification in hand samples and thin sections, crystal structures, physical properties, chemical compositions, occurrences and uses. Lab will focus on mineral identification by physical and optical properties.

**ERTH 201, Geobiology 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite: a 100-level EARTH course and associated lab*  
*Offered spring semester, odd-numbered years*

Consideration of life and its impact on the Earth System over the course of Earth history including its preserved geochemical and fossil remains, study of the observable geological effects of life processes and in turn the impact of geological, hydrological, and atmospheric effects on the origins and subsequent evolution of life. Field trips.

**ERTH 202, Earth Surface Processes and Landforms, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: Any EARTH 100 level class and associated lab*  
*Offered fall semester, odd-numbered years*

A study of the interactions between the atmosphere and the internal heat of the Earth which result in the development of landscapes observable at the Earth's surface today. Topics will include atmospheric circulation, climate, fluvial processes, and the record of paleoclimate contained in the landscape. Field trips.

**ERTH 203, Earth's Crust: Materials, Processes, and Dynamics, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: a 100-level EARTH course and associated lab*  
*Offered spring semester*

Overview of the evolution of the crust of the Earth, the major rock types and processes that form it, and the main methods used to study it. Topics include sedimentology, petrology, structural geology, geochronology, subsurface fluid flow, and petroleum geology. Field trips.

**ERTH 204, Introduction to Whole Earth Structure and Composition, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite: a 100-level EARTH course and associated lab*  
*Offered fall semester, even-numbered years*

Introduction to geophysical and geochemical methods used to study the deep Earth. Formation, composition and internal structure of the Earth, plate tectonics, gravitational and magnetic fields, heat flow and thermal history, earthquakes, and interaction of Earth systems with emphasis on the crust, mantle and core. Introduction to mantle convection, geochemical reservoirs, and mantle plumes. Field trips.

**ERTH 205, Earth Science Practicum, 1 cr, 3 lab hrs**

*Prerequisite: a 100-level EARTH course and associated lab*  
*Offered fall semester.*

Instruction and practice in computational methods used to solve Earth science problems. Simple ways to describe physical processes mathematically, then approximate them numerically. Introduction to spreadsheets and graphics programs. Review of math and statistics.

**ERTH 325, Near-Surface Geophysics, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites: PHYS 121; a 100-level EARTH course and associated lab*

*Offered fall semester, even-numbered years.*

Theory and practice of geophysical methods for exploring the shallow subsurface, with emphasis on electromagnetic methods including resistivity, EM conductivity, ground-penetrating radar, and magnetic field strength. Applications to environmental hazards, hydrogeological features, and/or archaeology are emphasized in a hands-on, field-oriented approach.

**ERTH 340, Global Change Hydrology, 3 cr, 3 cl hrs**

*Prerequisites: MATH 132, EARTH 202, PHYS 122*

*Offered spring semester, even-numbered years*

How is global warming affecting the occurrence of floods and droughts, and human development influencing their severity and extent? This class will provide an introduction to the global hydrologic cycle and the potential changes caused by global climate change in the presence of a growing human population. Examples of recent research pointing to an accelerated hydrologic cycle will be discussed, including remote sensing and numerical modeling studies. Implications for sustainable human development and ecosystems will be explored, especially for the semiarid Southwest.

**ERTH 356 Volcanoes, 3 cr, 3 cl hrs**

*Prerequisite: EARTH 203 or 204*

*Offered fall semester, odd-numbered years*

An introduction to volcanoes, volcanic processes and their environmental impact. A weekly recitation will examine on-going volcanic eruptions, discuss take home exercises and review videos of volcanic activity.

**ERTH 370, Formation Evaluation, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites: PHYS 122, EARTH 203*

The qualitative and quantitative interpretation of electric, sonic, and radioactive well logs. Physical and electrical properties of saturated rock. Formation testing and analysis. Laboratory exercises in log reading and interpretation. Preparation of subsurface maps for estimation of reserves. (Same as PETR 370)

**ERTH 380, Igneous and Metamorphic Petrology, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: EARTH 200, 203, CHEM 121, CHEM 122*

*Offered spring semesters, odd-numbered years*

Origin, occurrence, identification and description of igneous and metamorphic rocks. Topics covered include fractional crystallization and melting processes, physical and chemical properties of magmas, granitic batholiths, metamorphic facies and their key mineral assemblages, metamorphic rock fabrics, and qualitative determination of P-T-t paths recorded by metamorphic rocks. Binary and ternary phase diagrams will be introduced and used. Examination and identification of igneous and metamorphic rocks and minerals and their salient textures in thin section and hand samples.

**ERTH 384, Stratigraphy, 1 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: EARTH 201 and EARTH 203*

*Offered spring semester, odd-numbered years*

Survey of lithostratigraphic, biostratigraphic and chronostratigraphic principles. Topics include seismic and sequence stratigraphy and stratigraphic modeling. Weekend field trip required. Meets with EARTH 385 for the first third of the semester.

**ERTH 385, Stratigraphy and Paleontology, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: EARTH 201 and EARTH 203*

*Offered spring semester, odd-numbered years*

Continuation of paleontologic and stratigraphic principles; survey of geologically important invertebrate biota preserved as fossils; their modes of preservation, collection techniques, taxonomy, evolution, paleobiology and paleoecology; overview of the late Precambrian and Phanerozoic biotic and stratigraphic histories in the context of North American tectonics. Weekend field trips required.

**ERTH 390, Principles of Geochemistry, 3 cr, 3 cl hrs**

*Prerequisites: CHEM 122 and EARTH 203 or 204*

*Offered fall semester, even-numbered years*

Application of chemical principles to geologic processes. Topics include mineral and rock chemistry, aqueous geochemistry and geochronology. Course will include computer modeling to solve geochemical problems.

**ERTH 405, Introduction to Soils, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite or Corequisite: EARTH 202*

*Offered spring semester*

Introduction to soil formation, pedogenic processes, and soil description and mapping techniques. Meets with GEOL 503.



**ERTH 408, Cooperative Education**

On-the-job training to supplement the academic program. Students alternate periods (usually six months long) of full-time semiprofessional employment in their chosen field with periods of full-time academic study.

**ERTH 409, Soil Geomorphology, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites: EARTH 202 and 405; or consent of instructor*  
*Offered on demand*

Discussion of the use of soils to interpret the rate and timing of geomorphic processes and changing environmental parameters. Field trips.

**ERTH 411, Experimental Mineralogy, 3 cr, 5 lab hrs**

*Prerequisite: EARTH 200, 203*  
*Offered on demand*

Study of the principles of mineralogy through experimentation in the laboratory. Techniques taught include hand sample identification, optical mineralogy, x-ray diffraction, thin section preparation, and mineral synthesis.

**ERTH 412, Introduction to Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs**

*Offered on Demand*

An introduction to the concepts of geographic information systems (GIS). Theoretical background to GIS; introduction to the nature and analysis of spatial data. ArcView and/or ArcGIS. Shares lecture with GEOL 512 but is graded separately. Same as ENV5 412.

**ERTH 422, Environmental Geochemistry, 3 cr, 3 cl hrs**

*Prerequisites: Any two of the following: CHEM 311, 331, or 333*  
*Offered on demand*

Application of chemical principles to the study of the environment. Includes natural processes and pollution problems related to water, air, and soil. (Same as CHEM 422)

**ERTH 424, Sedimentary Petrography, 3 cr, 4 lab hrs**

*Prerequisite: EARTH 200, 202, 203 or consent of instructor*  
*Offered Spring Semesters, on demand*

Petrographic analysis and interpretation of sedimentary rocks, with emphasis on siliciclastics. Topics include: grain identification and provenance, identification of diagenetic minerals and textures, and interpretation of porosity and permeability characteristics.

**ERTH 425, Carbonate Sedimentology and Diagenesis, 3 cr, 3 cl hrs**

*Prerequisite: EARTH 200, 202 and 203 or consent of instructor*  
*Offered on demand*

This class covers the basics of carbonate sedimentation and diagenesis and looks at the evolution of carbonate sediments through geologic time (from Precambrian to recent). Included in the class are discussions of the impact of diagenesis on petroleum reservoir and aquifer potential. Shares lecture with GEOL 525 but is graded separately.

**ERTH 427, Carbon Sequestration Science, 3 cr, 3 cl hrs**

*Prerequisite: Math 132, Chem 122, Phys 122, one 100-level EARTH course*  
*Offered on demand*

Overview of geological carbon sequestration. Topics include: Earth's changing climate, sources and sinks of greenhouse gases, carbon capture, reservoirs and caprocks, physical and aqueous chemistry of CO<sub>2</sub>. Field trips.

**ERTH 430, Active Tectonics, 3 cr hrs**

*Prerequisites: EARTH 202, 203*  
*Offered on demand*

Study of Quaternary faults, including basic field techniques, tectonic geomorphology from fault scarps to mountain fronts, patterns of faulting, structural analysis of faults in alluvium, relation of surface to subsurface structures, paleoseismology, and review of Quaternary dating methods.

**ERTH 432, Interdisciplinary Field Research, 3 cr, 8 lab hrs**

*Prerequisite: Consent of instructor*  
*Offered fall semester on demand*

Introduction to field-based research. Activities include proposal writing, data collection, interpretation, and preparation of a written report. Field work is an important part of the course, and hiking is required. The course is team-taught by several instructors.

**ERTH 434, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: PHYS 122 or 132 or consent of instructor*

Introduction to the theory and practical use of remotely sensed satellite images. Principles of radiation physics; sensor systems; data acquisition; image analysis; classification schemes. Remote sensing applications to atmospheric sciences, hydrology, mineral and oil exploration, natural hazards monitoring, and land and resources management. Laboratory exercises deal primarily with computer analysis of remotely-sensed images with some field exercises. Shares lecture/lab with GEOL/HYD 534 but is graded separately.

**ERTH 436, Advanced Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: EARTH 434 or HYD 534 or GEOL 534*

This class deals with quantitative remote sensing for determination of the components of the energy balance (net radiation, latent and sensible heat fluxes, soil heat flux) and soil moisture, hyperspectral and multispectral image processing, radar and microwave imagery. In addition, advanced applications for geology, geophysics and geochemistry will be discussed. (Shares lecture/lab with GEOL/HYD 536 but is graded separately.)

**ERTH 437, Volcanology Field Trip, 1-6 cr**

*Prerequisite: EARTH 455 or EARTH 456, or consent of instructor.*

*Offered on demand*

Field trip to study volcanic rocks in a specific area or volcanological processes at an active volcano. A weekly seminar will precede a one-to two-week field trip. A paper is required. A student may register for the class more than once for a total of six credit hours. Same as GEOL/GEOC/GEOP 537 but EARTH 437 is graded separately with less work.

**ERTH 440, Hydrological Theory and Field Methods, 3 cr, 3 cl hrs**

*Prerequisites: MATH 132, PHYS 132*

*Offered fall semester*

Fundamentals of hydrological flow and transport will be presented. Precipitation, runoff processes, and flood generation. Capillarity, unsaturated flow, and infiltration. Laws of flow in porous media, hydraulic storage, and flow to wells.

**ERTH440L, Hydrological Theory and Field Methods Laboratory, 1 cr, 3 lab hours.**

*Prerequisites: MATH 132, PHYS 132; Co- or prerequisite: EARTH 440*

*Offered fall semester*

Laboratory and field exercises that demonstrate and implement fundamental concepts of the hydrological cycle.

**ERTH 441, Hydrogeology, 1 cr, 1 cl hr**

*Prerequisite: EARTH 440*

*Offered spring semester*

Hydrogeologic controls on the occurrence, movement, and chemical and isotopic composition of groundwater. Hydrogeologic properties. Groundwater recharge and stream/aquifer interaction. Groundwater in different geological, climate, and physiographic regimes.

**ERTH 442, Vadose Zone Processes, 1 cr, 1 cl hr**

*Prerequisite: EARTH 440*

*Offered spring semester*

Physics of unsaturated flow in porous media, multiphase flow, potentials and water retention, unsaturated hydraulic conductivity, transient flow problems.

**ERTH 443, Atmospheric Dynamics and Rainfall and Evaporation Processes, 1 cr, 1 cl hr**

*Prerequisite: EARTH 440*

*Offered spring semester*

Principles of atmospheric processes with an emphasis on rainfall generation and evaporation at the Earth's surface. Warm and cloud convection, orographic controls on precipitation, cyclogenesis and frontal storms. Particular attention paid to the measurement and assessment of rainfall and evaporation in space and time.

**ERTH 444, Principles of Isotope Geochemistry, 3 cr, 3 cl hrs**

*Prerequisites: CHEM 122; EARTH 203*

*Offered spring semester*

Principles of radiogenic isotope geochemistry and applications to geologic dating and to the petrogenesis of rock suites.

**ERTH 445, Exploration Seismology, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites: PHYS 121 or equivalent; a 100-level EARTH course and associated lab; upper-class standing*

*Offered fall semester, odd-numbered years*

An introductory course on seismic refraction and reflection imaging of the subsurface, including methods of data acquisition, processing, and interpretation in two and three dimensions. Designed for students with a range of Earth science and engineering backgrounds.

**ERTH 446, Reflection Seismic Data Interpretation, 3 cr, 2 cl hrs, 2 lab hrs**

*Prerequisites: EARTH 445 or equivalent, upper-class standing, or consent of instructor*

*Offered on demand*

An overview of the fundamentals of the geologic (both structural and stratigraphic) interpretation of 2D and 3D reflection seismic data. An introduction to seismic acquisition and processing and their effects on interpretation. Techniques covered include: well log to seismic ties, contour maps, fault plane maps, time-to-depth conversion, seismic sequence analysis, and workstation interpretation of 3D data. Designed for students with a range of earth science and engineering backgrounds.

**ERTH 447, Depositional Systems and Basin Analysis, 3 cr, 3 cl hrs**

*Prerequisites: EARTH 202 and EARTH 203*

*Offered fall semester*

Discussion of the spectrum of modern and ancient depositional environments and their relationships to tectonic settings. Shares lecture with GEOL 547, but is graded separately.

**ERTH 448, General Geophysics, 3 cr, 3 cl hrs**

*Prerequisites: PHYS 122 or equivalent; a 100-level EARTH course and associated lab; upper-class standing*

*Offered fall, even-numbered years*

An introduction to the general field of solid Earth geophysics. Subjects covered are the origin of the Earth; structure and internal properties of the Earth; gravity, magnetic, and temperature fields of the Earth; origin of the Earth's atmosphere, hydrosphere, and surface features.

**ERTH 449 Astrobiology, 3 cr, 3 cl hours**

*Prerequisites: CHEM 121, 122, PHYSICS 121, 122, plus one other science course and consent of instructor.*

*Offered spring semester, even-numbered years*

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Shares lecture with GEOL/GEOC 549, but is graded separately. (Same as BIOL 449/549)

**ERTH 450, Cave and Karst Systems, 3 cr, 3 cl hrs**

*Prerequisites: CHEM 121 & 122; and either a 100-level EARTH course with associated lab, or BIOL 111*

*Offered fall semester, odd-numbered years*

A system-based study of caves and karstic terrains over time including formation mechanisms (speleogenesis), hydrology, geochemistry, mineralogy, and geomicrobiology. Emphasis on caves as interactive microcosms cross-cutting many disciplines. Shares lecture with GEOL 550, but is graded separately.

**ERTH 450L, Cave and Karst Lab, 1 cr, 3 lab hrs**

*Offered spring semester, even years*

*Corequisite: EARTH 450*

Survey of techniques applicable to various aspects of speleology and karst studies. Project-based lab, developed for each student in consultation with instructor. Meets with GEOL 550L but is graded separately.

**ERTH 451, Volcano Geophysics, 3 cr, 3 cl hrs**

*Prerequisites: EARTH356; MATH283*

*Offered spring semester, odd-numbered years.*

Provides an overview of geophysical tools and techniques used for monitoring and scientific study of active volcanoes. Subject material will focus on seismology, infrasound, geodesy, and optical remote sensing mostly from ground-based perspectives although reference to related satellite techniques will be covered. EARTH451 and GEOP551 share lecture and lab work, but GEOP 551 is graded separately and additional graduate-level work is required.

**ERTH 453 Intermediate Structural Geology, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: EARTH 203; PHYS 121 or 131; MATH 131*

*Offered fall semester, odd-numbered years.*

Builds on basics of structural geology taught in EARTH 203. Elements of fault, fold, and rock mechanics; strain analysis and inference of stress in Earth's crust; construction of balanced, kinematically viable cross sections; brittle and ductile shear-sense indicators in faults and shear zones. Shares lecture and lab with Geol 553 but graded separately.

**ERTH 454, Volcanology Seminar, 3 cr, 3 cl hrs**

*Prerequisite: EARTH 455 or EARTH 456, or consent of instructor.*

*Offered on demand*

Seminar discussions of selected topics in volcanology. EARTH 454 and GEOL/GEOP/GEOC 554 share lecture but EARTH 454 is graded separately.

**ERTH 455, Volcano Geophysics Field Trip, 1-6 cr**

*Prerequisites: Consent of instructor.*

*Offered on demand*

An intensive field and lab computer-based class to teach the principles of hardware installation, data collection, digital signal processing, and analysis of geophysical data in an active volcanic environment. Students will be grounded in seismic data acquisition, but material may also include infrasound, geodesy, thermal, and gas sensing surveys. EARTH 455 and GEOP 555 share lecture and field work, but EARTH455 is graded separately.

**ERTH 456, Advanced Volcanology, 3 cr, 2–3 cl hrs, 1–3 lab hrs**

*Prerequisite:* EARTH 356 or consent of instructor  
*Corequisite:* EARTH380  
*Offered on demand*

Detailed studies of volcanic process, pyroclastic rocks and mechanism of volcanic eruptions. Field trips to nearby volcanic regions. EARTH 456 and GEOL/GEOP/GEOC 556 share lecture and fieldwork, but EARTH 456 is graded separately with less work.

**ERTH 457, Reflection Seismic Data Processing, 3 cr, 2 cl hrs, 2 lab hrs**

*Prerequisites:* EARTH 445 or equivalent, upper-class standing, or consent of instructor  
*Offered spring semester, odd numbered years*

The computer application of digital signal processing to reflection seismic data from environmental, petroleum, and crustal surveys. Topics covered include: definition of survey geometries, data editing techniques, amplitude recovery, bandpass filtering, deconvolution, velocity analysis, F-K filtering, and migration.

**ERTH 460, Subsurface and Petroleum Geology, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* EARTH 203 or consent of instructor  
*Offered spring semester*

Principles and techniques of subsurface geology with emphasis on subsurface mapping, facies analysis, fluid-related rock properties, composition, movement and entrapment of subsurface fluids (oil, natural gases, water), and petroleum source rocks. Laboratory work emphasizes subsurface analysis and mapping with logs, cuttings, and cores. Applications to hydrocarbon exploration and development.

**ERTH 462, Mineral Deposits, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* EARTH 203  
*Offered spring semester, alternate years*

Geologic and geochemical characteristics of metallic mineral deposits; theories of origin and classification.

**ERTH 463, Geology of the Colorado Plateau, 3 cr, 2 cl hrs, field trips**

*Prerequisites:* EARTH 203; or consent of instructor  
*Offered fall semester*

Discussion of geology, archeology, and ecology of the Colorado Plateau, emphasizing the Canyonlands region. Geological topics include geomorphology, sedimentology, tectonics, igneous rocks, and surficial processes. Field trips are an important part of the course, and hiking is required.

**ERTH 464, Field Geology and Ecology of New Mexico, 3 cr**

*Prerequisites:* EARTH 201, 202, 203

Investigation of the geologic and ecologic history of New Mexico. Covers techniques for observing, describing and interpreting rocks and native plant communities in the field. Numerous local field trips and at least two weekend field trips. Moderate hiking is required.

**ERTH 468, Evolution of the Earth, 3 cr, 3 cl hrs, optional field trip**

*Prerequisites:* EARTH 201, 203, 204  
*Offered spring semester*

Origin of the solar system and of the Earth; the evolution of continents, atmosphere, and oceans; comparative planetary evolution; tectonic regimes in geologic history. Field trip required.

**ERTH 470, Geology of the Cayman Islands and Field Trip, 3 cr**

*Prerequisites:* EARTH 203 or consent of instructor  
*Offered spring semester alternate years*

Investigation of modern and ancient reefs in an easily accessed area, as well as study of the environmental implications of living on an island. Weekly meeting followed by an end-of-semester seven to nine day field trip. Students are expected to complete field exercises, make oral presentations, and write a paper on a topic such as reef ecology through time on the Cayman Islands, the tectonic evolution of the Caribbean and the Caymans, or environmental concerns of island life.

**ERTH 480, Field Methods in Earth Science, 6 cr**

*Prerequisites:* EARTH 200, 203, 380 and 385 or 384. EARTH 202 recommended.

*Offered summers (6 weeks); NMT students should register for this course in the spring semester.*

Collection, processing, and interpretation of field data developed by geologic mapping in sedimentary, igneous, and metamorphic terrane. Presentation of geologic reports involving maps, cross sections, and sample data.

**ERTH 483, Field Methods in Earth Science I, 2 cr**

*Prerequisites:* EARTH 200, 203, 380 and 385 or 384

*Offered Summers (2 weeks); NMT students should register for this course in the spring semester.*

Collection, processing and interpretation of geological data from stratified rocks, collected by geologic mapping and other means. Presentation of geologic reports involving stratigraphic sections, maps, cross sections, and other data.

**ERTH 484, Field Methods in Earth Science II, 2 cr**

*Prerequisites: EARTH 483; EARTH 202 or equivalent recommended*

*Offered summers (2 weeks); NMT students should register for this course in the spring semester.*

Collection, processing and interpretation of geological data from landforms and unconsolidated regolith, collected by geologic mapping and other means. Presentation of geologic reports involving maps, cross sections, and other data.

**ERTH 485, Field Methods in Earth Science III, 2 cr**

*Prerequisites: EARTH 483*

*Offered summers (2 weeks); NMT students should register for this course in the spring semester.*

Collection, processing and interpretation of geological data from igneous, metamorphic and/or structurally complex rocks. Presentation of geologic reports involving maps, cross sections, and other data.

**ERTH 491, Special Topics, hrs and crs to be arranged**

Individual directed study in Earth Sciences.

**ERTH 492, Senior Thesis, 3 cr**

*Prerequisite: 3.0 GPA in Earth science courses and consent of instructor*

Individual research under the direction of a faculty member. Two semesters are usually necessary to complete the research project. Grading will be based on a written report which details the research goals, data collected, interpretation, and conclusions.

**Five-Year Program: Earth Science with Environmental Geology Option B.S./Geology M.S. Degree Program**

The degrees Earth Science with Environmental Geology Option and Geology M.S. are achieved in five years by fulfilling the requirements for a B.S. degree in Earth Science with the Environmental Geology Option in four years and an M.S. degree in Geology the following year. A minimum of 158 credit hours is required to complete both degrees.

Students should apply to the Environmental Geology five-year program at the end of their sophomore year. Admission is contingent upon the acceptability of a proposed course of study, academic performance, and on the number of vacancies in the program. Students who have upper-division standing may also be considered, depending upon prior course work.

Once admitted to the program, every undergraduate student will work with a research group. Required courses include EARTH 405 or Geol 503, EARTH 409 or Geol 509, EARTH 491 or 492 (one credit hour per semester for three semesters), Geol 592 (2 credit hours), EARTH 325, EARTH

440, Chem 311, Chem 333 and Chem 422 Recommended courses include, EARTH 441, EARTH 442 and EARTH 443

Students in the Environmental Geology five-year program must apply for graduate standing, normally in their seventh semester. Graduate admission will be contingent upon adherence to the approved program of studies, a 3.0 minimum cumulative grade point average, and a 3.0 earned grade point average in mathematics, science, and engineering courses. Graduate status will be granted upon fulfillment of the requirements for the B.S. degree.

**Five-Year Program: Science or Engineering B.S./Hydrology M.S. Degree**

The five-year B.S./Hydrology M.S. degrees are achieved by fulfilling the separate requirements of both an undergraduate degree in a science or engineering field and a graduate degree in hydrology in a five-year period. A minimum of 158 total credit hours is required to complete both degrees.

Students should apply to the program at the end of their sophomore year. Admission is contingent upon the acceptability of a proposed course of study, academic performance, and on the number of vacancies in the program. Students having upper-division standing may also be considered, depending upon prior course work.

Once admitted to the program, every undergraduate student will work with a research group. Required courses include:

- EARTH 491 (one credit hour per semester for three semesters)
- EARTH 440
- HYD 507, 510, 508, 547
- Six credits from the following: EARTH 441, EARTH 442, EARTH 443, HYD 531, HYD 532, HYD 533, HYD 541, HYD 542, HYD 543, HYD 544
- HYD 591 (at least six credit hours)
- HYD 592 (two credit hours)
- EARTH 202 or equivalent
- MATH 283 or 382 or equivalent
- Three additional graduate-level course credits approved by the advisory committee

During the senior year, the student in this program must select a graduate advisory committee and formalize his or her graduate research topic.

Students in the Hydrology five-year program must normally apply for graduate standing at the end of their seventh semester. Graduate admission will be contingent upon adherence to the approved program of studies, a 3.0 cumulative grade point average, and a 3.0 earned grade point average in mathematics, science, and engineering courses. Graduate status will be granted upon fulfillment of the requirements for the B.S. degree.

# Geology

*The Geology program offers an undergraduate degree in Earth Science with Geology option. See page 141.*

## Graduate Program

### Master of Science in Geology

The master's candidate must demonstrate competence in mathematics, chemistry, and physics comparable to the requirements for the Bachelor of Science degree in Geology. The Master of Science degree in Geology may be earned under either of the following plans:

#### With Thesis:

The student's course of study must be approved by the advisory committee and must fulfill the general requirements for the master's degree with thesis and must include EARTH 480 or the equivalent, if not previously satisfied, two credits of GEOL 592, at least six credit hours of GEOL 591, and at least four credit hours of GEOL 593, unless the degree is completed in a shorter time. Credits earned in GEOL 592 and 593 may not be applied towards the 30 credits required for the M.S. degree.

#### Without Thesis:

The student's course of study must be approved by the advisory committee and must fulfill the general requirements for the master's degree without thesis and must include EARTH 480 or the equivalent, if not previously satisfied, two credits of GEOL 592, at least three credit hours of GEOL 590, and at least four credit hours of GEOL 593, unless the degree is completed in a shorter time. Credits earned in GEOL 592 and 593 may not be applied towards the 30 credits required for the M.S. degree.

### Doctor of Philosophy in Earth and Environmental Science with Dissertation in Geology

Students of exceptional ability, as demonstrated in previous courses or in a master's degree program, may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in Earth and environmental science with specialization in geology should develop a good background in geology, chemistry, physics, and mathematics, in addition to achieving a high level of competence in the field of specialization. Ph.D. students must include three credits of GEOL 592 and at least six credit hours of GEOL 593, unless the degree is completed in a shorter time. Additional information is found under the Graduate Program (page 47).

Research fields appropriate for the geology candidate include petrology, volcanology, mineral deposits, geochronology, stable isotopes, environmental geology,

coal geology, geohydrology, sedimentation and stratigraphy, regional tectonics, and structural geology. Interdisciplinary programs in the Earth science fields are encouraged.

## Geology Graduate Courses:

### GEOL 500, Directed Research, cr to be arranged

*This course may not be used to fulfill graduate degree requirements.*

Research under the guidance of a faculty member.

### GEOL 503, Introduction to Soils, 3 cr, 2 cl hrs, 3 lab hrs

*Prerequisite: EARTH 202 or 203; or consent of instructor  
Offered fall semester*

Introduction to soil formation, pedogenic processes, and soil description and mapping techniques. Shares lecture/lab with EARTH 405, but is graded separately and additional graduate-level work is required.

### GEOL 507, Ore Deposit Seminar and Field Trip, 1–6 cr

*Offered spring semester*

Ore deposits and geology of a specific geographic area are studied in a weekly seminar and a one- to two-week field trip. The field trip will generally be international in alternate years. A paper is required. Students may register for the course more than once for a total of six credit hours.

### GEOL 509, Soil Geomorphology, 3 cr, 2 cl hrs, 3 lab hrs

*Prerequisites: EARTH 202 and 405; or consent of instructor  
Offered spring semester, alternate years*

Discussion of the use of soils to interpret the rate and timing of geomorphic processes and changing environmental parameters. Field trips. Shares lecture/lab with EARTH 409, but is graded separately and additional graduate-level work is required.

### GEOL 512, Introduction to Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs

*Offered Spring semester on demand*

An introduction to the concepts of geographic information systems (GIS). Theoretical background to GIS; introduction to the nature and analysis of spatial data. ArcView and/or ArcGIS. (Same as ENV 541)

### GEOL 522, Advanced Igneous Petrology, 3 cr, 3 cl hrs

*Prerequisites: EARTH 380 and graduate standing; or consent of instructor*

*Offered on demand*

Applications of phase diagrams, experimental petrology, and field and petrographic relationships to the origin of magmas. Field trips. Shares lecture/lab with EARTH 420, but is graded separately and additional graduate-level work is required.

**GEOL 524, Sedimentary Petrography, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: Graduate standing*

*Offered spring semester, alternate years*

Petrographic analysis and interpretation of sedimentary rocks, with emphasis on siliciclastics. Topics include: grain identification and provenance, identification of diagenetic minerals and textures, and interpretation of porosity and permeability characteristics. Shares lecture/lab with EARTH 424, but is graded separately and additional graduate-level work is required.

**GEOL 525, Carbonate Sedimentology and Diagenesis, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of instructors*

*Offered fall semester, alternate years*

This class covers the basics of carbonate sedimentation and diagenesis and looks at the evolution of carbonate sediments through geologic time (from Precambrian to recent). Included in the class are discussions of the impact of diagenesis on petroleum reservoir and aquifer potential. Shares lecture with EARTH 425 but is graded separately.

**GEOL 528, Carbon Capture and Storage, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing and Math 132, Phys 122,*

*Chem 122 or equivalents. Introductory geology course recommended but not required. Students from other departments (e.g. Petroleum Engineering, Chemistry, Physics, Mathematics) are encouraged to enroll.*

*Offered on demand.*

This course will explore the efforts to reduce the buildup of greenhouse gases by sequestering carbon in geological reservoirs. Topics include Earth's climate history, atmospheric chemistry, sources and sinks for greenhouse gases, carbon capture technology, geological reservoirs and seals, water/rock interaction, subsurface flow modeling, site monitoring for verification, decision making rationale, and policy issues. This class is jointly taught with the University of Utah using Tech's Distance Education facilities. Numerous guest lectures from experts in the field.

**GEOL 530, Active Tectonics, 3 cr hrs**

*Prerequisites: EARTH 202, 203, or consent of instructor*

*Offered in alternate years*

Study of Quaternary faults, including basic field techniques, tectonic geomorphology from fault scarps to mountain fronts, patterns of faulting, structural analysis of faults in alluvium, relation of surface to subsurface structures, paleoseismology, and review of Quaternary dating methods. Shares lecture/lab with EARTH 430, but is graded separately and additional graduate-level work is required.

**GEOL 532, Interdisciplinary Field Research, 3 cr, 8 lab hrs**

*Prerequisite: Consent of instructor*

*Offered fall semester*

Introduction to field-based research. Activities include proposal writing, data collection, interpretation, and preparation of a written report. Field work is an important part of the course, and hiking is required. The course is team-taught by several instructors. Shares lecture/lab with EARTH 432, but is graded separately, and additional graduate-level work is required.

**GEOL 534, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: PHYS 122 or 132 or consent of instructor*

Introduction to the theory and practical use of remotely sensed satellite images. Principles of radiation physics; sensor systems; data acquisition; image analysis; classification schemes. Remote sensing applications to atmospheric sciences, hydrology, mineral and oil exploration, natural hazards monitoring, and land and resources management. Laboratory exercises deal primarily with computer analysis of remotely-sensed images with some field exercises. Shares lecture/lab, with EARTH 434 but is graded separately and additional graduate-level work is required. (Same as GEOP/HYD 534)

**GEOL 535, Crustal and Mantle Evolution, 3 cr, 3 cl hrs**

Origin and evolution of continents and evolution of the mantle. (Same as GEOC 535)

**GEOL 536, Advanced Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: EARTH 434 or HYD 534 or GEOL 534*

This class deals with quantitative remote sensing for determination of the components of the energy balance (net radiation, latent and sensible heat fluxes, soil heat flux) and soil moisture, hyperspectral and multispectral image processing, radar and microwave imagery. In addition, advanced applications for geology, geophysics and geochemistry will be discussed. Shares lecture/lab with EARTH 436 but is graded separately. (Same as HYD 536)

**GEOL 537, Volcanology Field Trip, 1-6 cr**

*Prerequisite: EARTH 455 or EARTH 456, graduate standing or consent of instructor.*

*Offered on demand*

Field trip to study volcanic rocks in a specific area or volcanological process at an active volcano. Weekly seminars will precede a one- to two-week field trip. A paper is required. Students may register for the course more than once for a total of six credit hours. Same as EARTH 437 but GEOL/GEOP/GEOC537 is graded separately and additional graduate-level work is required.

**GEOL 538, Advanced Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: Consent of instructor*

Advanced topics in geographic information systems (GIS) with a focus on applications in environmental sciences. Emphasis on theoretical aspects and practical applications of GIS science and technology and its integration with remote sensing data and field measurements. Computing exercises and programming projects utilizing GIS software. Discussion of GIS integration with environmental modeling. (Same as ENVS 438/HYD 538)

**GEOL 540, Clastic and Carbonate Diagenesis, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of instructor*

*Offered spring semester, alternate years*

Discussion of clastic and carbonate diagenesis. Topics include: mineralogy and chemistry of authigenic minerals, rock-water interaction, mass transfer, influence of bacteria on diagenetic reactions, application of isotopes, diagenetic controls on porosity and permeability, and influence of depositional environment and detrital mineralogy on diagenesis.

**GEOL 547, Depositional Systems and Basin Analysis, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of instructor*

*Offered fall semester*

Discussion of the spectrum of modern and ancient depositional environments and their relationships to tectonic settings.

**GEOL 549, Astrobiology, 3cr, 3 cl hours**

*Prerequisites: graduate standing or consent of instructor.*

*Offered on demand*

An in-depth and interdisciplinary study of astrobiology, including between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principals of astrophysics and astronomy, geosciences and planetary science, chemistry and bioscience. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Meets with EARTH/BIOLOG 449 (astrobiology), but graded separately and graduate-level work is required.

**GEOL 550, Cave and Karst Systems, 3 cr, 3 cl hrs**

*Prerequisites: CHEM 121 & 122; and either any 100 level EARTH or BIOLOG 111*

*Offered spring semester, even years*

A system-based study of caves and karstic terrains over time including formation mechanisms (speleogenesis), hydrology, geochemistry, mineralogy, and geomicrobiology. Emphasis on caves as interactive microcosms cross-cutting many disciplines. Shares lecture with EARTH 450, but is graded separately and additional graduate-level work is required.

**GEOL 550L, Cave and Karst Lab, 1 cr, 3 lab hrs**

*Offered spring semester, even years*

*Corequisite: GEOL 550*

Survey of techniques applicable to various aspects of speleology and karst studies. Project-based lab, developed for each student in consultation with instructor. Meets with EARTH 450L but is graded separately.

**GEOL 551, Industrial Minerals, 3 cr, 3 cl hrs**

*Prerequisites: Graduate standing or consent of instructor*

*Offered alternate years*

Study of basic concepts of production and use of industrial minerals in modern society. Emphasis on complex interactions between economics, geology, processing, marketing, and transportation. Selected industrial minerals studied in detail. Several field trips to operations and occurrences. (Same as ME 551)



**GEOL 553 Intermediate Structural Geology, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: EARTH 203; PHYS 121 or 131; MATH 131 or consent of instructor.*

*Offered alternate years.*

For entering graduate students lacking undergraduate structural geology background. Elements of fault, fold, and rock mechanics; strain analysis and inference of stress in Earth's crust; construction of balanced, kinematically viable cross sections; brittle and ductile shear-sense indicators in faults and shear zones. Shares lecture and lab with Earth 453 but graded separately.

**GEOL 554, Volcanology Seminar, 3 cr, 3 cl hrs**

*Prerequisite: EARTH 455 or EARTH 456, graduate standing or consent of instructor.*

*Offered on demand*

Seminar discussions of selected topics in volcanology. EARTH 454 and GEOLGEOP/GEOC 554 share lecture and field work, but GEOL/GEOP/GEOC 554 is graded separately and additional graduate-level work is required.

**GEOL 555, Advanced Aqueous Geochemistry, 3 cr, 3 cl hrs**

*Prerequisite: HYD 507 or consent of instructor*

Advanced topics in aqueous geochemistry, including chemical weathering, surface reactivity, colloidal phenomena, environmental organic chemistry, process-based reactive transport modeling, and other topics of interest to those enrolled. The course consists of introductory lectures on each topic followed by review and discussion of current papers from the literature. (Same as GEOC 555 and HYD 555).

**GEOL 556, Advanced Volcanology, 3 cr, 2-3 cl hrs, 1-3 lab hrs**

*Prerequisite: EARTH 356; graduate standing or consent of instructor*

*Corequisite: EARTH 380*

*Offered on demand*

Detailed studies of volcanic processes, pyroclastic rocks and mechanism of volcanic eruptions. Field trips to nearby volcanic fields. EARTH 456 and GEOL/GEOP/GEOC 556 share lecture and field work, but GEOL/GEOP/GEOC 556 is graded separately and additional graduate-level work is required.

**GEOL 558, Mechanics of Earthquakes and Faulting, 3 cr, 3 cl hrs**

*Prerequisites: EARTH 453 or equivalent and graduate standing; or consent of instructor*

*Offered on demand*

Observational and theoretical aspects of brittle failure in the Earth. Fracture mechanics; fault zone geometry and structure; earthquake sources; paleoseismic studies; seismic hazard assessments. (Same as GEOP 558)

**GEOL 566, Regional Tectonics, 3 cr, 3 cl hrs**

*Prerequisite: graduate standing or consent of instructor*

*Offered on demand*

Study of major orogenic belts and processes of orogeny, with emphasis on the tectonic evolution of western North America. Fundamentals of plate tectonics, relationships between plate tectonics and orogeny.

**GEOL 571, 572, Advanced Topics in Geology, 2-3 cr**

Study of a special topic in geology, normally one related to a field of research at Tech.

**GEOL 581, Directed Study, cr to be arranged**

Study under the guidance of a member of the geology staff. In general, subject matter will supplement that available in the other graduate offerings in geology.

**GEOL 590, Independent Study, cr to be arranged**

Organized independent student research coordinated with a faculty member and documented in a final written report.

**GEOL 591, Thesis (master's program), cr to be arranged**

**GEOL 592, Graduate Seminar, 1 cr, 1 cl hr**

*Prerequisite: Graduate standing*

*Offered spring semesters*

Seminar presentations by graduate students on their current research topics. M.S. students must present at least one seminar; Ph.D. students must present at least one seminar in each of two different semesters. Graded on S/U basis; credits earned may not be applied towards the 30 credits required for the M.S. degree. (Same as GEOC 592, GEOP 592, HYD 592)

**GEOL 593, Seminar, 1 cr, 1 cl hr**

*Prerequisite: Graduate standing*

*Offered fall and spring semesters*

Seminar presentations by faculty, students, and outside speakers. Graded on S/U basis. Satisfactory performance consists of regular attendance at approved seminars.

Credit earned may not be applied towards the 30 credits required for the M.S. degree. (Same as GEOC 593, GEOP 593, HYD 593)

**GEOL 595, Dissertation (doctoral degree program), cr to be arranged**

*Prerequisite: CHEM 595*

## Geochemistry

*The Geochemistry program offers an undergraduate degree in Earth Science with Geochemistry Option. See page 141.*

### Master of Science in Geochemistry

The Master of Science degree in Geochemistry may be earned either with thesis or without thesis in accordance with the general requirements of the Graduate Program.

The master's candidate must demonstrate competence in chemistry, geology, mathematics, and physics comparable to the requirements for the Bachelor of Science degree in either chemistry, one of the engineering sciences, or one of the geological sciences.

A program of study for the master's degree must be approved by the student's advisory committee and must satisfy the general requirements for the degree, including GEOC 590 (at least three credit hours) or GEOC 591 (at least six credit hours). Students must complete two credit hours of GEOC 592, at least four credit hours of GEOC 593 (unless the degree is completed in a shorter time), 12 credit hours in geochemistry, (which can also include EARTH 390 (Principles of Geochemistry)) and six credit hours in upper-division or graduate chemistry courses. As part of the degree requirements, students must have completed CHEM 331; GEOC 544, EARTH 200 (mineralogy); or their equivalents.

### Doctor of Philosophy in Earth and Environmental Science with Dissertation in Geochemistry

Students of exceptional ability as demonstrated in previous courses or in a master's degree program may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in Earth and environmental science with specialization in geochemistry should develop a good background in chemistry, geology, mathematics, and physics in addition to achieving a high level of competence in the field of specialization. Ph.D.

students must include three credit hours of GEOC 592 and at least six credit hours of GEOC 593, unless the degree is completed in a shorter time. Additional information is found under the Graduate Program (page 47).

Fields of doctoral dissertation research include geochemistry of ore deposits, trace element and isotope geochemistry of igneous and metamorphic systems, fluid-inclusion geochemistry, geochronology, hydrogeochemistry, stable isotope geochemistry, and environmental geochemistry. Interdisciplinary programs in the Earth science fields are encouraged.

## Geochemistry Graduate Courses:

**GEOC 500, Directed Research, cr to be arranged**

*This course may not be used to fulfill graduate degree requirements.*

Research under the guidance of a faculty member.

**GEOC 507, Hydrogeochemistry, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 122*

*Pre- or Corequisite: EARTH 440*

The thermodynamics and aqueous chemistry of natural waters, with emphasis on groundwater. Chemical equilibrium concepts, surface chemistry, redox reactions, and biochemistry. The interaction of water with the atmosphere and geologic materials. Basic concepts applied to problems of groundwater quality evolution, water use, and groundwater contamination. Shares lecture with EARTH 407. (Same as HYD 507 and CHEM 531)

**GEOC 516, <sup>40</sup>Ar/<sup>39</sup>Ar Geochronology, 3 cr, 3 cl hrs**

*Prerequisite: EARTH 444 or consent of instructor*

*Offered fall semester*

Principles and applications of <sup>40</sup>Ar/<sup>39</sup>Ar geochronology and thermochronology, with applications to geologic systems.

**GEOC 517, Advanced <sup>40</sup>Ar/<sup>39</sup>Ar Geochronology, 3 cr, 3 cl hrs**

Advanced topics, specialized applications, and current research in <sup>40</sup>Ar/<sup>39</sup>Ar geochronology.

**GEOC 535, Crustal and Mantle Evolution, 3 cr, 3 cl hrs**

Origin and evolution of continents and evolution of the mantle. (Same as GEOL 535)

**GEOC 537, Volcanology Field Trip, 1-6 cr**

*Prerequisite: EARTH 455 or EARTH 456, graduate standing, or consent of instructor*

*Offered on demand*

Field trip to study volcanic rocks in a specific area of volcanological processes at an active volcano. A weekly seminar will precede a one-to two-week field trip. A paper is required. A student may register for the class more than once for a total of six credit hours. Same as EARTH 437 but GEOL/GEOP/GEOC 537 is graded separately and additional graduate-level work is required.

**GEOC 544, Principles of Isotope Geochemistry, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 122; EARTH 200; EARTH 203*

*Offered spring semester*

Principles of radiogenic isotope geochemistry and applications to geologic dating and to the petrogenesis of rock suites. Same as EARTH 444 but graded separately with additional graduation-level work.

**GEOC 550, Cave and Karst Systems, 3 cr, 3 cl hrs**

*Prerequisites: CHEM 121 & 122; and either any 100 level EARTH or BIOL 111*

*Offered spring semester, even years*

A system-based study of caves and karstic terrains over time including formation mechanisms (speleogenesis), hydrology, geochemistry, mineralogy, and geomicrobiology. Emphasis on caves as interactive microcosms cross-cutting many disciplines. Shares lecture with EARTH 450, but is graded separately and additional graduate-level work is required. Same as GEOC 550.

**GEOC 550L, Cave and Karst Lab, 1 cr, 3 lab hrs**

*Offered spring semester, even years*

*Corequisite: GEOL/GEOC 550*

Survey of techniques applicable to various aspects of speleology and karst studies. Project-based lab, developed for each student in consultation with instructor. Meets with EARTH 450L but is graded separately. Same as GEOL 550L.

**GEOC 554, Volcanology Seminar, 3 cr, 3 cl hrs**

*Prerequisite: EARTH 455 or EARTH 456, graduate standing, or consent of instructor*

*Offered on demand*

Seminar discussions of selected topics in volcanology. EARTH 454 and GEOL/GEOP/GEOC 554 share lecture and field work, but GEOL/GEOP/GEOC 554 is graded separately and additional graduate-level work is required.

**GEOC 555, Advanced Aqueous Geochemistry, 3 cr, 3 cl hrs**

*Prerequisite: HYD 507 or consent of instructor*

Advanced topics in aqueous geochemistry, including chemical weathering, surface reactivity, colloidal phenomena, environmental organic chemistry, process-based reactive transport modeling, and other topics of interest to those enrolled. The course consists of introductory lectures on each topic followed by review and discussion of current papers from the literature. (Same as GEOL 555 and HYD 555).

**GEOC 556, Advanced Volcanology, 3 cr, 2-3 cl hrs, 1-3 lab hrs**

*Prerequisite: EARTH 356, graduate standing, or consent of instructor*

*Corequisite: EARTH 380*

*Offered on demand*

Detailed studies of volcanic process, pyroclastic rocks and mechanism of volcanic eruptions. Field trips to nearby volcanic fields. EARTH 456 and GEOL/GEOP/GEOC 556 share lecture and field work, but GEOL/GEOP/GEOC 556 is graded separately and additional graduate-level work is required.

**GEOC 558, Environmental Tracers in Hydrology, 3 cr, 3 cl hrs**

*Prerequisites: EARTH 440; HYD 507*

*Offered in alternate years*

Atomic structure and abundances of environmental isotopes. Stable isotope fractionation. Mass spectrometry. Applications of the stable isotopes of hydrogen, oxygen, and carbon to meteorology and hydrology. Radioactive decay and radionuclide production. Applications of tritium,  $^3\text{He}$ ,  $^{14}\text{C}$ ,  $^{36}\text{Cl}$ , and other radionuclides. Application of  $\text{Cl}^-$ , Br, chlorofluorocarbons and other environmental tracers to hydrologic problems. (Same as HYD 558)

**GEOC 565, Stable Isotope Geochemistry, 3 cr, 3 cl hrs**

*Offered fall semester*

Principles of stable isotope geochemistry with applications to geologic systems.

**GEOC 566, Practical Aspects of Mass Spectrometry, 3 cr, 1 cl hr, 6 lab hrs**

*Prerequisites: GEOC 565; consent of instructor*

*Offered spring semester*

Theory and application of stable isotope mass spectrometry. Through lectures, problem sets, and laboratory exercises, students learn how to analyze geologic samples to determine stable isotope composition.

**GEOC 567, Practical Aspects of Argon Mass Spectrometry, 2 cr, 2 cl hr**

*Prerequisites: GEOC 516 or consent of instructor  
Offered spring semester*

Theory and application of noble gas mass spectrometry. Through lectures, problem sets, and laboratory exercises students obtain hands-on experience for analysis of geologic samples to determine sample age and/or thermal history. Each student conducts a research project and presents the results in written and oral reports.

**GEOC 571, 572, Advanced Topics in Geochemistry, 2 or 3 cr**

Study of a special topic in geochemistry, normally one related to a field of research at Tech.

**GEOC 575, Theory and Practice of Electron Microprobe Analysis, 1 cr**

*Prerequisites: EARTH 380; consent of instructor*

Principles, techniques and applications of electron microprobe analysis: X-ray theory, sample preparation techniques, hands-on analysis using the electron microprobe, techniques of instrument calibration and data reduction. Emphasis on analysis of geological samples. Class participation is required for students who plan to use the electron microprobe as part of their thesis research. Class time will be divided between lecture and hands-on sample preparation and analysis.

**GEOC 581, Directed Study, cr to be arranged**

Study under the guidance of a member of the geochemistry staff. In general, subject matter will supplement that available in the other graduate offerings in geochemistry.

**GEOC 590, Independent Study, cr to be arranged**

Organized independent student research coordinated with a faculty member and documented in a final written report.

**GEOC 591, Thesis (master's program), cr to be arranged**

**GEOC 592, Graduate Seminar, 1 cr, 1 cl hr**

*Prerequisite: Graduate standing  
Offered spring semesters*

Seminar presentations by graduate students on their current research topics. M.S. students must present at least one seminar; Ph.D. students must present at least one seminar in each of two different semesters. Graded on S/U basis; credits earned may not be applied towards the 30 credits required for the M.S. degree (same as GEOL 592, GEOP 592, HYD 592)

**GEOC 593, Seminar, 1 cr, 1 cl hr**

*Prerequisite: Graduate standing  
Offered fall and spring semesters*

Seminar presentations by faculty, students, and outside speakers. Graded on S/U basis. Satisfactory performance consists of regular attendance at approved seminars. Credit earned may not be applied towards the 30 credits required for the M.S. degree. (Same as GEOL 593, GEOP 593, HYD 593)

**GEOC 595, Dissertation (doctoral degree program), cr to be arranged**

*Prerequisite: CHEM 595*

## Geophysics (Solid Earth)

*The Geophysics program offers an undergraduate degree in Earth Science with Geophysics option. See page 141.*

### Graduate Program

#### Requirements for the Master of Science in Geophysics (Solid Earth)

The Master of Science degree in Geophysics (Solid Earth) may be earned under either of the plans outlined below:

##### With Thesis:

The student's course of study must be approved by the advisory committee and must fulfill the general requirements for the master's degree with thesis and must include (unless taken in undergraduate work): EARTH 325, 445, and 448, or their equivalents; upper-division geology, six credit hours; competence in mathematics corresponding to nine credit hours beyond calculus; at least six credit hours of GEOP 591, two credit hours of GEOP 592, at least four credit hours of GEOP 593, unless the degree is completed in a shorter time, and twelve additional credit hours in graduate geophysics (up to six credit hours of this requirement may be replaced with non-geophysics graduate courses with the advisor's approval).

##### Without Thesis:

Courses approved by the student's advisory committee must fulfill the general requirements for the master's degree without thesis and must include (unless taken in undergraduate work): EARTH 325, 445, and 448, or their equivalents; upper-division geology, six credit hours; competence in mathematics corresponding to nine credit hours beyond calculus; at least three credit hours of GEOP 590, two credit hours of GEOP 592, at least four

credit hours of GEOP 593, unless the degree is completed in a shorter time, and twelve additional credit hours of graduate courses in geophysics (up to six credit hours of this requirement may be replaced with non-geophysics graduate courses with the advisor's approval).

### **Doctor of Philosophy in Earth and Environmental Science with Dissertation in Geophysics**

Students of exceptional ability as demonstrated by previous academic achievement may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in Earth and environmental science with specialization in physics of the solid Earth should develop a solid background in physics, mathematics, and geology in addition to achieving a high level of competence in the field of geophysics.

With the approval of the advisory committee, the student should select a program including a minimum of nine credit hours in graduate geophysics beyond the M.S. degree, three credit hours of GEOP 592, at least four credit hours of GEOP 593, unless the degree is completed in a shorter time, plus additional courses in related fields.

Research fields appropriate for the geophysics candidate include crustal exploration, earthquake seismology, tectonophysics, environmental, and hydrogeothermal studies. Interdisciplinary programs in the Earth science fields are encouraged.

## **Geophysics Graduate Courses:**

### **GEOP 500, Directed Research, cr to be arranged**

*This course may not be used to fulfill graduate degree requirements.*

Research under the guidance of a faculty member.

### **GEOP 505, Analysis of Time Series and Spatial Data, 3 cr, 3 cl hrs**

*Offered in alternate years*

An introductory overview of methods for analyzing temporal and spatial series with an emphasis on scientific applications. Linear systems in continuous and discrete time, Fourier analysis, spectral estimation, convolution and deconvolution, filtering, the z and Laplace transforms, stationary and nonstationary time series, ARIMA modeling, forecasting, and generalizations to multidimensional and multichannel applications. (Same as MATH 587 and HYD 587)

### **GEOP 523, Theoretical Seismology, 3 cr, 3 cl hrs**

*Offered in alternate years*

Linear elastic wave theory including reflection and refraction of elastic waves, propagation of body and surface waves, free oscillations of an elastic sphere, seismic rays in a spherically-stratified Earth, and earthquake mechanisms.

### **GEOP 524, Observational Seismology, 3 cr, 3 cl hrs**

*Offered in alternate years*

Techniques and methods in earthquake seismology including seismometry and seismic networks, earthquake location, earthquake statistics, strong-motion seismology, and seismic source parameters.

### **GEOP 525, Tectonophysics, 3 cr, 3 cl hrs**

*Offered in alternate years*

An analytical study of the problems of earthquake generation, faulting, mountain building, and volcanism. Emphasis is placed upon the formulation of mathematical models which explain the physical observations.

### **GEOP 529, Geophysical Inverse Methods, 3 cr, 3 cl hrs**

*Offered in alternate years*

Theory and practice of the various techniques of inverting geophysical data to obtain models. Primary emphasis is on the understanding and use of linear inverse techniques. (Same as MATH 519)

### **GEOP 534, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: PHYS 122 or 132 or consent of instructor*

Introduction to the theory and practical use of remotely sensed satellite images. Principles of radiation physics; sensor systems; data acquisition; image analysis; classification schemes. Remote sensing applications to atmospheric sciences, hydrology, mineral and oil exploration, natural hazards monitoring, and land and resources management. Laboratory exercises deal primarily with computer analysis of remotely-sensed images with some field exercises. EARTH 434 and GEOP 534 share lecture/lab, but GEOP 534 is graded separately and additional graduate-level work is required. (Same as GEOL/HYD 534)

### **GEOP 537, Volcanology Field Trip, 1-6 cr**

*Prerequisite: EARTH 455 or EARTH 456, graduate standing, or consent of instructor*

*Offered on demand*

Field trip to study volcanic rocks in a specific area of volcanological processes at an active volcano. A weekly seminar will precede a one-to two-week field trip. A paper is required. A student may register for the class more than once for a total of six credit hours. Same as EARTH 437 but GEOL/GEOP/GEOC 537 is graded separately and additional graduate-level work is required.

**GEOP 546, Reflection Seismic Data Interpretation, 3 cr, 2 cl hrs, 2 lab hrs**

*Prerequisites: EARTH 445 or equivalent, graduate standing or consent of instructor.*

*Offered alternate years.*

An overview of the fundamentals of the geologic (both structural and stratigraphic) interpretation of 2D and 3D reflection seismic data. An introduction to seismic acquisition and processing and their effects on interpretation. Techniques covered include: well log to seismic ties, contour maps, fault plane maps, time-to-depth conversion, seismic sequence analysis, and workstation interpretation of 3D data. Designed for student with a range of earth science and engineering backgrounds. Shares lecture/lab with EARTH 446, but is graded separately and additional graduate-level work is required.

**GEOP 551, Volcano Geophysics, 3 cr, 3 cl hrs**

*Prerequisites: Graduate Standing*

*Offered spring semester, odd-numbered years.*

Provides an overview of geophysical tools and techniques used for monitoring and scientific study of active volcanoes. Subject material will focus on seismology, infrasound, geodesy, and optical remote sensing mostly from ground-based perspectives although reference to related satellite techniques will be covered. EARTH451 and GEOP551 share lecture and lab work, but GEOP 551 is graded separately and additional graduate-level work is required.

**GEOP 554, Volcanology Seminar, 3 cr, 3 cl hrs**

*Prerequisite: EARTH 455 or EARTH 456, graduate standing, or consent of instructor*

*Offered on demand*

Seminar discussions of selected topics in volcanology. EARTH 454 and GEOL/GEOP/GEOC 554 share lecture and field work, but GEOL/GEOP/GEOC 554 is graded separately and additional graduate-level work is required.

**GEOP 555, Volcano Geophysics Field Trip, 1-6 cr**

*Prerequisites: Consent of instructor.*

*Offered on demand*

An intensive field and lab computer-based class to teach the principles of hardware installation, data collection, digital signal processing, and analysis of geophysical data in an active volcanic environment. Students will be grounded in seismic data acquisition, but training may also include infrasound, geodesy, thermal, and gas sensing surveys. EARTH 455 and GEOP 555 share lecture and field work, but EARTH 455 is graded separately.

**GEOP 556, Advanced Volcanology, 3 cr, 2-3 cl hrs, 1-3 lab hrs**

*Prerequisite: EARTH 356, graduate standing, or consent of instructor*

*Corequisite: EARTH 380*

*Offered on demand*

Detailed studies of volcanic process, pyroclastic rocks and mechanism of volcanic eruptions. Field trips to nearby volcanic fields. EARTH 456 and GEOL/GEOP/GEOC 556 share lecture and field work, but GEOL/GEOP/GEOC 556 is graded separately and additional graduate-level work is required.

**GEOP 557, Reflection Seismic Data Processing, 3 cr, 2 cl hrs, 2 lab hrs**

*Prerequisites: EARTH 445 or equivalent, graduate standing or consent of instructor.*

*Offered alternate years.*

The computer application of digital signal processing to reflection seismic data from environmental, petroleum, and crustal surveys. Topics covered include: definition of survey geometries, data editing techniques, amplitude recovery, bandpass filtering, deconvolution, velocity analysis, F-K filtering, and migration. Shares lecture/lab with EARTH 457, but is graded separately and additional graduate-level work is required.

**GEOP 558, Mechanics of Earthquakes and Faulting, 3 cr, 3 cl hrs**

*Prerequisites: EARTH 453 or equivalent and graduate standing; or consent of instructor*

*Offered on demand*

Observational and theoretical aspects of brittle failure in the Earth. Fracture mechanics; fault zone geometry and structure; earthquake sources; paleoseismic studies; seismic hazard assessments. (Same as GEOL 558)

**GEOP 570, Current Topics in Earthquake Seismology, 3 cr, 3 cl hrs**

*Prerequisite: consent of instructor*

*Offered on demand*

A seminar of current research topics in earthquake seismology with an emphasis on the critical review of recently published papers and preprints.

**GEOP 571, 572, Advanced Topics in Geophysics, 2-3 cr each semester**

*Offered on demand*

Study of advanced topics in geophysics.

**GEOP 581, Directed Study, cr to be arranged**

Study under the guidance of a member of the graduate faculty. In general, subject matter will supplement that available in the other graduate course offerings.

**GEOP 590, Independent Study, cr to be arranged**

Organized independent student research coordinated with a faculty member and documented in a final written report.

**GEOP 591, Thesis (master's program), cr to be arranged****GEOP 592, Graduate Seminar, 1 cr, 1 cl hr**

*Prerequisite: Graduate standing*

*Offered spring semesters*

Seminar presentations by graduate students on their current research topics. M.S. students must present at least one seminar; Ph.D. students must present at least one seminar in each of two different semesters. Graded on S/U basis; credits earned may not be applied towards the 30 credits required for the M.S. degree (same as GEOL 592, GEOC 592, HYD 592)

**GEOP 593, Seminar, 1 cr, 1 cl hr**

*Prerequisite: Graduate standing*

*Offered fall and spring semesters*

Seminar presentations by faculty, students, and outside speakers. Graded on S/U basis. Satisfactory performance consists of regular attendance at approved seminars. Credit earned may not be applied towards the 30 credits required for the M.S. degree. (Same as GEOC 593, GEOL 593, HYD 593)

**GEOP 595, Dissertation (doctoral degree program), cr to be arranged**

*Prerequisite: CHEM 595*

# Hydrology

*The Hydrology program offers an undergraduate degree in Earth Science with Hydrology option. See page 141.*

## Graduate Program

### Master of Science in Hydrology

The Master of Science degree in Hydrology requires completion of a thesis according to the general requirements of the Graduate Program.

The student's course of study must be approved by the advisory committee and must fulfill the general requirement for the master's degree and must include:

- EARTH 440, HYD 507, 508, 510, 547
- Six credits from the following: EARTH 441, EARTH 442, EARTH 443, HYD 531, HYD 532, HYD 533, HYD 541, HYD 542, HYD 543, HYD 544, or other approved 1-credit HYD courses
- HYD 591 (at least six credit hours)
- HYD 592 (two credit hours) and HYD 593 (four credit hours)
- EARTH 202 or equivalent
- MATH 283 or 382 or equivalent
- At least three additional graduate-level course credits approved by the advisory committee.
- Note that credits earned in HYD 592 and 593 may not be applied toward the 30 credits required for the M.S. degree.
- The Institute Graduate Degree Requirements must also be satisfied.

Examples of courses other than hydrology which are appropriate for graduate programs in hydrology include, but are not limited to: BIOL 343, 442, 446; CHEM 331, 332, 333, 334; EARTH 370, 405, 409, 444, 445, 448, 460; GEOC 543; GEOL 503, 509, 547, 553; GEOP 505, 529; MATH 332, 382, 384, 410, 411, 415, 433, 434, 435, 436, 438, 483, 486, 488, 511, 512, 533, 534, 586, 587; PETR 445, 523, 544, 546, 564; PHYS 421, 526.

### Master of Science in Hydrology Options in Petroleum and Environmental Geofluids

The Geofluids option offers multidisciplinary course curricula leading to the Masters of Science Degree in Hydrology with tracks in Petroleum or Environmental studies.

The student's course of study must be approved by the advisory committee and must fulfill the general requirement for the master's degree and must include:

- EARTH 440 and 440L, EARTH 441, EARTH 460, HYD 508, HYD 510, HYD 571, HYD 592, HYD 591.

### Geofluids Petroleum Track

- Nine credits from the following: EARTH 325, EARTH 445, GEOL 547, GEOP 546, PETR 370, PETR 345, PETR 445, PETR 546

### Geofluids Environmental Track

- Nine credits from the following: EARTH 325, EARTH 422, GEOL 509, HYD 507, HYD 532, HYD 538, HYD 541, HYD 544, HYD 546, HYD 547, HYD 558.

### Doctor of Philosophy in Earth and Environmental Science with Dissertation in Hydrology

Students of exceptional ability as demonstrated in previous courses or in a master's degree program may pursue a program leading to the doctoral degree.

The prospective doctoral candidate in Earth and environmental science with specialization in hydrology should develop a good background in physics, mathematics, chemistry, and geology in addition to achieving a high level of competence in the field of specialization.

With approval of the advisory committee, the student should select a program including a minimum of nine credits in graduate hydrology beyond the M.S. degree, three credits of HYD 592, six credits of HYD 593, plus additional courses in related fields. Some appropriate courses are given under the Master of Science degree requirements.

Research fields appropriate for the doctoral candidate include regional hydrology, groundwater recharge, vadose zone hydrology, stochastic subsurface hydrology, hydrogeochemistry, isotope hydrology, hydroclimatology, pollutant transport, aquifer restoration, multi-phase flow of immiscible fluids, deterministic and stochastic numerical aquifer simulation, finite difference and finite element numerical methods, and field instrumentation.

Interdisciplinary programs in the Earth science fields are encouraged.

### Graduate Certificate Program in Hydrology

The Hydrology Certificate program is aimed at working professionals or students who wish to increase their qualifications in Hydrology outside of a degree program. The program covers fundamentals of atmospheric, surface, and subsurface hydrology while leaving flexibility to focus on related areas of particular individual interest. The Certificate requires a minimum of 15 credit hours of graduate and upper division course work as follows:

- EARTH 440 (3), EARTH 441 (1), EARTH 442 (1), EARTH 443 (1)
- HYD 510 (3)
- Additional credits of advisor-approved graduate-level coursework (6)

## Hydrology Graduate Courses:

### HYD 500, Directed Research, cr to be arranged

*This course may not be used to fulfill graduate degree requirements.*

Research under the guidance of a faculty member.

### HYD 507, Hydrogeochemistry, 3 cr, 3 cl hrs

*Prerequisite: CHEM 122*

*Pre- or Corequisite: EARTH 440*

*Offered fall semesters*

The thermodynamics and aqueous chemistry of natural waters, with emphasis on groundwater. Chemical equilibrium concepts, surface chemistry, redox reactions, and biochemistry. The interaction of water with the atmosphere and geologic materials. Basic concepts applied to problems of groundwater quality evolution, water use, and groundwater contamination. Shares lecture with EARTH 407. (Same as GEOC 507)

### HYD 508, Flow and Transport in Hydrologic Systems, 4 cr, 3 cl hrs, 3 lab/recitation hrs

*Prerequisites: EARTH 440, 440L and 510*

*Offered spring semester*

Principles of flow and transport in hydrological systems, including rivers, lakes, aquifers, the vadose zone, glaciers and the lower atmosphere. Fluid mechanical and thermodynamic properties, fluid statics, fluid dynamics, including mass, momentum and energy conservation, and transport of heat, particles and non-reactive chemicals with fluid flow. Single and multiphase laminar flow in porous and fractured permeable media. Turbulence and related topics that are of particular interest to hydrologists.

### HYD 510, Quantitative Methods in Hydrology, 3 cr, 2 cl hrs, 3 lab hrs

*Prerequisite: MATH 231; Pre or Corequisite EARTH 440*

*Offered fall semester*

Introduction to the methods of mathematical physics used in hydrologic science. Presented in the context of mathematical models of water and energy balances, fluid flow, and heat & solute transport. Application to aquifers, the vadose zone, land-surface runoff, rivers, and the atmospheric boundary layer. Methods span advanced engineering calculus, including numerics and differential equations. Use of software (Matlab, Maple, and COMSOL Multiphysics) for problem solving and solution presentation. Programming with Matlab.



**HYD 531, Aquifer Mechanics, 1 cr, 1 cl hr**

*Prerequisite: EARTH 440 and 440L*

*Offered spring semester*

Physics of flow to wells, steady-state and transient solutions to well hydraulics equations, image well theory, responses of aquifers to perturbations.

**HYD 532, Vadose Zone Dynamics, 1 cr, 1 cl hr**

*Prerequisite: EARTH 440, 440L, 442, HYD 510 or consent of instructor*

*Offered spring semester*

Physical processes governing fluid, solute, heat, and gas transport through the vadose zone; plant water uptake; applications of the model HYDRUS1D for the evaluation of these physical processes.

**HYD 533, Runoff and Flood Processes, 1 cr, 1 cl hr**

*Corequisite: EARTH 440 and 440L or HYD 510*

*Offered spring semester*

Processes leading to runoff formation in watersheds and the transformation of a flood pulse through a channel network system. Emphasis on physical mechanisms and their treatment in models, as well as observations made in the field.

**HYD 534, Introduction to Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: PHYS 122 or 132 or consent of instructor*

Introduction to the theory and practical use of remotely sensed satellite images. Principles of radiation physics; sensor systems; data acquisition; image analysis; classification schemes. Remote sensing applications to atmospheric sciences, hydrology, mineral and oil exploration, natural hazards monitoring, and land and resources management. Laboratory exercises using ERDAS Imagine deal primarily with computer analysis of remotely sensed images with some field exercises. Shares lecture/lab with EARTH 434, but is graded separately. (Same as GEOL/GEOP 534)

**HYD 535, Engineering and Science Applications of Vadose Zone Modeling, 1 cr, 1 cl hr**

*Prerequisites: EARTH 440, EARTH 442, HYD 510 or consent of instructor*

Application of the HYDRUS models in 1, 2, and 3-dimensions, and COMSOL Multiphysics, for the evaluation of variably saturated flow and transport. After an introduction to the HYDRUS models, hydrology and engineering students will work on their own HYDRUS application dealing with typical geotechnical, agricultural, and ecohydrological simulations including slope stability, drainage through tailings and rock piles, hazardous waste migration, soil moisture controls on evapotranspiration and vegetation growth.

**HYD 536, Advanced Remote Sensing, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: EARTH 434 or HYD 534 or GEOL 534*

*Offered on demand*

This class deals with quantitative remote sensing for determination of the components of the energy balance (net radiation, latent and sensible heat fluxes, soil heat flux) and soil moisture, hyperspectral and multispectral image processing, radar and microwave imagery. In addition, advanced applications for geology, geophysics and geochemistry will be discussed. Shares lecture/lab with EARTH 436, but is graded separately. (Same as GEOL 536)

**HYD 538, Advanced Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: Consent of instructor*

Advanced topics in geographic information systems (GIS) with a focus on applications in environmental sciences. Emphasis on theoretical aspects and practical applications of GIS science and technology and its integration with remote sensing data and field measurements. Computing exercises and programming projects utilizing GIS software. Discussion of GIS integration with environmental modeling. (Same as ENV 438/GEOL 538)

**HYD 541, Water Resources Management, 1 cr, 1 cl hr**

*Prerequisite: EARTH 440 and 440L*

*Offered alternate spring semesters*

Social and economic basis for administering water. Comparison of American Indian and European attitudes toward the hydrological system. Fundamentals of water law and policy in the United States.

**HYD 542, Hillslope Hydrology, 1 cr, 1 cl hr**

*Prerequisites: EARTH 440, 440L, 442, HYD 510, HYD 532 or consent of instructor*

Physical processes governing water flow through hillslope systems and into receiving streams.

**HYD 543, Ecohydrology, 1 cr, 1 cl hr**

*Prerequisites: EARTH 440 and 440L*

Interactions between terrestrial plants and water, nutrients, and light resources in semiarid environments. Ecohydrological processes, dynamics, and simple numerical models.

**HYD 544, Groundwater Remediation, 1 cr, 1 cl hr**

*Prerequisites:* EARTH 440, HYD 507, HYD 510

*Pre- or corequisite* EARTH 441

*Offered alternate spring semesters*

Coverage of accepted and emerging techniques to remove or control groundwater contaminants. Emphasis is placed on the suitability of techniques for dealing with inorganic, organic, and biological contaminants of differing properties. Evaluation of the current and projected regulatory environment as a driver for groundwater cleanup.

**HYD 545, Stochastic Methods in Groundwater****Hydrology, 3 cr, 3 cl hrs**

*Prerequisites:* HYD 508; MATH 382, 586

*Offered on demand*

Selected topics from the theory of stochastic processes and random fields with applications to natural variability in groundwater hydrology; stochastic differential equations, spectral representation, perturbation methods, Monte Carlo simulation, Kalman filtering, kriging, Bayesian estimation, conditional simulation and related topics. Applications include estimation of aquifer parameters, effective properties of heterogeneous media, macroscopic dispersion, and monitoring network design.

**HYD 546, Contaminant Hydrology, 3 cr, 3 cl hrs**

*Prerequisites:* EARTH 440; HYD 507

*Pre- or Corequisite:* HYD 508

*Offered alternate fall semesters*

The physics, chemistry, and biology of inorganic, organic, and microbial contaminants in groundwater and surface water systems. Mechanisms by which contaminants are introduced. Transport and transformations of contaminants in surface waters, the vadose zone, and the saturated zones. Movement, capillary trapping, and solubility of relatively immiscible organic liquids. Contaminant isolation and remediation techniques.

**HYD 547, Hydrological Modeling, 3 cr, 3 cl hrs**

*Prerequisites:* EARTH 440, HYD 508, HYD 510

Analysis and synthesis of issues in hydrologic science. Related engineering problem solving. Conceptual modeling process: model conceptualization and parameterization, model diagnosis, testing and validation, and model prediction. Conceptual models for testing scientific hypotheses, assimilating data, developing policy, and solving engineering design and operational problems. Applications to land-surface, surface water, vadose zone, and groundwater, singly and together, and to their interfaces with the atmosphere and oceans.

**HYD 548, Laboratory and Field Methods in Hydrology, 3 cr, 1 cl hr, 6 lab hrs**

*Prerequisite:* Consent of instructor

*Offered on demand*

Instrumentation and methodologies used in hydrological investigations in a field or laboratory setting. Course topics may range across a variety of physical and chemical hydrological techniques in vadose, groundwater and surface hydrology. Examples of potential topical areas include, but are not limited to, aquifer, lake and stream sample collection, storage and analysis, aquifer and watershed characterization, discharge measurements and tracer tests, land surface-atmosphere flux measurements, and hydrologic field campaigns.

**HYD 552, Fluid/Surface Interactions, 3 cr, 3 cl hrs**

*Prerequisite:* Consent of instructor

*Offered in alternate years*

The physics and chemistry of interfaces, focusing on the behavior of multifluid systems both in the presence and absence of solids. How basic interactions among microscopic particles can explain macroscopic phenomena. Application-oriented, focusing on interactions important in hydrology, petroleum engineering, and environmental engineering. (Same as PETR 552)

**HYD 554, Environmental Physics for****Evapotranspiration, 3 cr, 3 cl hrs**

*Prerequisites:* EARTH 440,508; or consent of instructor.

The first part of the course includes elements of environmental physics: radiation balance of the Earth's surface; transfer of momentum, heat, and mass; and crop micrometeorology. The second part focuses on vegetation water use and evapotranspiration: measurement methods; evaluation from meteorological observations; and prediction of spatial and temporal distribution of regional evapotranspiration using remote sensing.

**HYD 555, Advanced Aqueous Geochemistry, 3 cr, 3 cl hrs**

*Prerequisite:* HYD 507 or consent of instructor

Advanced topics in aqueous geochemistry, including chemical weathering, surface reactivity, colloidal phenomena, environmental organic chemistry, process-based reactive transport modeling, and other topics of interest to those enrolled. The course consists of introductory lectures on each topic followed by review and discussion of current papers from the literature. (Same as GEOL 555 and GEOC 555.)

**HYD 558, Environmental Tracers in Hydrology, 3 cr, 3 cl hrs**

*Prerequisites: EARTH 440; HYD 507*

*Offered in alternate years*

Atomic structure and abundances of environmental isotopes. Stable isotope fractionation. Mass spectrometry. Applications of the stable isotopes of hydrogen, oxygen, and carbon to meteorology and hydrology. Radioactive decay and radionuclide production. Applications of tritium,  $^3\text{He}$ ,  $^{14}\text{C}$ ,  $^{36}\text{Cl}$ , and other radionuclides. Application of  $\text{Cl}^-$ ,  $\text{Br}$ , chlorofluorocarbons and other environmental tracers to hydrologic problems. (Same as GEOC 558)

**HYD 560, Applied Groundwater Hydrology, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites: HYD 508*

*Offered on demand*

Topics for in-depth investigation may include well design, aquifer pumping test design and interpretation, groundwater flow simulation, and aquifer contamination. Field experiments, field trips, lab analysis, computer work, technical report preparation, and oral presentations.

**HYD 570, Seminar in Hydrology, 2 cr, 2 cl hrs**

Review and discussion of papers relating to hydrology.

**HYD 571, 572, Advanced Topics in Hydrology, 1–3 cr each semester**

*Offered on demand*

Study of special topics in hydrology.

**HYD 581, Directed Study, cr to be arranged**

Study under the guidance of a member of the graduate faculty. In general, subject matter will supplement that available in the other graduate course offerings.

**HYD 587, Analysis of Time Series and Spatial Data, 3 cr, 3 cl hrs**

*Offered in alternate years*

An introductory overview of methods for analyzing temporal and spatial series with an emphasis on scientific applications. Linear systems in continuous and discrete time, Fourier analysis, spectral estimation, convolution and deconvolution, filtering, the  $z$  and Laplace transforms, stationary and nonstationary time series, ARIMA modeling, forecasting, and generalizations to multidimensional and multichannel applications. (Same as MATH 587 and GEOP 505)

**HYD 590, Independent Study, cr to be arranged**

Organized independent student research coordinated with a faculty member and documented in a final written report.

**HYD 591, Thesis (master's program), cr to be arranged****HYD 592, Graduate Seminar, 1 cr, 1 cl hr**

*Prerequisite: Graduate standing*

*Offered spring semesters*

Seminar presentations by graduate students on their current research topics. M.S. students must present at least one seminar; Ph.D. students must present at least one seminar in each of two different semesters. Graded on S/U basis; credits earned may not be applied towards the 30 credits required for the M.S. degree (same as GEOL 592, GEOC 592, GEOP 592)

**HYD 593, Seminar, 1 cr, 1 cl hr**

*Prerequisite: Graduate standing*

*Offered fall and spring semesters*

Seminar presentations by faculty, students, and outside speakers. Includes both Department and hydrology-specific seminars. Graded on S/U basis. Satisfactory performance consists of regular attendance at approved seminars. Credit earned may not be applied towards the 30 credits required for the M.S. degree. (Same as GEOC 593, GEOL 593, GEOP 593)

**HYD 595, Dissertation (doctoral degree program), cr to be arranged**

*Prerequisite: CHEM 595*

## Faculty Research Interests

Aster—Earthquake and Volcano Seismology, Seismic Imaging, Inverse Methods, Antarctic Geophysics, Seismic Instrumentation

Axen—Continental Tectonics, Fault Mechanics, and Geothermal Resources

Bilek—Earthquake Rupture Processes, Stresses and Structure of Fault Zones, Shallow Subduction Zone Processes, Tsunami

Blamey—Fluid Inclusions, Geothermal and Hydrothermal Systems, Ore Deposits, Fluid-Rock Equilibria

Boston—Caves, Karst Systems, Geomicrobiology, Extremophile Organisms, Geobiochemical Cycling, Astrobiology, Robotic and Human Exploration of Other Planets, Comparative Planetology, Evolutionary Implications of Conjoined Organic/Cybernetic Devices

Campbell—Metallic Ore Deposits, Stable Isotope Geochemistry, Carbon Sequestration

Condie—Trace Element and Isotope Geochemistry, Precambrian Studies

Harrison—Soil Properties, Recurrence Intervals of Earthquakes, Soil Salinization in Arid Environments, Soil Stability

Hendrickx—Vadose Zone Hydrology, Remote Sensing of Energy Balance, Soil Physics, Environmental Biophysics

D. Johnson—Biostratigraphy, Paleozoic Depositional Environments

J. Johnson—Volcanology, eruptive processes, integrated geophysical measurements, numerical modeling

Kyle—Igneous Geochemistry, Antarctic Geology, Volcanology

McIntosh—Cenozoic Volcanism, Paleomagnetism, Antarctic Studies, Argon Dating

Mozley—Environmental Geology, Sedimentary Petrology, Low-Temperature Geochemistry, Carbon Sequestration

Murray—Crustal Deformation and Rheology, Geodetic Measurements, Earthquake and Volcano Hazards

Person—Paleohydrology, Basin-Scale Numerical Modeling, Geothermal Systems, Carbon Sequestration, Role of Groundwater in Geologic Processes

Phillips—Groundwater Chemistry, Isotope Hydrology, Groundwater Dating, Quaternary Studies

Reusch—Polar climates and climate change through meteorology, ice cores, sea ice, climate modeling and artificial neural network techniques.

Spinelli—Marine Hydrogeology and Heat Flow,

Groundwater-Surface Water Interactions, Sediment Physical Properties

Ulmer-Scholle—Carbonate Diagenesis; Sedimentary Petrography, Fluid Inclusions and Thermal and Fluid Histories of Carbonate Basins, Carbonate Depositional Environments, Carbon Sequestration, Computer-Based Applications and Geological Training

Wilson—Groundwater Hydrology, Numerical and Analytical Modelling, Stochastic Hydrology, Colloid and Bacteria Transport

## Adjunct Faculty Research Interests

Bauer—Structural Geology and Tectonics, Precambrian Geology

Blamey—Fluid Inclusions, Geothermal and Hydrothermal Systems, Ore Deposits, Fluid-Rock Equilibria

Broadhead—Petroleum Geology, Stratigraphy

Cather—Clastic and Volcaniclastic Sedimentology, Basin Analysis, Regional Tectonics

Chamberlin—Ignimbrite Calderas of Central New Mexico, Structure & Stratigraphy of Central Rio Grande Rift

Chapin—Volcanology, Tectonics, Economic Geology

Connell—Neogene and Quaternary Geology and Stratigraphy, Geomorphology

Creech-Eakman—Characterization of Exoplanet Atmospheres and Associated Planetary Properties (NESSI—New Mexico Tech Extrasolar Spectroscopic Survey Instrument); Mid-infrared Imaging, Spectroscopy and Optical Interferometry; Pulsation and Dust Production in Mira Variables

Dunbar—Igneous Petrology, Volcanology, Trace Element Behavior in High- and Low-Temperature Aqueous Systems, Microprobe Geochemical Analysis

Hawley—Geomorphology, Quaternary Stratigraphy, Environmental Geology, Hydrogeology

Heizler— $^{40}\text{Ar}/^{39}\text{Ar}$  Thermochronology

Kelley—Fission-Trace Thermochronology, Tectonics, Thermal Studies

Kieft—Geomicrobiology of Soils and Subsurface Environments

Land—Cave and Karst Hydrology, Hydrogeology

Love—Environmental Geology, Quaternary Geology, Sedimentology

McCord—Vadose Zone Hydrology, Numerical Modeling, Stochastic Hydrology

McLemore—Economic Geology  
 Pullin—Aqueous environmental chemistry; natural organic carbon and metal ions in the environment; analytical methods for natural waters.  
 Reiter—Geothermics, Hydrogeothermics, Crustal Geodynamics  
 Rowe—Volcano and Structural Seimology, Signal Processing  
 Scholle—Carbonate Sedimentology and Petroleum Geology; Controls on Diagenesis and Porosity in Chalks; Paleozoic Carbonates of New Mexico  
 Stephens—Hydrogeology, Unsaturated Flow, Groundwater Flow Modeling  
 Tidwell—Fluid Flow, Solute Transport, Media Heterogeneity, Laboratory Technologies, and Water Resources Management  
 Timmons—NM StateMap Manager, Field Geology, Structural Geology and Tectonics  
 Vivoni—Hydrometeorology, Watershed Modeling, Surface Hydrology, Ecohydrology, Environmental Fluid Mechanics, Turbulence

## **Emeritus Faculty Research Interests**

Budding—Metamorphic Petrology, Geotectonics  
 G. Gross—Electrical and Electrochemical Properties of Ice, Isotope Hydrology, Geophysics, Desert Geomorphology  
 D. Johnson—Biostratigraphy, Paleozoic Depositional Environments  
 Lattman—Geomorphology, Remote Sensing  
 Sanford—Earthquake Seismology, Crustal Exploration, Tectonophysics, Geophysical Methods for Shallow Exploration  
 Schlue—Seismology, Surface Waves, Rift Studies, Inverse Methods

# Environmental Science

*Environmental Science Advisory Committee:*

*Dr. Michael Pullin, Chemistry*

*Dr. Bruce Harrison, Earth and Environmental Science*

*Dr. Rebecca Reiss, Biology*

*Dr. Clint Richardson, Environmental Engineering*

Many faculty at New Mexico Tech have an interest in the application of their research to environmental problems. Their research interests are listed in the appropriate departmental section of the catalog.

**Degrees Offered: B.S. in Environmental Science with Options in Biology, Chemistry, Geology, Hydrology, and Instrumentation and Measurements**

The Bachelor of Science degree in Environmental Science draws upon courses from biology, chemistry, Earth science, physics, and environmental engineering. Students must be aware of the complexity of environmental problems, yet have a rigorous background to address specific aspects of those problems. To ensure that graduates are competitive in the marketplace for diverse environmentally oriented careers, Environmental Science students take classes in all of the disciplines listed above. They additionally select a specialization in biology, chemistry, geology, hydrology, or instrumentation and measurements. Each option is sufficiently in-depth to allow students to continue their education in a traditional graduate program within that discipline, should they choose.

An advisory committee, composed of faculty from the specific disciplines, is convened to help students plan their programs.

## Undergraduate Program

### Core Requirements for the Bachelor of Science Degree in Environmental Science

*In addition to the General Education Core Curriculum Requirements (page 100) the following core program is required of all Environmental Science students:*

- BIOL 331 (3), 343 & 343L (4)
- CHEM 311 & 311L (4), 333 & 333L (4), 422 & 422L (4)
- A 100-level EARTH course and associated lab (4)
- EARTH 201 & 201L (4), EARTH 202 & 202L (4), EARTH 440 (4)
- MATH 231 (4), 283 (3)
- ENVS 472 (1)
- All students in the Environmental Science program are required to attend the Environmental Science Senior Seminar (ENVS 472) for four years or, if transfer students, for the duration of their enrollment in the Environmental Science program. In the first three years,

students need only audit the seminar, but in their senior year, they are required to present at the seminar and take the class for a grade.

- Three credit hours of courses numbered 491 and 492 taken in the appropriate department in the subject area of environmental science. These credit hours shall comprise a supervised research project, supervised scholarship project, or a supervised internship, and must result in a written paper or senior thesis. Prior to beginning the research project or internship, the student must prepare a short proposal of the activity. This proposal must be approved by the student's advisor and two faculty from the Environmental Science Advisory Committee. Following completion of the project, all three faculty must sign off on the resulting research paper.

### Bachelor of Science in Environmental Science with Biology Option

*Minimum credit hours required—135*

*In addition to the General Degree Requirements (page 100), and the core Environmental Science Requirements (above), the following courses are required:*

- BIOL 112 & 112L (4), 311 & 311L (4), 333 & 333L (4)
- Technical Electives (12)—Technical electives to be approved by the Advisory Committee

### Bachelor of Science in Environmental Science with Chemistry Option

*Minimum credit hours required—135*

*In addition to the General Degree Requirements (page 100), and the core Environmental Science Requirements (above), the following courses are required:*

- CHEM 331 & 331L (4), 334 & 334L (4), 411 & 411L (4)
- Technical Electives (14)—Recommended technical electives, which must be approved by the advisory committee, include CHEM 332, 441, 442

### Bachelor of Science in Environmental Science with Geology Option

*Minimum credit hours required—135*

*In addition to the General Degree Requirements (page 100), and the core Environmental Science Requirements (above), the following courses are required:*

- EARTH 203 & 203L (4), EARTH 204 & 204L (4), EARTH 380 (3), EARTH 385 (3), EARTH 405 (3)
- Electives to meet minimum credit hours required.

### **Bachelor of Science in Environmental Science with Hydrology Option**

*Minimum credit hours required—135*

*In addition to the General Degree Requirements (page 100), and the core Environmental Science Requirements (above), the following courses are required:*

- EARTH 204 & 204L (4), EARTH 340 (3), EARTH 440 (4), EARTH 441 (1), EARTH 442 (1), EARTH 443 (1)
- MATH 335 (3)
- Electives to meet minimum credit hours required.

### **Bachelor of Science in Environmental Science with Instrumentation and Measurements Option**

*Minimum credit hours required—135*

*In addition to the General Degree Requirements (page 100), and the core Environmental Science Requirements (above), a minimum of 25 credit hours from the following (at least 17 credit hours must be numbered 300 or above) are required:*

- ES 332 (3)
- EE 211 (3), 212 & 212L (4), 231 & 231L (4), 308 & 308L (4), 321 & 321L (4)
- CHEM 331 & 331L (4), 411 & 411L (4)
- EARTH 353 (3), 370 (3)
- Electives to complete 135 credit hours

### **Environmental Science Courses:**

#### **ENVS 412, Introduction to Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs**

*Offered Spring semester on demand*

An introduction to the concepts of geographic information systems (GIS). Theoretical background to GIS; introduction to the nature and analysis of spatial data. ArcView and/or ArcGIS. Shares lecture with GEOL 512 but is graded separately. Same as EARTH 412.

#### **ENVS 438, Advanced Geographic Information Systems, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: Consent of instructor*

Advanced topics in geographic information systems (GIS) with a focus on applications in environmental sciences. Emphasis on theoretical aspects and practical applications of GIS science and technology and its integration with remote sensing data and field measurements. Computing exercises and programming projects utilizing GIS software. Discussion of GIS integration with environmental modeling. Shares lecture with GEOL/HYD 538 but is graded separately.

#### **ENVS 472, Senior Seminar, 1 cr, 1 cl hrs**

*Offered in spring semester*

Undergraduate students in Environmental Science are required to give one seminar on research resulting from the paper written for 491 or 492.

# Education

*Professor Cormack*

*Associate Professor Samuels (Chair of the Department)*

*Instructor & Director Osowski*

*Adjunct Instructor Williams*

## Teacher Certification

The Alternative Licensure Program of the Department of Education makes available foundation and skills courses in education and relevant areas of psychology. These are intended to provide the student with knowledge about professionally accepted teaching methods and practices; the historical background and philosophy of education out of which the practices arose; and the currently validated, psychological knowledge about persons of the age range taught in secondary schools.

The more specific aim of the program is to provide students enrolled in a Bachelor of Science degree program at Tech or those who already have a bachelor's degree with the opportunity to attain certification as secondary school teachers. Undergraduates are restricted to math and science teaching fields.

## Procedures for Admission to Alternative Licensure Program and Application for Certification

In order to be admitted to the Alternative Licensure Program, a student must be enrolled as a student at New Mexico Tech and be in good academic standing. The student must have passed basic skills tests in reading, mathematics, and writing (or have already passed the relevant college-level courses), and must have completed an application for admission form. This form can be obtained from the chairman or coordinator of the education department.

To qualify for an alternative teaching license, the student must take a specific set of courses in education. Students working toward a bachelor's degree at New Mexico Tech must also complete an approved program in math and/or science teaching fields\* and certain requirements beyond the general requirements for the Bachelor of Science degree. These must include any course in **American History (3); PSY 323, Psychology of Child and Adolescent Development (3); and PSY 311, Tests and Measurements (3)**. Those students who already have a bachelor's degree from a regionally accredited institution must have completed 30 credit hours (C- or better) in a secondary teaching field. Finally, the student must pass state-approved tests in professional education and teaching field(s). Students transferring into the program must complete EDUC 403 & EDUC 411 at New Mexico Tech.

Upon successful completion of all required courses and tests, the candidate should obtain an application for New Mexico Licensure, fill out appropriate sections, and forward it, together with official transcripts and state-approved test scores, to the New Mexico State Department of Education.

\* In addition to the general degree science requirements, science field requirements must include at least 4 credits each in Biology, Earth Science and Computer Science.

## Specific Education Course Requirements for Alternative Certification

- EDUC 340 (2), 341 (3), 343 (3), 401 (3), 403 (4), 411 (3).
- Passing scores on state-approved tests

## Minor in Education

*Minimum credit hours required—18*

*The following courses are required:*

- EDUC 340 (2), 341 (3), 343 (3), 401 (3), 403 (4), 411 (3)

## Education Courses:

### EDUC 340, Concepts in Education, 2 cr, 2 cl hrs

Brief survey of the history (especially modern history) of education together with the professional requirements and structure of educational systems. Understanding standards-based education and how to address the needs of culturally diverse school populations.

### EDUC 341, Matching Teaching Strategies to Student Learning, 3 cr, 2.5 cl hrs, 1.5 lab hrs\*

How students learn and develop; including cognitive, social, emotional and physical development as it relates to students individual needs and strengths. How to teach in a classroom of diverse learners; including differentiating instruction, modifying for special needs students, and motivating student learning. Lab hours will be spent observing and working in public school classrooms.

### EDUC 343, Classroom Management and Discipline, 3 cr, 2 cl hrs, 3 lab hrs\*

*Prerequisites: Permission of the Alternative Licensure Program Coordinator, enrollment in Alternative Licensure Program.*

Principles of classroom management and discipline, student and teacher rights and responsibilities. Lab involves study, observation and participation in the public schools. Includes interviewing and evaluation.



**EDUC 401, Assessing and Teaching Reading in Content Areas, 3 cr, 3 cl hrs**

*Prerequisites: Permission of the Alternative Licensure Program Coordinator, enrollment in Alternative Licensure Program.*

Concepts, methods and materials for the teaching of reading in the context of the secondary curriculum. Topics include measurement of reading achievement and ability, reading training, motivation for reading, and reading disabilities.

**EDUC 403 Methods and Practices of Secondary School Teaching, 4 cr, 3 cl hrs, 3 lab hrs\***

*Prerequisites: eight (8) credit hours of upper-division education courses, permission of the Alternative Licensure Program Coordinator, enrollment in Alternative Licensure Program.*

A study of essential teaching principles including: instructional planning and implementation; assessment of student learning, appropriate feedback, and subsequent lesson modification; effective questioning to encourage student participation and to promote individual thinking and problem solving. The implementation of a variety of instructional strategies to meet the needs of all learners. The use of various resource materials and technology. Lab hours will be spent observing and working in public school classrooms.

**EDUC 411 Directed Teaching\*, 3 cr**

*Prerequisites: Senior or graduate standing; permission of the Alternative Licensure Program Coordinator, enrollment in the Alternative Licensure Program, education minor added, EDUC 403, and consent of a public school principal. Lab fee may be assessed for teaching outside of Socorro.*

Practice teaching in a local secondary school. Students will experience all aspects of teaching. It involves a commitment of 2 hours per day, five days a week, in the classroom. Expect to spend an equal number of hours in preparation. Student teachers will also meet one hour per week with the Education Instructor.

\* New Mexico Schools require students to participate in a background check & pay associated fees.

## Faculty Research Interests

Cormack—Psychophysics, Visual Perception, Sensory Mechanisms

Samuels—Cognitive Development, Reasoning and Problem Solving, Memory, Brain Injury and Rehabilitation

# Fine Arts

The fine arts program provides an opportunity for students to work in drawing, sculpture, painting, and other endeavors employing creative imagination. Although it is a nonmajor program, fine arts is significant as an area of study, offering elective possibilities in other curricula.

All fine arts offerings are dependent upon student interest and the availability of instructors.

For a complete listing of current Fine Arts offerings, visit <http://mediaserve.nmt.edu/website/> or call (575) 835.6581.

## Fine Arts Courses:

*The following sampling of Fine Arts courses are graded S/U and may be used for elective credit only. Classes may be taken multiple times for credit.*

### **F A 130C Intro to New Mexico Tin Punching** 1 cr, 2 cl hrs

Fundamental tools and processes in creating traditional Hispanic folk art.

### **F A 150C Drawing and Painting** 1 cr, 2 cl hrs

Survey of introductory skills and techniques using a variety of drawing and painting media

### **F A 151C Technical and Industrial Drawing** 1 cr, 2 cl hrs

Free hand three dimensional and industrial drawing techniques

### **F A 152C Painting in Oils** 1 cr, 2 cl hrs

Basic skills and techniques of oil painting

### **F A 153C Painting in Acrylics** 1 cr, 2 cl hrs

Basic methods and skills in acrylic painting

### **F A 160C Stained Glass and Mosaics** 1 cr, 2 cl hrs

Introduction to materials and construction techniques of stained glass panels and mosaic objects

### **F A 240C Photography** 2 cr, 3 cl hrs

Technical and aesthetics process in Photography as an art form

### **F A 260C Stained Glass I** 2 cr, 3 cl hrs

Investigation of tools and techniques in creating inspired stained glass compositions.

### **F A 261C Glass Fusing/Slumping** 2 cr, 3 cl hrs

Fundamental tools and processes in creation of glass objects; mold making and slumping processes used in basic kiln forming.

### **F A 262C Glass Bead Making** 2 cr, 3 cl hrs

Exploration of flame working methods and techniques used in creating wearable art

### **F A 263C Stained Glass II** 2 cr, 3 cl hrs

*Prerequisite: FA 260C or consent of instructor*

Students will investigate more complex designs, tools and equipment in stained glass, including three dimensional and sculptural designs.

### **F A 264C Stained Glass Design** 2 cr, 3 cl hrs

*Prerequisite: FA 260C or consent of instructor*

Students will learn to design stained glass, and will explore design elements, pattern making, and pattern alignment.

### **F A 265C Stained Glass Interpretation** 2 cr, 3 cl hrs

*Prerequisite: FA 260C or consent of instructor*

Students will study art masterpieces in other media and recreate them in stained glass.

### **F A 270C Hand Building in Clay** 2 cr, 3 cl hrs

Studio arts survey of hand forming techniques used in creating diverse utilitarian and sculptural ceramics. Accommodates all skill levels

### **F A 271C Wheel Thrown Ceramics I** 2 cr, 3 cl hrs

*Prerequisite: FA 270C, Hand Building in Clay*

Technical and aesthetic processes used in functional wheel thrown ceramics. Accommodates all skill levels

### **F A 273C Wheel Thrown Ceramics II** 2 cr, 3 cl hrs

*Prerequisite: FA 270C, Hand Building in Clay*

Students will learn and practice advanced wheel and decorative techniques.

### **F A 272C Sculptural Ceramics** 2 cr, 3 cl hrs

Studio art class in three dimensional construction of abstract and figurative sculpture. Accommodates all skill levels

### **F A 280C Beginning Enameling** 2 cr, 3 cl hrs

The art of fusing glass to metal, safe handling of equipment and chemicals in beginning techniques

### **F A 281C Enameling II** 2 cr, 3 cl hrs

*Prerequisite: FA 280C, Beginning Enameling*

The art of fusing glass to metal using advanced techniques and methods

### **F A 282C Beginning Metal Arts/Lapidary** 2 cr, 3 cl hrs

Fabrication techniques in metal construction: cutting, shaping and soldering, lost wax casting. Lapidary works of cut stone may be incorporated into metal processes.

**F A 283C Metal Arts/Lapidary II 2 cr, 3 cl hrs**

*Prerequisite: FA 282C, Beginning Metal Arts/Lapidary*

Continued development of skills and processes in lapidary and metal work

**F A 284C Precious Metal Clay 2 cr, 3 cl hrs**

*Prerequisites: FA 283C and consent of instructor*

The art of kiln fired fused copper, bronze and silver metals in creating wearable art. Safe handling of kilns and equipment

**F A 285C Precious Metal Clay II 2 cr, 3 cl hrs**

*Prerequisite: FA 284C and consent of instructor*

Continued exploration of skills and techniques acquired in PMCI

**F A 286C Armor Making 2 cr, 3 cl hrs**

*Prerequisite: FA 282C, Beginning Metal Arts/Lapidary*

Hot and cold working of steel and leather in historical design and construction of wearable medieval protective clothing.

# Information Technology

*Professors Liebrock (Program Coordinator), Soliman, Sueyoshi, Sung*

*Associate Professors Anselmo (Program Coordinator), Liebrock (Program Coordinator), Mazumdar, Shin, Wedeward  
Assistant Professor Zheng*

## **Degree Offered: B.S. in Information Technology**

Information Technology (IT) is an evolving interdisciplinary subject that has been driven and shaped by the rapid development of computing, communication, and Internet-related technologies and their tremendous impact on our daily lives. In contrast to the more traditional Information Systems discipline, Information Technology deals with the development, utilization, interrelation, and confluence of computers, networking, telecommunication, business, and technology management in the context of the global Internet. As we enter the Information Age of the 21st century, society will be increasingly dependent on Information Technology and demand for IT professionals will remain high throughout the decades to come.

The Bachelor of Science in Information Technology program at New Mexico Tech is administered jointly by the Computer Science and Management departments. The curriculum includes relevant computer science, management, and engineering courses and emphasizes secure information systems and information assurance that are among the areas of research at Tech's Institute for Complex Additive Systems Analysis (ICASA) where IT students may find employment or internship opportunities. Students must also take a sequence of 12 hours of technical electives to broaden or deepen their knowledge in an IT area of their interest. Graduates of the IT program will be well prepared for immediate industry employment or graduate study in an IT-related discipline.

## **Undergraduate Program**

### **Bachelor of Science in Information Technology**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

- CSE 222 (3)
- IT 101 (2), IT 113 (4), 122 (3), 213 (3), 221 (3), 263 (3), 311 (3), 321 (3), 326 (3), 351 (3), 373 (3), 382 (3), 481 (3), 482 (3)
- MATH 221 (3), 283 (3)
- PSY 121 (3) (can be applied as a social science course in the general education core curriculum)
- Technical Electives: a sequence of 12 hours of computer science, information technology, or management courses numbered 300 or higher must be *pre-approved* by the student's advisor and an IT Program Coordinator. Students are encouraged to select a coherent set of courses

as technical electives that will prepare them for a specific focus in their career.

- Each of the above courses must be completed with a grade of C or better.
- Electives to complete 130 credit hours.

### **Sample Curriculum for the Bachelor of Science Degree in Information Technology**

#### *Semester 1*

- 4 MATH 131 (calculus)
- 1 IT 101 (introduction to comp sci & information tech)
- 4 IT 113 (introduction to programming)
- 3 ENGL 111 (college English)
- 4 CHEM 121 & 121L (general)
- 16 Total credit hours

#### *Semester 2*

- 4 MATH 132 (calculus)
- 3 PSY 121 (general psychology)
- 3 IT 122 (algorithms and data structures)
- 4 CHEM 122 & 122L (general)
- 3 ENGL 112 (college English)
- 17 Total credit hours

#### *Semester 3*

- 3 IT 221 (computer and network organization)
- 3 IT 263 (information protection and security)
- 3 MATH 221 (formal logic and discrete mathematics)
- 5 PHYS 121 & 121L (general)
- 3 Humanities
- 17 Total credit hours

#### *Semester 4*

- 3 CSE 222 (systems programming)
- 3 IT 351 (complex system modeling and simulation)
- 3 IT 213 (intro to object oriented programming)
- 3 MATH 283 (introduction to applied statistics)
- 5 PHYS 122 & 122L (general)
- 17 Total credit hours

#### *Semester 5*

- 3 IT 321 (internet and web programming)
- 3 IT 311 (human info processing and decision making)
- 3 IT 373 (intro to database design and management)
- 3 ENGL 341 (technical writing)
- 3 Social Science
- 1 Elective
- 16 Total credit hours

#### *Semester 6*

- 3 IT 326 (software engineering)
- 3 IT 382 (legal and ethical info technology issues)
- 4 Biology/Earth Science/Engineering with lab
- 6 Electives
- 16 Total credit hours

*Semester 7*

- 6 Technical Electives
- 3 IT 481 (senior secure system design project)
- 3 Social Science
- 3 Humanities
- 3 Electives
- 18 Total credit hours

*Semester 8*

- 6 Technical Electives
- 3 IT 482 (senior secure system design project)
- 3 Humanities/Social Science
- 3 Electives
- 15 Total credit hours

## Information Technology Courses:

### IT 101, Introduction to Computer Science & Information Technology, 2 cr, 2 cl hrs

Brief overview of the discipline of computer science and information technology topics including computer architecture, operating systems and networks, automata and models of computation, programming languages and compilers, data structures, algorithms, databases, security and information assurance, artificial intelligence, graphics, and social/ethical issues of computing. (Same as CSE 101)

### IT 113, Introduction to Programming, 4 cr, 3 cl hrs, 3 lab hrs

*Prerequisite: MATH 103 or equivalent*

Introduction to programming in a structured language (e.g., C): problem solving, algorithm development, top-down design, modular programming, debugging, testing, control structures including selection, iteration and recursion, data types including arrays, strings, pointers, and dynamic structures. Concepts implemented through extensive programming using good programming style. (Same as CSE 113)

### IT 122, Algorithms and Data Structures, 3 cr, 3 cl hrs

*Prerequisite: IT 113*

*Corequisite: Math 132*

Fundamental data structures including linked lists, trees, hash tables, and graphs. Algorithms for sorting, searching, and other fundamental operations. Introduction to mathematical foundations for analysis of iterative and recursive algorithms and for basic correctness proofs. Analysis of algorithms. Implementation of selected algorithms using sound programming methodologies.. (Same as CSE 122).

### IT 213, Introduction to Object Oriented Programming, 3 cr, 3 cl hrs

*Prerequisite: IT 113, 122*

Introduction to programming in an object oriented language (e.g., Java): review of problem solving, algorithm development, top-down design, modular programming, debugging, testing, control structures including selection, iteration and recursion, data types including arrays, strings, pointers, and dynamic structures. Object oriented concepts will include: objects, classes, inheritance, instances, methods, interfaces, packages, encapsulation, and polymorphism. Concepts implemented through extensive programming using good programming style. (Same as CSE 213)

### IT 221, Computer and Network Organization, 3 cr, 3 cl hrs

*Prerequisite: IT 122*

The hardware/software interface. Basic organization of computers, operating systems, and computer networks. Memories, buses, interrupts, input and output, and instruction set architecture. Basics of assembly language programming. (Same as CSE 221)

### IT 263, Information Protection and Security, 3 cr, 3 cl hrs

*Prerequisite: IT 113; Corequisite: IT 221*

Concepts of information, message and data. Storage and transmission, retrieval and communications. Authorized users and penetrators. Threats to information confidentiality, integrity, availability, and accountability. Attacks. Degrees of security and costs. Protection mechanisms and security precautions. Authentication and authorization. Encryption. Secure operating systems, communications and networks. Defenses against viruses, worms, and hostile code.

### IT 311, Human Information Processing and Decision Making, 3 cr, 3 cl

*Prerequisite: PSY 121 and upper division standing in the IT program*

Recent advances in knowledge about how people process and act upon information are presented. Models of human decision making are analyzed in the context of secure information systems and used to assess ways to best manage the people and technology associated with secure information systems.

**IT 321, Internet and Web Programming, 3 cr, 3 cl hrs***Prerequisite: IT 213, 221*

This course has a practical emphasis on the design and techniques for developing internet-based applications, mainly focusing on web programming. Topics include HTML, client-side scripting language (JavaScript), server-side programming (Servlets, JSP, and J2EE), and XML/web services (Java and .NET). This course will also cover some important topics needed for internet-based application developments, such as Internet architectures, basic object-oriented programming (OOP) concepts, and web security. Course work includes substantial programming homework and team-based projects. (Same as CSE 321)

**IT 326, Software Engineering, 3hrs***Prerequisites: IT 122, 213*

This course provides the introductory overview of software engineering, concentrating on large-scale software system design and implementation. Topics include software life cycle, UML-based design language, design tools and techniques, design documentation, software testing, and software project management. Course work includes a team-based project. (Same as CSE 326)

**IT 328, Secure Software Construction, 3 cr, 2 cl hrs, 1 lab hr***Prerequisite: CSE 222, IT 213*

Formal methods and practical techniques for the specification, design, implementation, and validation of computer software. Current software engineering and management practices, with emphasis on ensuring software reliability, safety, and security. Course work includes a team project to develop a sizeable, real-world application software. (Same as CSE 328)

**IT 351, Modeling and Simulation Technologies for Information Systems, 3 cr, 3cl hrs***Prerequisites: IT 122; MATH 221*

Fundamentals and techniques for designing and using simulation, modeling, and optimization algorithms with applications in system performance modeling, business infrastructure modeling, and distributed and parallel computing. An introduction to advanced complex systems models. (Same as CSE 351)

**IT 353, Data & Computer Communications, 3 cr, 3 cl hrs***Prerequisites: CSE 222*

Basic concepts of data communication. Transmission media (wireline and wireless) characteristics and utilization. Digital and analog data signaling, modulation, and coding. Signal and channel analysis. Concepts from information theory. Data multiplexing and switching. Connection-oriented vs. connectionless networking. Synchronous and asynchronous carriers (ATM, SONET/ SDH). Overview of the OSI vs. TCP/IP protocol stacks. The Internet protocol structure- "subnet" and interfaces. Channel access and allocation. Examples of LAN, MAN, and WAN. Data link control, design issues, link management, error and flow control. Principles of internetworking: relays and protocols. (Same as CSE 353)

**IT 373, Introduction to Database Systems, 3 cr, 3 cl hrs***Prerequisite: IT 122*

Conceptual modeling and database design using the entity-relationship model. The relational model; relational algebra and relational query languages; design theory for relational databases. Database integrity. Physical data organization. Introduction to problems of concurrency control, recovery, security, and distributed databases. Course work includes a project using SQL and the Oracle Database Management System. (Same as CSE 373)

**IT 382, Legal, Ethical,& Social Issues of IT, 3 cr, 3 cl hrs***Prerequisite: IT 326; or consent of instructor*

A survey of current legal IT (and general business and management) issues is presented in this course. Also, social and ethical issues associated with IT and management of secure information systems are surveyed and discussed.

**IT 441, Cryptography and Applications, 3 cr, 3 cl hrs***Prerequisites: IT 122; MATH 221*

Basic theory of encryption and decryption. The RSA algorithm and the public/private key system. Cryptography systems in use for Internet and business applications. (Same as CSE 441)

**IT 451, Introduction to Parallel Processing, 3 cr, 3 cl hrs***Prerequisites: CSE 122 or IT 122*

Introduction to supercomputers and massively-parallel machine architecture, models of parallel computation, parallel algorithms, synchronization, parallel languages, data and functional parallelism, parallel performance analysis, popular interfaces, and parallel debugging. Students will gain experience in parallelization of sequential algorithms and implementation of parallel algorithms. (Same as CSE 451)

**IT 453, Computer Networks & the Internet, 3 cr, 3 cl hrs***Prerequisite: IT 353*

Layering of protocols (ISO, ITU and TCP/IP stacks) and network architectures. Fiber optics technology and high speed networks. Internetworking: global addresses/names and translation, virtual networks and tunnels, routing, subnetting, IPv6, multicasting. Mobile IP. End-to-end protocols, TCP and UDP. Congestion control and resource allocation. Socket interfacing, client-server and API. The QoS mechanism integrated/differentiated, ATM QoS. Network security: information and link security, encryption, internetworking security, IPsec, firewalls, VPN, wireless security. (Same as CSE 453)

**IT 462, Systems, Risk and Decision Analysis, 3 cr, 3 cl 3 hrs**

*Prerequisites: MATH 283 or 382; upper division standing*

Analysis of systems and managerial decisions under conditions of risk or uncertainty. Optimal project evaluations and ranking of alternatives using expected value and expected utility criteria. Topics include risk sharing, Bayesian revision of probabilities, value of information, and preference assessment procedures. (Same as MGT 462)

**IT 463, Information Assurance, 3 cr, 3 cl hrs**

*Prerequisite: Senior standing*

Defense and offensive information warfare. Information system security. Computer break-ins, hacking, and other attack methods. Vulnerability and risk analysis. Theory and applications of cryptography. Intrusion detection and incident response. Security planning and management. (Same as CSE 463)

**IT 476, Visualization, 3 cr, 3 cl hrs**

*Prerequisite: CSE 222 or consent of instructor*

This course presents application of graphical visualization to current problems, with a focus on extracting and representing information in multidimensional data sets using 2D and 3D graphics. Topics include visualization tools and techniques, human vision and perception, color mapping, sound, data representation for insight extraction, time visualization, visual analytics, volume rendering, surface extraction and rendering. Students will develop visualizations of real world problems. (Same as CSE 476)

**IT 481 / IT 482, Senior Secure System Design Project, 3 cr, 3 lab hrs ea**

*Prerequisite: must have completed all junior-level IT courses*

A substantial system and security-related project taken over 2 regular semesters, under the supervision of a faculty member.

**Faculty Research Interests**

Anselmo— Agent-Based Financial System Modeling and Simulation, Non-Financial Risk Modeling and Analysis

Liebrock— Computer Forensics, Information Assurance, Parallel Processing, Well Posedness Analysis, Visualization

Mazumdar— Databases, Information Systems, Software Integrity

Shin— Access Control, Identity Management, Security Engineering, Software Engineering

Soliman— Computer Networks, Programming Languages, Sensor Networks

Sueyoshi — Management Science, Data Envelopment Analysis, Risk and Policy Analysis

Sung— Computational Intelligence, Information Security, Bioinformatics

Wedeward— Adaptive Control, Robotic Systems

Zheng— Computer Architecture, Wireless Networking, Mobile Computing, Digital Design, Image Processing

# Management

*Professor Sueyoshi*

*Associate Professors Anselmo (Chair of the Department),*

*Stuteville, Ostergren*

*Assistant Professor Ulibarri*

*Adjunct Faculty: Foster, Mazumdar, Peterson, Sung*

***Degrees offered: A.S. in Business; B.S. in Management and B.S. in Management of Technology***

The Department of Management provides undergraduate degree programs that draw heavily on Tech's strengths in science, engineering, and technology. The aim of the department is to develop in students substantive decision-making skills and tools, as well as the functional knowledge required to effectively manage complex technology-based organizations in today's competitive global economy. Management students take the same basic science and math courses required of every Tech student—two semesters each of chemistry, physics, calculus, and another lab science such as biology, engineering, or geology. Added to this foundation are courses in accounting, business computer systems, economics, finance, management, marketing, operations research, and statistics.

New Mexico Tech offers degrees in management and management of technology. The B.S. in Management is appropriate for those planning to enter the fields of human resources management, labor relations, or general management. The B.S. in Management of Technology integrates management course work with study in an engineering field of the student's choice. This degree focuses on the application of quantitative methods to problem solving in management. In accordance with the overall mission of New Mexico Tech, it is expected that problems addressed will be primarily within engineering and applied science disciplines, including natural resource and environmental management problems. Each management student is assigned a faculty advisor who will help him or her select a degree option and recommend courses to be taken.

The Department of Management also offers an Associate of Science degree in Business. This program is designed for students seeking to complete a two-year degree in business, and/or those who may wish to transfer to a four-year bachelor's program in business or management. Required courses are transferable among participating New Mexico institutions.

## Undergraduate Program

### Associate of Science in Business

Minimum credit hours required—65

*The following courses are required:*

- ACCT 201 (3), 202 (3), 371 (3)
  - BA 315 (3), 317 (3)
  - ECON 251 (3), 252 (3)
  - ENGL 111 (3), 112 (3)
  - Mathematics: Six credit hours chosen from MATH 103 (3), 104 (3), 105 (5), 131 (4)
  - TC 151 (3)
  - Business Electives: Nine credit hours selected in consultation with the faculty advisor
  - Humanities and Social Science Elective: Three credit hours chosen from Area 4 or Area 5 of the General Education Core Curriculum (page 100)
  - A total of eight credit hours in courses with associated laboratories from the disciplines of biology, chemistry, earth science, or physics
  - Electives to complete 65 credit hours
- Students must achieve a minimum GPA of 2.0 in required courses in order to graduate.

### *Sample Curriculum for the Associate of Science in Business*

#### *Summer*

5 Mathematics

5 Total credit hours

#### *Semester 1*

3 ENGL 111 (college English)

3 Mathematics

3 ACCT 201 (fundamentals I)

3 ECON 251 (macroeconomics)

12 Total credit hours

#### *Semester 2*

3 ENGL 112 (college English)

4 Science with lab (biol, chem, earth science, or physics)

3 ACCT 202 (fundamentals II)

3 ECON 252 (microeconomics)

13 Total credit hours



*Semester 3*

3	BA 315 (business law I)
3	ACCT 371 (financial accounting)
4	Science with lab (biol, chem, earth science, or physics)
3	TC 151 (intro to visual communication)
<u>3</u>	Humanities/Social Science
16	Total credit hours

*Semester 4*

3	BA 317 (business law II)
9	Business Electives
<u>4</u>	Electives
16	Total credit hours

**Core Requirements for the Bachelor of Science in Management**

*In addition to the General Education Core Curriculum (page 100), the following core of business and economics courses is required of all Management students:*

- ACCT 201 (3), 202 (3); ACCT 350 is recommended
- BA 315 (3), 490 (3)
- BCS 283 (3)
- CSE 113 (4) or ES 111 (3)
- FIN 302 (3)
- MGT 101 (1), 330 (3), 462 (3), 472 (3), 481 (3)
- MKT 335 (3)
- ECON 251 (3), 252 (3). *These courses may be used to fulfill the Area 4 of the General Education Core Curriculum, page 89.*
- At least two semesters of a single approved foreign language are strongly suggested but not required.
- Electives to complete 130 credit hours. To be selected in consultation with a faculty advisor.

Any required class or technical elective used toward a B.S. in Management or a B.S. in Management of Technology may not be taken on an S/U basis. Management majors must achieve a minimum GPA of 2.0 in required courses in order to graduate.

**Bachelor of Science in Management**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum (page 100) and the core business requirements (above), the following courses are required:*

- Management Elective Sequence: At least nine (9) credit hours selected in consultation with and approved by the student's faculty advisor.
- ACCT 350 (3) is recommended

**Sample Curriculum for the Bachelor of Science in Management***Semester 1*

1	MGT 101 (modern management issues)
3	ENGL 111 (college English)
4	CHEM 121 & 121L (general)
4	MATH 131 (calculus)
<u>4</u>	CSE 113 or ES 111
16	Total credit hours

*Semester 2*

3	ENGL 112 (college English)
4	CHEM 122 & 122L (general)
4	MATH 132 (calculus)
<u>4</u>	Biology/Earth Science/Engineering with lab
15	Total credit hours

*Semester 3*

5	PHYS 121 & 121L (general)
3	ACCT 201 (fundamentals I)
3	ECON 251 (macroeconomics)
3	Elective
<u>3</u>	Social Science
17	Total credit hours

*Semester 4*

5	PHYS 122 & 122L (general)
3	ACCT 202 (fundamentals II)
3	BCS 283 (applied statistics)
3	ECON 252 (microeconomics)
<u>3</u>	Humanities/Social Science
17	Total credit hours

*Semester 5*

3	ACCT 350 (managerial accounting)
3	BA 315 (business law I)
3	MGT 330 (organizational behavior)
3	MKT 335 (principles)
<u>3</u>	Management Elective
18	Total credits

*Semester 6*

3	FIN 302 (principles)
3	MGT 462 (decision analysis)
3	ENGL 341 (technical writing)
3	Management Elective
<u>6</u>	Electives
18	Total credit hours

*Semester 7*

- 3 MGT 451 (leadership & motivation)
- 3 MGT 472 (production & operations)
- 3 Humanities
- 3 Management Elective
- 3 Elective
- 15 Total credit hours

*Semester 8*

- 3 BA 490 (business policy)
- 3 MGT 473 (production and operations II)
- 3 MGT 481 (senior seminar)
- 3 Humanities
- 3 Management Elective
- 15 Total credit hours

**Bachelor of Science in Management of Technology**

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum (page 100) and the core business requirements (page 177), the following courses are required:*

- ES 201 (3), 216 (3), and nine (9) approved credit hours of engineering courses numbered 300 or above
- ES 316 does not count toward the Management of Technology degree
- MATH 231 (4)
- At least two semesters of a single approved foreign language are strongly suggested but not required.
- Electives to complete 130 hours

**Sample Curriculum for the Bachelor of Science in Management of Technology***Semester 1*

- 1 MGT 101 (modern management issues)
- 3 ACCT 201 (fundamentals I)
- 3 ENGL 111 (college English)
- 4 CHEM 121 & 121L (general)
- 4 MATH 131 (calculus)
- 12 Total credit hours

*Semester 2*

- 3 ACCT 202 (fundamentals II)
- 3 ENGL 112 (college English)
- 4 CHEM 122 & 122L (general)
- 4 MATH 132 (calculus)
- 3 ES 111 or CSE 113 (4 cr)
- 17 or 18 Total credit hours

*Semester 3*

- 5 PHYS 121 & 121L (general)
- 3 ECON 251 (macroeconomics)
- 4 MATH 231 (calculus)
- 3 ES 201 (statics)
- 16 Total credit hours

*Semester 4*

- 5 PHYS 122 & 122L (general)
- 3 BCS 283 (applied statistics)
- 3 ECON 252 (microeconomics)
- 3 ES 216 (fluid mechanics)
- 4 Biology/Earth Science/Engineering with lab
- 18 Total credit hours

*Semester 5*

- 3 ACCT 350 (managerial accounting)
- 3 BA 315 (business law I)
- 3 MGT 330 (organizational behavior)
- 3 MKT 335 (principles)
- 3 Engineering prerequisite or elective
- 15 Total credit hours

*Semester 6*

- 3 FIN 302 (principles)
- 3 ENGL 341 (technical writing)
- 3 Humanities
- 3 Social Science
- 6 Engineering prerequisite or Elective
- 18 Total credit hours

*Semester 7*

- 3 MGT 462 (decision analysis)
- 3 MGT 472 (production & operations I)
- 3 Humanities
- 6 Engineering prerequisite or Elective
- 15 Total credit hours

*Semester 8*

- 3 BA 490 (business policy)
- 3 MGT 481 (senior seminar)
- 3 Engineering Elective
- 3 Humanities/Social Science
- 3 Management or Engineering Elective
- 15 Total credit hours

## Minor in Management

Minimum credit hours required—18

The following courses are required:

- FIN 302 (3)
- MGT 330 (3), 472 (3)
- MKT 335 (3)
- Six (6) credit hours of Management Department courses numbered 300 or above.

Note: ECON 252 and BCS/MATH 283 are prerequisites for FIN 302 and MKT 335. Non-majors must obtain instructor consent in lieu of the prerequisite of ACCT 202 for FIN 302.

## Accounting Courses:

### ACCT 201, Fundamentals of Accounting I, 3 cr, 3 cl hrs

Financial accounting procedures, concepts, and reports for sole proprietorships.

### ACCT 202, Fundamentals of Accounting II, 3 cr, 3 cl hrs

*Prerequisite:* ACCT 201

Financial accounting for partnerships and corporations, an introduction to managerial accounting concepts.

### ACCT 350, Managerial Accounting, 3 cr, 3 cl hrs

*Prerequisite:* ACCT 202 or consent of instructor

Cost-benefit choices among accounting methods and systems in support of strategic decisions and operational control, including behavioral effects of accounting systems within organizations. Analysis of cost behavior patterns and how they alter cost accounting for automated manufacturing environments. Construction of budgets, forecasts, and estimates for new product/process costs.

### ACCT 353, Cost Accounting, 3 cr, 3 cl hrs

*Prerequisite:* ACCT 202 or consent of instructor

The development and use of cost accounting for inventory valuation, income determination, cost control including process accounting and variance analysis.

### ACCT 371, Financial Accounting I, 3 cr, 3 cl hrs

*Prerequisite:* ACCT 202

A detailed study of the financial recording and reporting process. Emphasis is placed on the form and content of financial statements.

### ACCT 372, Financial Accounting II, 3 cr, 3 cl hrs

*Prerequisite:* ACCT 371

Current financial accounting theory and practice as they relate to financial statement preparation and analysis. Emphasis on special topics includes accounting for pensions and leases, accounting changes, and earnings per share presentation. Topics of current financial accounting interest are reviewed as they develop.

### ACCT 403, Tax Accounting, 3 cr, 3 cl hrs

*Prerequisite:* ACCT 372 or consent of instructor

Federal income tax laws and the determination of taxable income for individuals, partnerships, corporations, and fiduciaries. Tax research and planning.

### ACCT 405, Accounting for Non-Profit Organizations, 3 cr, 3 cl hrs

*Prerequisite:* ACCT 372 or consent of instructor

Control and reporting problems for government organizations and other non-profit entities. Fund accounting principles, procedures, and reports.

### ACCT 490, Selected Topics, 1–3 cr, 1–3 cl hrs

*Prerequisite:* ACCT 202; FIN 302; ECON 251, 252; MGT 330; BCS 283; MKT 335; senior standing

Current topics in accounting.

### ACCT 491, Directed Study, 1–3 cr, 1–3 cl hrs

*Prerequisite:* upper-class standing or consent of instructor

Individual studies directed by consenting faculty with prior approval of the department head.

## Business Administration Courses:

### BA 315, Business Law I, 3 cr, 3 cl hrs

*Prerequisite:* ENGL 112 or consent of instructor

Origin and development of law, judicial procedure, torts, law of contracts, and personal property.

### BA 317, Business Law II, 3 cr, 3 cl hrs

*Prerequisite:* BA 315

Sales, negotiable instruments, secured transactions, bankruptcy. Agencies, partnerships, and corporations.

### BA 490, Business Policy/Corporate Strategy, 3 cr, 3 cl hrs

*Prerequisites:* ACCT 202; FIN 302; ECON 251, 252; MGT 330; BCS 283; MKT 335; senior standing

Integration of the basic functions of a business enterprise—e.g., marketing, finance, and production—through case analysis. From the perspective of top management, emphasis will be placed on examination of external environments, and the development of strategies for the organization's creation of proper relationships and responses to social, political, and economic conditions.

## Business Computer Systems Courses:

### BCS 254, Introduction to Applied Linear Algebra, 3 cr, 3 cl hrs, 1.5 lab hrs

*Prerequisite: MATH 131 passed with grade C- or better*

Solution of linear systems. Matrix algebra. Rank. Determinants. Eigenvalues and eigenvectors. Numerical aspects of matrix calculation. Introduction to vector spaces and linear transformations. Applications. (Same as MATH 254)

### BCS 283, Elementary Applied Statistics, 3 cr, 3 cl hrs, 1.5 lab hrs

*Prerequisite: MATH 132 passed with grade C- or better*

Exploratory data analysis. Introduction to probability and random variables. Concepts of population and sample. Estimation and hypothesis testing. Simple linear regression and one-way analysis of variance. Techniques in data analysis using statistical computer packages. (Same as MATH 283)

### BCS 415, Introduction to Operations Research: Deterministic Methods, 3 cr, 3 cl hrs

*Prerequisite: BCS 254 passed with grade C- or better*

A survey of operations research techniques including linear programming, non-linear models, and graph theoretical models. (Same as MATH 415)

### BCS 486, Introduction to Stochastic Processes, 3 cr, 3 cl hrs

*Prerequisites: MATH 254 and 382, each passed with grade C- or better*

Conditioning. The Poisson process. Theory of Markov chains, continuous time Markov and semi-Markov processes. Topics from renewal theory and Markov renewal theory. Queuing Theory. Applications in science and engineering. (Same as MATH 486)

### BCS 488, Introduction to Operations Research: Stochastic Methods, 3 cr, 3 cl hrs

*Prerequisites: Math 382, passed with grade C- or better*

Monte Carlo Simulation Theory. Application of simulation to problems in science, engineering, and business. Queuing systems simulation. Inventory theory. (Same as MATH 488)

### BCS 491, Directed Study, 1–3 cr, 1–3 cl hrs

*Prerequisite: upper-class standing or consent of instructor*

## Economics Courses:

*These courses may be used to Area 4: Social Sciences of the General Education Core Curriculum, page 100.*

### ECON 251, Principles of Macroeconomics, 3 cr, 3 cl hrs

Macroeconomic theory and policy analysis.

Economic aggregates; fiscal and monetary policy; productivity and economic growth; banking system; national debt. Policy innovation: crisis and response; Keynesian, monetarist and supply-side models. Free trade, protectionist and mercantilist strategies. Exchange rate systems and macroeconomic management. [NMCCNS ECON 2113: General Education Area IV]

### ECON 252, Principles of Microeconomics, 3 cr, 3 cl hrs

Microeconomic theory and applications. Market allocation of resources; supply and demand; theory of marginal analysis; market types; market failure; regulation and antitrust; economic growth and innovation; business finance; economic globalization; and cultures of capitalism. [NMCCNS ECON 2123: General Education Area IV]

### ECON 362, Managerial Economics, 3 cr, 3 cl hrs

*Prerequisites: ECON 251, 252*

A coordination of economic theory and managerial practice. Consumer demand, production functions, cost behavior, output determination, and pricing within various market structures.

### ECON 372, Natural Resource and Environmental Economics, 3 cr, 3 cl hrs

*Prerequisites: ECON 362 or ES 316 or consent of instructor*

Introduction to the economic concepts and methods used in defining and analyzing natural resources and environmental quality problems.

### ECON 490, Selected Topics, 1–3 cr, 1–3 cl hrs

*Prerequisite: Upper-class standing or consent of instructor*

Current topics in economics.

### ECON 491, Directed Study, 1–3 cr, 1–3 cl hrs

*Prerequisite: Upper-class standing or consent of instructor*

## Finance Courses

### FIN 302, Principles of Finance, 3 cr, 3 cl hrs

*Prerequisites: ACCT 202; BCS 283; ECON 252; or consent of instructor*

Theory and techniques of financial management for business.

**FIN 410, Theory of Financial Decisions, 3 cr, 3 cl hrs**

*Prerequisites: FIN 302; BCS 283; or consent of instructor*

Detailed study of contemporary capital market and market equilibrium theories. Consideration of individual and firm risk attitudes and ways of dealing with financial risk. Discussion of firm valuation methods and firm level approaches to risky financial decision making.

**FIN 480, Investments, 3 cr, 3 cl hrs**

*Prerequisites: BCS 283; FIN 302 or ES 316; or consent of instructor*

Portfolio theory and empirical capital market analysis. Contemporary investment theory, including option pricing models and derivatives. Active portfolio management in light of the vast array of financial investment alternatives available in today's markets.

**FIN 490, Selected Topics, 1–3 cr, 1–3 cl hrs**

*Prerequisite: Upper-class standing or consent of instructor*

Current topics in finance.

**FIN 491, Directed Study, 1–3 cr, 1–3 cl hrs**

*Prerequisite: Upper-class standing or consent of instructor*

**Management Courses:****MGT 101, Modern Management Issues, 1 cr, 1 cl hr**

Seminar on modern management issues and the role of managerial personnel in today's technology firms. Guest speakers and faculty presenting overview of current issues and research topics.

**MGT 301, Survey of Engineering Management, 3 cr, 3 cl hrs**

*Prerequisites: ES 110 and 111 or equivalent*

Survey designed for engineering majors. Topics include introductions to qualitative and quantitative management models and their implementation.

**MGT 330, Management and Organizational Behavior, 3 cr, 3 cl hrs**

*Prerequisites: ENGL 112 and upper-class standing or consent of instructor*

Classical and contemporary organization theories, interpersonal and organization behavior, motivation, communication, leadership, decision process in organizations.

**MGT 331, Human Resource Management, 3 cr, 3 cl hrs**

Planning and utilization of human resources, including recruitment, selection, equal employment opportunity, safety, compensation, appraisal, unions, training, and job evaluation.

**MGT 381, Strategic Market Analysis, 3 cr, 3 cl hrs**

*Prerequisites: BCS 283; FIN 302; MKT 335; upper-class standing*

Analysis of data derived from either survey instruments, archival sources, or both. Design and implementation of instruments designed to elicit information useful to managers. Single and multiple variable impacts on managerial decision making.

**MGT 451, Technology Management Seminar, 3 cr, 3 cl hrs**

*Prerequisite: MGT 330*

Seminar focused on current management issues in complex technology organizations. Motivating and measuring performance in ambiguous situations. Leadership and growth issues in entrepreneurial technology organizations.

**MGT 462, Systems, Risk, and Decision Analysis, 3 cr, 3 cl hrs**

*Prerequisites: BCS 283 or MATH 283 or MATH 382 and upper-class standing or consent of instructor. Management majors should enroll in BCS 283.*

Analysis of systems and managerial decisions under conditions of risk or uncertainty. Optimal project evaluations and ranking of alternatives using expected value and expected utility criteria. Topics include risk sharing, Bayesian revision of probabilities, value of information, and preference assessment procedures. (Same as IT 462)

**MGT 472, Production and Operations Management I, 3 cr, 3 cl hrs**

*Prerequisites: BCS 283 and upper-class standing or consent of instructor*

Application of quantitative methods to problems encountered in management. Problem solving emphasis with extensive use of applications software. Topics include linear and integer programming, forecasting, queueing theory and simulation.

**MGT 473, Production and Operations Management II, 3 cr, 3 cl hrs**

*Prerequisites: MGT 472 and upper-class standing or consent of instructor*

Application of concepts and principles related to management of the production function in manufacturing and services. Problem solving emphasis with extensive use of applications software. Topics include independent and dependent demand inventory models, facility layout, facility location; quality control; and project management.

**MGT 481, Senior Seminar, Technical Management, 3 cr, 3 cl hrs**

*Prerequisite: upper-class standing and consent of instructor*

**MGT 488, Technology Entrepreneur Workshop, 3 cr, 3 cl hrs**

*Prerequisites: FIN 302; MGT 381; ACCT 202; senior standing; or consent of instructor*

This workshop is designed to familiarize participants with the process of technology marketing. Assessment of new-product marketability, development of marketing and business plans, presentation of plans in a competitive environment to an evaluation panel composed of people from various business backgrounds.

**MGT 490, Selected Topics, 1–3 cr, 1–3 cl hrs**

*Prerequisite: Upper-class standing or consent of instructor*  
Current topics in management.

**Marketing Courses:****MKT 335, Principles of Marketing, 3 cr, 3 cl hrs**

*Prerequisite: ECON 252; BCS 283; or upper-class standing and consent of instructor*

Processes, principles, and functions in current marketing systems.

**MKT 490, Selected Topics, 1–3 cr, 1–3 cl hrs**

*Prerequisite: Upper-class standing or consent of instructor*  
Current topics in marketing.

**MKT 491, Directed Study, 1–3 cr, 1–3 cl hrs**

*Prerequisite: Upper-class standing or consent of instructor*

**Faculty Research Interests**

Anselmo—Decision Analysis and Risk Management, Computational Finance, Electronic Commerce

Mazumdar—Database Systems, Massive Storage Systems, Computational Logic

Ostergren—Program Management, Product Development, Total Quality Management

Peterson—Management, Economics, Accounting

Stuteville—Telecommunication Law and Regulation, Ethical Issues in Information Assurance and Security

Sueyoshi—Management Science, Data Envelopment Analysis, Risk and Policy Analysis

Sung—Information Security, E-commerce

Ulibarri—Financial Economics, Cultural Economics, Natural Resource and Environmental Economics

# Mathematics

*Professors Avramidi, Borchers, Hossain (Chair of the Department), Stone*

*Associate Professors Aitbayev, Kerr, Makhnin, Schaffer, Starrett, Wang*

*Instructors Ballou, Bukowski*

*Emeritus Faculty: Arterburn, Ball, Sharples*

**Degrees Offered: B.S. in Mathematics, M.S. in Mathematics with specialization in Operations Research and Statistics, M.S. in Mathematics with specialization in Analysis, M.S. in Mathematics with specialization in Industrial Mathematics; Ph.D. in Applied and Industrial Mathematics**

Students and faculty in the mathematics department at Tech are involved in many areas of mathematics, from pure mathematics to applied mathematics, operations research, and statistics. The department offers bachelors, masters, and Ph.D. degrees in mathematics, and plays an important role in teaching mathematics to students in other disciplines. Faculty and students are also involved in a number of research projects, many of them in conjunction with researchers in other departments at Tech and at other institutions.

There are career opportunities for mathematics students at both the bachelor's and master's levels. Students in mathematics can prepare for actuarial careers, careers in education, and careers in a number of industries, including telecommunications, aerospace, and computer. Preparation for a career in industry should include a broad background in mathematics, modeling skills, computer skills, expertise in an area outside mathematics, and communication skills. Degree requirements are designed to help students develop these important abilities.

Mathematics can also be studied in preparation for more advanced work in a variety of fields including pure mathematics, applied mathematics, operations research, statistics, scientific computing, and business administration. Many students choose to combine a major in mathematics with a major in a second field such as management, computer science, engineering, or physics. A strong background in mathematics can be very helpful in graduate studies.

Students in the mathematics department at both the undergraduate and graduate level have many opportunities to interact with faculty and participate in a variety of mathematical activities. The department has weekly seminars in which faculty, graduate students, and visitors present their research. Both undergraduates and graduates are involved in research projects. Many students are employed by the department as graders, lab facilitators,

teaching assistants, and research assistants.

Undergraduate students regularly compete in the William Lowell Putnam mathematics competition and in the COMAP contest in mathematical modeling.

## Undergraduate Program

### Bachelor of Science in Mathematics

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

- *Introduction to Computer Science:* CSE 113 (4) or ES 111 (3)
- *Basic Mathematics:* MATH 221 (3), 231 (4), 254 (3), 335 (3), 352 (3), 372 (3), 382 & 382L (4), 454 (3)
- *Mathematical Modeling:* MATH 430 (3)
- *Mathematics Electives:* Four courses from at least two of the following areas:
  1. *Applied Mathematics:* 336 (3), 410 (3), 411 (3), 435 (3), 436 (3), 437 (3), 438 (3)
  2. *Pure Mathematics:* 442 (3), 455 (3), 456 (3), 461 (3), 471 (3), 472 (3)
  3. *Operations Research and Statistics:* 415 (3), 483 (3), 484 (3), 486 (3), 488 (3)
- *Electives in a single subject other than mathematics:* A sequence of at least 18 credit hours in a single subject area other than mathematics approved by the advisor. Courses chosen to satisfy other requirements may be used in the sequence. At least six hours must be in courses numbered 300 or above.
- *Minimum of 130 credit hours coursework:* Electives to complete the minimum of 130 credit hours.

*Sample Curriculum Notes: General education requirements should be fulfilled as early as possible. The sequence MATH 352, 372 is a key prerequisite to many advanced courses and should be taken as early as possible, in no case later than the junior year.*

### Sample Curriculum for the Bachelor of Science in Mathematics

*Semester 1*

- 4 MATH 131 (calculus)
- 5 CHEM 121, 121L, 121 R (general chemistry)
- 4 Biology/Earth Science/Engineering/Computer Science with lab
- 3 ENGL 111 (college English)
- 16 Total credit hours

*Semester 2*

- 4 MATH 132 (calculus)
- 5 CHEM 122, 122L, & 122R (general chemistry)
- 4 Biology/Earth Science/Engineering/Computer Science with lab
- 3 ENGL 112 (college English)
- 1 Elective
- 17 Total credit hours

*Semester 3*

- 3 MATH 221 (formal logic and discrete mathematics)
- 4 MATH 231 (calculus)
- 5 Phys 121 & 121L
- 3 Humanities
- 1 Electives
- 16 Total credit hours

*Semester 4*

- 3 MATH 254 (intro to linear algebra)
- 3 MATH 352 (basic concepts)
- 5 PHYS 122 & 122L (general)
- 4 CSE 113 or ES 111
- 1 Electives
- 16 Total credit hours

*Semester 5*

- 3 MATH 372 (basic concepts of analysis)
- 3 MATH 335 (ordinary differential equations)
- 4 MATH 382 & 382L
- 3 Social Science
- 4 Electives\*
- 17 Total credit hours

*Semester 6*

- 3 MATH 454 (linear algebra)
- 3 ENGL 341 (technical writing)
- 3 Math Elective
- 7 Electives\*
- 16 Total credit hours

*Semester 7*

- 3 MATH 430 (mathematical modeling)
- 3 Math Elective
- 3 Social Science
- 7 Electives\*
- 16 Total credit hours

*Semester 8*

- 3 Math Elective
- 3 Math Elective
- 3 Humanities/Social Science
- 7 Electives\*
- 16 Total credit hours

\* Choice of electives must include courses for approved 18-hour sequence. It is strongly recommended that elective choices include advanced science and/or a foreign language.

**Minor in Mathematics**

Minimum credit hours required—18

The following courses are required:

- MATH 254 (3), 335 (3), 352 (3), 382 (3)
- Six (6) additional hours of upper-division mathematics

**Graduate Program****Master of Science in Mathematics**

A program fulfilling the general requirements must be completed. Two basic plans are offered: for the program without thesis, MATH 590 (three credit hours) must be completed; for the program with thesis, MATH 591 (six credit hours) must be completed. There is no foreign language requirement for either program. The student must fulfill the requirements for the undergraduate program in mathematics. In addition, the student must fulfill the requirements of one of the following three specializations. Students interested in continuing for the PhD in Applied and Industrial Mathematics should take care to choose their courses so that they will fit that program as well.

**Five-Year Bachelor's/Master's Degree Program in Mathematics**

The five-year mathematics B.S./M.S. program provides the student the opportunity to obtain both a bachelor's degree and a master's degree in mathematics in five years. A minimum of 158 total credit hours are required to complete the dual degree program.

Students should apply to the program before their seventh semester. Admission is contingent on academic performance and acceptance of a proposed course of study. Graduate status is granted upon completion of the general requirements for the bachelor's degree in mathematics or one of its options with a 3.0 minimum cumulative grade point average. The master's degree is granted upon completion of the requirements of the master's degree program.

The student will work with a professor in the Mathematics Department who will assist the student in developing the course of study and advise the student on their master's thesis or independent study.



## Master of Science in Mathematics with Specialization in Industrial Mathematics

Industry and business provide many areas for the application of advanced mathematics, and many possibilities for mathematicians to make significant contributions. New Mexico Tech offers a program to prepare students for these opportunities. Students need a basic background in numerical analysis, differential equations, and statistics at the undergraduate level. The graduate requirements are:

- 1) Modeling courses (6 credits): MATH 430 (Mathematical Modeling); MATH 530 (Modeling Case Studies)
- 2) Core industrial mathematics courses (6 credits)—two of the following: MATH 511 (Numerical Methods); MATH 518 (Nonlinear Programming); MATH 532 (Perturbation Methods); MATH 535 (Mathematical Physics); MATH 587 (Time Series)
- 3) A concentration of four related courses (12 credits), at least two at the 500-level (beyond the two in requirement 2) and at least two in another department, and additional courses to satisfy the general requirements of the Master of Science degree. The courses to satisfy this requirement must be approved by the Industrial Mathematics group.
- 4) Each student spends one term, usually summer, in an internship in an industrial position. This internship is arranged by the student, with the approval of the Industrial Mathematics group and should involve mathematical modeling, computation and analysis.

### Industrial Mathematics Committee

Avramidi—Mathematical Physics, Analysis on Manifolds, Quantum Field Theory  
 Borchers—Optimization, Inverse Problems  
 Sharples—Applied Analysis, Asymptotic Expansions  
 Stone—Differential Equations, Mathematical Biology, Industrial Mathematics

## Master of Science in Mathematics with Specialization in Operations Research and Statistics

An interdisciplinary program in operations research and statistics is available at the graduate level within the various departments at New Mexico Tech. To specialize in this area, the student must fulfill the requirements for the undergraduate program in mathematics and complete MATH 415, 483, and one of either MATH 486 or 488, or the equivalent.

Graduate work would consist of:

- 1) A minimum of 12 credit hours from MATH 515, 516, 517, 518, 519, 582, 583, 586, 587, 588, 589. At least one course (three credit hours) must be chosen from MATH 515, 517, or 518.

- 2) Additional courses subject to the approval of the student's advisor to complete the requirements of the Graduate School. Related courses include ES 316; MGT 462, 472, 473; MATH 384, 386, 410, 411, 484, 505, and 521.

## Master of Science in Mathematics with Specialization in Analysis

To specialize in this area the student must fulfill the requirements of the undergraduate program in mathematics and complete Math 435 and Math 471 or the equivalent.

Graduate work consists of:

- 1) A minimum of 12 credits from Math 531, 533, 534, 535, 536, 537, 575, 576, and 577.
- 2) Additional courses subject to the approval of the student's advisor to complete the requirements of the Graduate School.

## Doctor of Philosophy in Applied and Industrial Mathematics

Students of exceptional ability, as demonstrated in a master's degree program or in previous courses, may pursue a program leading to the doctoral degree. Although the master's degree is not a requirement for the Ph.D. degree, the experience gained in writing a master's thesis or independent study project is valuable.

### Degree Requirements

- Up to 30 hours from a master's degree, excluding thesis and S/U courses, may be included. Students are normally expected to take MATH 501 and 502 in their first year, and MATH 503 each semester after that.
- 48 hours of coursework approved by the student's advisory committee, including:
- All of the following, if not already taken: MATH 410, 411, 435, 437, 438, 471
- 500-level MATH courses (30 credit hours) consisting of:
  1. MATH 530 (3), 532 (3)
  2. Six (6) credit hours of core classes: MATH 511, 535, 538, 539, 577
  3. Four or more of the remaining classes are to be additional core classes (above), courses from the list of recommended classes (below) or other classes approved in advance by the student's committee. Students are strongly encouraged to include MATH 509, Graduate Internship, in their program. *Recommended classes: MATH 509, 510, 512, 518, 519, 531, 533, 536, 537, 587 or other*
- 12 hours of upper-division or graduate-level courses

from outside the math department

- Dissertation (24 credit hours): MATH 595
- Preliminary exams in differential equations, analysis, and numerical analysis (usually taken in the third semester, or in the second semester for students who already have a master's degree). Students may, if necessary, repeat one or more exams the following semester. Students who do not receive satisfactory scores after two attempts will not be accepted into the Ph.D. program.

## Mathematics Courses:

Tech's mathematics department offers courses in eight sub-fields of mathematics. The middle digit of each mathematics course number specifies the sub-field in which that course belongs. The middle digits and the sub-fields they represent are:

- 1—operations research and numerical methods
- 2—discrete mathematics
- 3—applied analysis
- 4—geometry
- 5—modern algebra
- 6—topology
- 7—real analysis (theory)
- 8—probability, statistics, stochastic processes

Thus, 415 is a course in operations research, etc. The middle digit 0 is used for the basic mathematics courses. The only exception to this system is MATH 581, the standard college number for directed studies.

### MATH 101, College Algebra, 3 cr, 2 cl hrs, 3 lab hrs

The fundamental algebraic operations—factoring, fractions, linear equations and inequalities, quadratic equations, ratio, proportion, variation, functions and their graphs, systems of equations. [NMCCNS MATH 1113: General Education Area II]

### MATH 103, Pre-Calculus, 3 cr, 2 cl hrs, 3 lab hrs

*Prerequisites: ACT Math score of at least 21 or SAT Math score of at least 500 or a score of 20 or higher on the algebra portion of the math placement test, or MATH 101 passed with grade C- or better*

Functions and relations, equations and inequalities, determinants and matrices, simultaneous equations, algebra of polynomials, complex numbers. [NMCCNS MATH 1613: General Education Area II]

### MATH 104, Trigonometry, 3 cr, 2 cl hrs, 3 lab hrs

*Prerequisite: MATH 103 passed with a grade of C- or better, or ACT Math score of at least 26 or SAT Math score of at least 590 or a score of 20 or higher on the advanced algebra portion of the math placement test (page 36)*

Trigonometric functions, identities, related angles, radian measure, graphs, inverse functions, trigonometric equations, logarithms, solution of plane triangles. [NMCCNS MATH 1114: General Education Area II]

### MATH 105, Pre-Calculus with Trigonometry, 5 cr, 4 cl hrs, 3 lab hrs

*Prerequisites: Same as for MATH 103*

*Offered summers only. Class consists of five 25-minute lectures and five 55-minute labs each week of summer session.*

A condensed course covering most of the topics of MATH 103 and 104. A maximum of six credits will be allowed for any combination of MATH 103, 104, 105.

### MATH 131, Calculus and Analytic Geometry I, 4 cr, 3 cl hrs, 3 lab hrs

*Prerequisites: MATH 103 and 104 or the equivalent passed with grade C- or better; or ACT Math score of at least 30 or SAT Math score of at least 670; or a combined score of at least 34 on the two components of the math placement tests (page 36); or MATH 104 and either ACT Math score of at least 26 or SAT Math score of at least 490.*

First course in calculus and analytic geometry. Includes introductory concepts in analytic geometry, limits, continuity, differentiation, applications of the derivative, the mean value theorem, the definite and indefinite integral, and applications of integration. [NMCCNS MATH 1614: General Education Area II]

### MATH 132, Calculus and Analytic Geometry II, 4 cr, 4 cl hrs

*Prerequisite: MATH 131 passed with grade C- or better*

Continuation of MATH 131. Transcendental functions, techniques of integration, polar coordinates, infinite series, and applications. [NMCCNS MATH 1623: General Education Area II]

### MATH 221, Formal Logic and Discrete Mathematics, 3 cr, 3 cl hrs

*Prerequisite: MATH 132 passed with a grade C- or better*

Analytical reasoning and critical thinking skills. Induction and recursion. Mathematical proofs. Propositional calculus and predicate calculus. Discrete and combinatorial mathematics: sets, functions, relations, trees, and graphs, permutations and combinations.

### MATH 231, Calculus and Analytic Geometry III, 4 cr, 4 cl hrs

*Prerequisite: MATH 132 passed with grade C- or better*

Vectors in the plane and 3-space, vector calculus in two dimensions, partial differentiation, multiple integration, topics in vector calculus, and complex numbers and functions.

**MATH 254, Introduction to Applied Linear Algebra, 3 cr, 3 cl hrs, 1.5 lab hrs**

*Prerequisite: MATH 131 passed with grade C- or better*

Solution of linear systems. Matrix algebra. Rank. Determinants. Eigenvalues and eigenvectors. Numerical aspects of matrix calculation. Introduction to vector spaces and linear transformations. Applications. (Same as BCS 254)

**MATH 283, Introduction to Applied Statistics, 3 cr, 3 cl hrs, 1.5 lab hrs**

*Corequisite: MATH 132*

Exploratory data analysis. Introduction to probability and random variables. Concepts of population and sample. Estimation and hypothesis testing. Simple linear regression and one-way analysis of variance. Techniques in data analysis using statistical computer packages. (Same as BCS 283)

**MATH 332, Vector Analysis, 3 cr, 3 cl hrs**

*Prerequisite: MATH 231 passed with grade C- or better*

Scalar and vector fields, gradient, divergence, curl, del operator, general orthogonal curvilinear coordinates, line integrals, surface and volume integrals, divergence theorem, Green's theorem, Stokes's theorem, applications.

**MATH 335, Ordinary Differential Equations, 3 cr, 3 cl hrs**

*Prerequisite: MATH 132 passed with grade C- or better*

Ordinary differential equations, series solutions, transform calculus.

**MATH 335L, Ordinary Differential Equations Computer Lab, 1 cr, 1 cl hr**

*Corequisite: MATH 335 or equivalent.*

Optional lab to accompany MATH 335. Basic introduction to the "Maple" syntax required to solve ordinary differential equations with computers. Emphasis on modeling, using graphing capabilities to illustrate how responses (solutions) are influenced by changes in the initial data and physical parameters.

**MATH 336, Introduction to Partial Differential Equations, 3 cr, 3 cl hrs**

*Prerequisites: MATH 231, 254 and 335, each passed with grade C- or better*

Orthogonal functions, Sturm-Liouville theory, Fourier series and integrals, heuristic derivation of examples of partial differential equations taken from heat conduction, vibration problems, electromagnetism, etc.; separation of variables, application to boundary value problems.

**MATH 337, Engineering Mathematics, 3 cr, 3 cl hrs**

*Prerequisites: MATH 231*

*Corequisite: MATH 335*

Selected topics from linear algebra are discussed, including vectors, matrices, determinants, Gaussian elimination, vector spaces and basis as well as Eigenvalues, eigenvectors and diagonalization of matrices. Of particular interest will be linear algebra techniques which are utilized of solving systems of (linear) algebraic equations and solving systems of coupled ordinary differential equations using Laplace transforms and linear algebra tools.

**MATH 352, Basic Concepts of Mathematics, 3 cr, 3 cl hrs**

*Prerequisite: MATH 132 passed with grade C- or better*

Mathematical proofs, set theory, mathematical induction and recursion, binary relations, functions, definition and development of some common number systems, cardinal numbers, abstract algebra.

**MATH 372, Basic Concepts of Analysis, 3 cr, 3 cl hrs**

*Prerequisite: MATH 352 or equivalent passed with grade C- or better*

Dedekind cuts, sequences, limits, differentiation, integrals, infinite series.

**MATH 382, Probability and Statistics, 3 cr, 3 cl hrs**

*Prerequisite: MATH 132 passed with grade C- or better*

Exploratory data analysis, random variables, estimation and hypothesis testing, linear regression and analysis of variance, basic concepts of discrete and continuous probability distributions, bivariate probability distribution functions, expected values, moment generating function and weak law of large numbers. Uses of the central limit theorem and its applications. This course provides an introduction to probability theory and statistical inference. The theory of probability is the primary mathematical tool used in statistical inference and therefore this course will concentrate heavily on probability and statistics. The course has been designed for computer science and engineering students; however, it is broad enough for students from outside these disciplines.

**MATH 382L, Probability and Statistics Lab, 1 cr, 1 cl hrs**

*Corequisite: Math382 or equivalent*

Entering data, descriptive statistics, graphing data, cross tabulation, hypothesis testing, and calculation of probabilities from different probability distributions. Each lab introduces a problem, provides some scientific background, suggests investigations for the data, and provides a summary of the theory used in the investigations.

**MATH 384, Applied Regression and Design of Experiments, 3 cr, 3 cl hrs**

*Prerequisite:* MATH 283 or 382 passed with grade C- or better  
Design of experiments, analysis of variance and covariance, linear and nonlinear curve fitting. Applications taken from metallurgy, mining and petroleum engineering, hydrology, and other disciplines.

**MATH 386, Nonparametric Statistics, 3 cr, 3 cl hrs**

*Prerequisite:* MATH 283 or 382 passed with grade C- or better  
Tests based on ranks for one-sample and two-sample problems, nonparametric estimates, multiple comparisons, nonparametric methods in regression. Applications in science and engineering.

**MATH 391, Special Studies, hrs and cr to be arranged****MATH 401, Putnam Competition, 1 cr, 1 cl hr**

*Graded S/U*

Students in this course will prepare for and then participate in the annual William Lowell Putnam Competition in mathematics. In preparation for the competition, students will learn problem-solving strategies and practice on problems from previous competitions. May be taken multiple times for credit.

**MATH 410, Numerical Methods for Scientists and Engineers I, 3 cr, 3 cl hrs**

*Prerequisite:* CS 113 or ES 111

*Corequisite:* MATH 335

Floating point arithmetic, solution of linear and nonlinear systems of equations, interpolation, numerical differentiation and integration, numerical solution of ordinary differential equations.

**MATH 411, Numerical Linear Algebra, 3 cr, 3 cl hrs**

*Prerequisites:* MATH 254; CS 111 or ES 111

Direct and iterative methods for solving linear systems, conditioning and stability, methods for computing eigenvalues and eigenvectors, linear least squares problems, applications, performance, software.

**MATH 414, Introduction to High Performance Computing, 3 cr, 3 cl hrs**

*Prerequisite:* MATH 410 passed with grade C- or better

Solving scientific problems in high-performance computing systems. Topics include: numerical methods, using software libraries and packages such as MATLAB, Mathematica, NAG, LAPACK, etc., matching algorithms to machines, measuring performance and scientific visualization. A number of computing architectures—such as high-performance workstations, the Cray Y-MP, and the Connection Machine—will be used to solve a small set of prototype problems.

**MATH 415, Introduction to Operations Research: Deterministic Methods, 3 cr, 3 cl hrs**

*Prerequisite:* MATH 254 passed with grade C- or better

A survey of operations research techniques including linear programming, nonlinear models, and graph theoretical models. (Same as BCS 415)

**MATH 430, Mathematical Modeling, 3 cr, 3 cl hrs**

*Prerequisites:* MATH 254 and 335; MATH 382; passed with grade C- or better

Introduction to the process of developing, analyzing, and refining mathematical models. Deterministic and probabilistic models considered for both discrete and continuous problems. Applications to a variety of fields.

**MATH 435, Complex Analysis, 3 cr, 3 cl hrs**

*Prerequisite:* MATH 336 passed with grade C- or better

Algebra of complex numbers, analytic functions and Cauchy-Riemann equations, complex integration and Cauchy's theorem, integral formulae, power series, residues and contour integration, analytic continuation, Riemann surfaces.

**MATH 436, Applications of Complex Analysis, 3 cr, 3 cl hrs**

*Prerequisite:* MATH 435 passed with grade C- or better

Topics selected from linear ordinary differential equations in the complex plane, special functions, conformal mapping, Laplace transform, Fourier and Hilbert transforms.

**MATH 437, Systems of Ordinary Differential Equations, 3 cr, 3 cl hrs**

*Prerequisites:* MATH 254 and 335, each passed with grade C- or better

Theory and application of systems of ordinary differential equations, linear and nonlinear systems, two-dimensional autonomous systems, stability, periodic solutions and limit cycles, interspecies competition and predator/prey problems, pendulum equation, Duffing equation, Van der Pol equation, Lienard equation.

**MATH 438, Partial Differential Equations, 3 cr, 3 cl hrs**

*Prerequisite:* MATH 336 passed with grade C- or better

Classification of classical partial differential equations of mathematical physics, boundary conditions, uniqueness theorems, first and second order equations, characteristics, boundary value problems, Green's functions, maximum principle.

**MATH 442, Introduction to Differential Geometry, 3 cr, 3 cl hrs**

*Prerequisite: MATH 254 passed with grade C- or better*

Introduction to the theory of manifolds, vector fields, tensors and differential forms.

**MATH 454, Linear Algebra, 3 cr, 3 cl hrs**

*Prerequisites: MATH 254 and 352, each passed with grade C- or better*

Finite dimensional vector spaces. Linear transformations. Equivalence and similarity of matrices. Eigenvectors and eigenvalues, canonical forms.

**MATH 455, 456, Introduction to Abstract Algebra, 3 cr, 3 cl hrs each semester**

*Prerequisite: MATH 352 passed with grade C- or better*

A study of abstract algebraic structures, semi-groups, groups, rings, ideals, integral domains, fields, vector spaces, field extensions.

**MATH 458, Introduction to Theory of Numbers, 3 cr, 3 cl hrs**

*Prerequisite: MATH 352 passed with grade C- or better*

Properties of integers, primes, congruences, related topics.

**MATH 461, Introduction to Topology, 3 cr, 3 cl hrs**

*Prerequisite: MATH 372 passed with grade C- or better*

Fundamental concepts of point-set topology, abstract topological spaces, metric spaces, continuous mappings, separation axioms, compactness, connectedness.

**MATH 464, Knot Theory, 3cr, 3 cl hrs**

General survey of knot theory concentrating on knot invariants, including numerical, polynomial and invariants of finite type, theory of braids, the Artin braid group, elementary template theory, applications to physics and biology.

**MATH 471, 472, Introduction to Analysis, 3 cr, 3 cl hrs each semester**

*Prerequisite: MATH 372 passed with grade C- or better*

Basic concepts of the real-number system, elements of point-set theory, infinite sequences, limits, continuity, differentiation of functions of one variable, Riemann-Stieltjes integral, series, functions of several variables.

**MATH 483, Mathematical Statistics, 3 cr, 3 cl hrs**

*Prerequisite: MATH 382 passed with grade C- or better*

Introduction to decision theory. Multivariate distributions. Sampling distributions for the normal case. Convergence of random variables. Different methods of estimation. Principles of hypothesis testing.

**MATH 484, Reliability and Quality Control, 3 cr, 3 cl hrs**

*Prerequisite: MATH 382 passed with grade C- or better*

Order statistics, testing and estimation for common lifetime distributions in reliability, accelerated life tests, Bayesian methods in reliability. Statistical techniques of industrial quality control, sampling methods, control charts. Applications in industry.

**MATH 486, Introduction to Stochastic Processes, 3 cr, 3 cl hrs**

*Prerequisites: MATH 254 and 382, each passed with grade C- or better*

Conditioning. The Poisson process. Theory of Markov chains, continuous time Markov and semi-Markov processes. Topics from renewal theory and Markov renewal theory. Queuing Theory. Applications in science and engineering. (Same as BCS 486)

**MATH 488, Introduction to Operations Research: Probabilistic Methods, 3 cr, 3 cl hrs**

*Prerequisite: MATH 382, passed with grade C- or better*

Monte Carlo Simulation Theory. Application of simulation to problems in science, engineering, and business. Queuing systems simulation. Inventory theory. (Same as BCS 488)

**MATH 491, Directed Study, hrs and cr to be arranged****MATH 500, Directed Research, hrs and cr to be arranged****MATH 501, 502, Professional Development Seminar, 3 cr, 3 cl hrs each semester**

A seminar in which students will develop skills in problem solving, communication, and research. Students will be expected to actively participate in the seminar by attending presentations, solving assigned problems, and preparing written and oral presentations. Graded S/U.

**MATH 503, Graduate Seminar, 0-1 cr, 1 cl hr**

*Prerequisite: Graduate standing.*

Attend and participate in departmental seminars. Graded on an S/U basis.

**MATH 505, Neural Nets, 3 cr, 3 cl hrs**

*Prerequisites: CS 344; MATH 254 and 382; or consent of instructor*

Neuron modeling. The perceptron and multilayer perceptrons. Learning algorithms. The Kohonen model, the Grossberg model, the Hopfield model. Associative memory. Applications. Recent developments in the field. (Same as CSE 565)

**MATH 509 Graduate Internship, credit to be arranged**

*Prerequisite: Graduate standing*

**MATH 510 Computational Fluid Dynamics, 3 cr, 3 cl hrs**

*Prerequisite: MATH 254, 336, 410 or equivalent*

Equations of fluid dynamics, flow models, discretization techniques, analysis of numerical schemes, numerical methods for solving linear and nonlinear systems of equations, numerical methods for inviscid and viscous flows.

**MATH 511, 512, Numerical Methods for Partial Differential Equations, 3 cr, 3 cl hrs each semester**

*Prerequisite: MATH 410 or consent of instructor*

Finite difference methods for parabolic and elliptic partial differential equations. Convergence and stability. Finite element methods. Advanced numerical linear algebra.

**MATH 513, Advanced Topics in Numerical Analysis, 3 cr, 3 cl hrs**

*Prerequisite: MATH 410 or consent of instructor*

Topics chosen from areas in numerical analysis, numerical partial differential equations, multigrid and domain decomposition methods, numerical linear algebra. May be taken multiple times for credit.

**MATH 515, Topics in Deterministic Operations Research, 3 cr, 3 cl hrs**

*Prerequisite: MATH 415 or consent of instructor*

Study of a special topic in deterministic operations research. May be taken multiple times for credit.

**MATH 516, Topics in Stochastic Operations Research, 3 cr, 3 cl hrs**

*Prerequisites: MATH 486 or consent of instructor*

Study of a special topic in stochastic operations research. May be taken multiple times for credit.

**MATH 517, Combinatorial Optimization, 3 cr, 3 cl hrs**

*Prerequisite: MATH 415 or consent of instructor*

Maximum flow, shortest path, and minimum cost flow problems on networks. Matching. Matroids. Cutting plane and branch and bound methods for integer programming. Computational complexity of combinatorial optimization problems.

**MATH 518, Methods of Nonlinear Programming, 3 cr, 3 cl hrs**

*Prerequisite: MATH 410 or 415 or consent of instructor*

Theory of constrained and unconstrained optimization. Methods for nonlinear programming, including quasi-Newton methods, conjugate direction methods, Levenberg-Marquardt methods, sequential quadratic programming, and sequential unconstrained minimization techniques.

**MATH 519, Inverse Problems, 3cr, 3 cl hrs**

Theory and practice of the various techniques of inverting geophysical data to obtain models. Primary emphasis is on the understanding and use of linear inverse techniques. (Same as GEOP 529.)

**MATH 521, Advanced Combinatorics, 3 cr, 3 cl hrs**

*Prerequisite: MATH 221*

Graph theory and applications. Graphs, trees, connectivity, Euler tours and Hamiltonian cycles, matchings, planar graphs, directed graphs, networks, cycle space, and bond space.

**MATH 530, Modeling Case Studies, 3 cr, 3 cl hrs**

*Prerequisite: MATH 430 or equivalent*

Open-ended modeling projects from actual applications.

**MATH 531, Topics in Ordinary Differential Equations, 3 cr, 3 cl hrs each semester**

*Prerequisite: MATH 437 or equivalent*

Study of a special topic in ordinary differential equations not usually treated. Normally one related to a field of research interest at Tech. May be taken multiple times for credit.

**MATH 532, Perturbation Methods, 3 cr, 3 cl hrs**

*Prerequisite: MATH 437 or equivalent*

A survey of expansion techniques. Regular and singular perturbations. Poincaré-Linstedt method. Matched asymptotic expansions. Multiple scales.

**MATH 533, 534, Topics in Partial Differential Equations, 3 cr, 3 cl hrs each semester**

*Prerequisite: MATH 438 or equivalent*

Study of a special topic in partial differential equations not usually treated. Normally one related to a field of research interest at Tech. May be taken multiple times for credit.

**MATH 535, 536, Methods of Mathematical Physics, 3 cr, 3 cl hrs each semester**

*Prerequisite: MATH 436*

Advanced topics selected from asymptotic expansions of integrals and ordinary differential equations, integral equations, singular integral equations, Wiener-Hopf technique, generalized functions.

**MATH 537, Bifurcation Theory, 3 cr, 3 cl hrs**

*Prerequisite: MATH 437 or equivalent*

Discrete and continuous models. Nonlinear buckling, expansion of the bifurcated solution, stability analysis, Hopf bifurcation, degree theory, the Rabinowitz theorem, and other topics.

**MATH 538, Wave Phenomena, 3 cr, 3 cl hrs**

*Prerequisite: MATH 438 or equivalent or consent of instructor*

Hyperbolic and dispersive waves. Characteristic methods, breaking and shock fitting, and weak solutions. Examples drawn from water waves, traffic flow problems, supersonic flight, and other areas.

**MATH 539 Fluid Dynamics, 3 cr, 3 cl hrs**

*Prerequisite: MATH 438 or equivalent*

The Navier-Stokes equations, inviscid flow, irrotational fluids, viscosity, and turbulence. Other topics as time and interest permit.

**MATH 561, 562, Topology, 3 cr, 3 cl hrs each semester**

*Prerequisites: MATH 471, 472; or MATH 461*

Point-set topology, abstract topological spaces, generalized convergence, product and quotient spaces, metric spaces, uniform spaces; elementary concepts of algebraic topology.

**MATH 575, 576, Functions of a Real Variable, 3 cr, 3 cl hrs each semester**

*Prerequisites: MATH 471, 472; MATH 461 or MATH 561 recommended*

Topological concepts, category, measure theory, Lebesgue measure and integration, derivatives and the Radon-Nikodym theorem, product spaces and measures, function spaces, normed linear spaces.

**MATH 577 Functional Analysis, 3 cr, 3 cl hrs**

*Prerequisite: MATH 471 or equivalent*

Normed vector spaces, Banach spaces, Banach fixed point theorem. Lebesgue integral, Lebesgue measure. Hilbert spaces and orthonormal systems, strong and weak convergence. Linear operators on Hilbert spaces, self-adjoint operators, compact operators, spectral theory, Fourier transform. Applications to integral and differential equations, Fredholm theory. Distributions and partial differential equations, fundamental solutions, resolvent, Green's functions, weak solutions.

**MATH 581, Directed Study, hrs and cr to be arranged**

An advanced course offered on demand under the guidance of a senior staff member.

**MATH 582, Linear Statistical Models with Applications, 3 cr, 3 cl hrs**

*Prerequisite: MATH 483 or consent of instructor*

An in-depth study of regression and analysis of variance models. Topics include multiple regressions and model building, analysis of residuals, analysis of variance as regression analysis, generalized linear models, generalized linear mixed models, nonlinear models, multi-factor models with equal and unequal sample sizes, random and fixed effects models, randomized complete block designs, and analysis of covariance. The statistical packages SAS and Minitab will be used for data analysis.

**MATH 583, 584, Topics in Probability and Statistics, 3 cr, 3 cl hrs each semester**

*Prerequisites: MATH 384 or 483; MATH 486 or consent of instructor*

Advanced topics selected from linear regression analysis, the design of experiments, decision theory. Bayes and empirical Bayes procedures. Markov chains, Markov and semi-Markov processes, renewal theory. May be taken multiple times for credit.

**MATH 585, Statistics for Technology Managers, 3 cr, 3 cl hrs**

*Prerequisite: Enrollment in the Engineering Management program*

Probability and random variables; simple and multiple linear regression using least squares and other methods; experimental design; other topics including nonlinear regression; applications to decision making.

**MATH 586, Spatial Variability and Geostatistics, 3 cr, 3 cl hrs**

*Prerequisite: MATH 382*

Introduction to spatial and temporal variability. Stationary and intrinsic random fields, variograms and estimation. Kriging, co-kriging, and simulation of random fields. Conditioning and conditional simulation. Indicator kriging and simulation. Applications from hydrology, mining, petroleum engineering, and other fields of science and engineering.

**MATH 587, Analysis of Time Series and Spatial Data, 3 cr, 3 cl hrs**

*Offered in alternate years*

An introductory overview of methods for analyzing temporal and spatial series with an emphasis on scientific applications. Linear systems in continuous and discrete time, Fourier analysis, spectral estimation, convolution and deconvolution, filtering, the  $z$  and Laplace transforms, stationary and nonstationary time series, ARIMA modeling, forecasting, and generalizations to multidimensional and multichannel applications. (Same as HYD 587 and GEOP 505)

**MATH 588, Advanced Data Analysis, 3 cr, 3 cl hrs**

*Prerequisite: MATH 483 or consent of instructor*

Topics include linear regression, inferential tools for regression, model checking and refinement, experimental design, repeated measures and other multivariate responses, comparisons of proportions or odds, logistic regressions and power analysis. Principal components and factor analysis are also introduced.

**MATH 589, Applied Multivariate Analysis, 3 cr, 3 cl hrs**

*Prerequisite: MATH 382; MATH 283 or 384 recommended*

Multivariate normal distribution and tests assessing multivariate normality. Estimation and hypotheses testing regarding the parameters of multivariate normal populations. Principal component analysis, factor analysis, canonical correlations analysis, classification and discriminant analysis, cluster analysis, multivariate linear models, and multivariate analysis of variance and covariance. Applications in science and engineering.

**MATH 590, Independent Study, cr to be arranged**

Under the direction of a faculty member appointed by the department, the student shall prepare a paper making use of standard reference sources on some topic not covered by other course work.

**MATH 591, Thesis (master's program), cr to be arranged**

**MATH 595 Dissertation (doctoral degree program), credit to be arranged**

*Prerequisite: CHEM 595*

## Faculty Research Interests

Aitbayev—Numerical Methods for Partial Differential Equations, Numerical Analysis  
 Avramidi—Mathematical Physics, Analysis on Manifolds, Quantum Field Theory  
 Borchers—Optimization, Inverse Problems  
 Hossain—Multivariate analysis, survival analysis, estimation reliability and regression diagnostics.  
 Kerr—Thermoelasticity, Integral Equations, Applied Mathematics  
 Makhnin—Stochastic Processes, Statistics  
 Schaffer—Applied Mathematics, Numerical Analysis  
 Starrett—Dynamical Systems, Physics Models, Knot Theory  
 Stone—Differential Equations, Mathematical Biology, Industrial Mathematics  
 Wang—Partial Differential Equations, Dynamical Systems, Applied Mathematics



# Optical Science and Engineering

*Advisory Board Members:*

*Fuierer (Materials Engineering)*

*Teare (Electrical Engineering)*

*Thomas (Electrical Engineering)*

*Westpfahl (Physics)*

**Offered: Minor in Optical Science and Engineering**

Students in the minor program in Optical Science and Engineering receive a broad introduction to optics as well as to specialized applications related to optical research activities on campus. The areas of research at New Mexico Tech include adaptive optics, interferometry, wavefront propagation, atmospheric turbulence, polarimetry and applications to directed energy, astronomy and communications. The prime optical research site at New Mexico Tech is the Magdalena Ridge Observatory (MRO), a dedicated astronomical observatory that will support a large optical interferometer and a 2.4m single telescope. This facility provides a world-class facility for scientific research in optics, optical controls and astronomical science applications. On campus, the Etscorn Observatory provides access to commercial telescopes and imaging cameras.

A Tech student may earn a minor in Optical Science and Engineering as part of a Bachelor of Science degree. While fulfilling the requirements for a Bachelor of Science degree the student must complete a minimum of ten (10) hours of core optics courses, three (3) hours of electromagnetic theory, and at least five (5) additional hours from approved optional courses.

## Minor in Optical Science and Engineering

*Minimum credit hours required—18*

- OPT 300 (4), OPT 400 (3), OPT 410 (3)
- One of: PHYS 333 (3); EE 333 (3); MATE 447 (3)
- Two of: EE 308 (3), EE 324 (3), EE 434 (3); MATE 441 (3), MATE 452 (3); PHYS 334 (3), PHYS 362 (2), PHYS 444 (3); OPT 420 (3), OPT 430 (3), OPT 460 (3), OPT 490 (2).

## Course Descriptions

### OPT 300, Introduction to Optics, 4 cr, 3 cl hrs, 3 lab hrs

*Prerequisites: PHYS 122 or 132; MATH 231*

An introduction to geometrical optics, aberration theory, image formation, Fourier optics, radiometry and photometry and engineering practice in working with optical systems. The course will also introduce optical fabrication concepts and optical coatings.

### OPT 400, Mathematical and Computational Optics, 3 cr, 3 cl hrs

*Prerequisites: OPT 300; MATH 254*

A mathematical approach to optics introducing standard aberration and optical calculation techniques. Topics include paraxial optics, polarization matrices, Seidel aberrations, ray tracing and wavefront propagation through materials. Students will be introduced to modern ray tracing tools.

### OPT 410, Advanced Optics, 3 cr, 3 cl hrs

*Prerequisite: OPT 400*

Topics include image evaluation, wavefront propagation, mode analysis, interferometry, spectrometers, optical testing and multilayer dielectric coatings.

### OPT 420, Interferometry and Optical Testing, 3 cr, 3 cl hrs

*Prerequisite: OPT 400 or consent of instructor.*

An advanced course in optical testing and interferometric systems.

### OPT 430, Thin Films, 3 cr, 3 cl hrs

*Prerequisite: OPT 400 or consent of instructor.*

An advanced course in designing and using thin film coatings.

### OPT 460, Optical Laboratory, 3 cr, 6 lab hrs

*Prerequisite: OPT 300*

An advanced laboratory in optics and photonic systems.

### OPT 490, Special Topics in Optics, cr and topics arranged

*Prerequisite: OPT 300*

Special topics course in optics. Topics may include lasers, fiber optics, adaptive optics and other subjects of interest.

# Physical Recreation

The Physical Recreation program provides students with the opportunity to take part in a wide variety of sports and activities. Classes entail basic skill instruction, and participation is required for credit.

PR classes are generally offered for one credit and are dependent upon student interest and the availability of instructors.

For a complete listing of current Physical Recreation offerings, visit <http://mediaserve.nmt.edu/website/> or call (575) 835.6581.

## Physical Recreation Courses:

*The following sample PR courses are graded S/U and may be used for elective credit only. Classes may be taken multiple times for credit.*

### **P R 100C Weight Lifting 1 cr, 2 cl hrs**

Introduction to basic principles and techniques of weight training

### **P R 101C Weight Lifting for Women 1 cr, 2 cl hrs**

Introduction to basic principles and techniques of weight training as related to women

### **P R 102C Physical Conditioning 1 cr, 2 cl hrs**

Physical fitness, stress management, weight management, nutrition and muscular strength and endurance

### **P R 103C Beginning Racquetball 1 cr, 2 cl hrs**

Basic fundamentals of all strokes and strategies used in the game of racquetball

### **P R 203C Intermediate Racquetball 1 cr, 2 cl hrs**

*Prerequisite: PR 103C or consent of instructor.*  
Perfection of all strokes and strategies used in the game of racquetball

### **P R 104C Beginning Tennis 1 cr, 2 cl hrs**

Fundamentals skills in footwork, forehand, back hand, volleys, and servings

### **P R 105C Badminton 1 cr, 2 cl hrs**

Instruction in basic skills such as serving, volleys, forehand and backhands

### **P R 106C Beginning Golf 1 cr, 2 cl hrs**

Instruction in the basic skills, equipment, rules, etiquette and shot-making and use of irons and woods.

### **P R 206C Intermediate Golf 1 cr, 2 cl hrs**

*Prerequisite: PR 106C or consent of instructor.*  
Instruction emphasizing actual play

### **P R 110C Beginning Volleyball 1 cr, 2 cl hrs**

Introduction to basic skills, rules, and strategies

### **P R 210C Intermediate Volleyball 1 cr, 2 cl hrs**

*Prerequisite: Prior experience is required.*  
Improve individual skill levels and apply more tactics and strategies

### **P R 111C Basketball 1 cr, 2 cl hrs**

Instruction and practice of game skills in a team setting

### **P R 112C Indoor Soccer 1 cr, 2 cl hrs**

Instruction and practice of basic skills in an indoor setting

### **P R 113C Flag Football 1 cr, 2 cl hrs**

Instruction and practice of basic skills, rules, field positions in a team setting

### **P R 120C Beginning Yoga 1 cr, 2 cl hrs**

Introductory practices focus on alignment, strength, breath relaxation, and restoration

### **P R 220C Intermediate Yoga 1 cr, 2 cl hrs**

*Prerequisite: PR 120C or consent of instructor.*  
Intermediate training and skill techniques in Yoga

### **P R 121C Gentle Yoga 1 cr, 2 cl hrs**

Focus on stress reduction, body/breath awareness and flexibility

### **P R 122C Slow Flow Yoga 1 cr, 2 cl hrs**

Instruction supports structural integrity of spine, back and abdominals

### **P R 123C Pilates Matwork 1 cr, 2 cl hrs**

Designed exercise program involves the entire body while focusing on strengthening the core muscles of the torso. Exercises promote coordination, balance and strength

**P R 124C Stretch and Relaxation 1 cr, 2 cl hrs**

Instruction emphasizes stretch and relaxation techniques

**P R 130C Aerobics 1 cr, 2 cl hrs**

Instruction in continuous movement using basic steps for improved cardio respiratory endurance.

**P R 131C Salsa Aerobics 1 cr, 2 cl hrs**

Instruction emphasizes exercise and cardiovascular endurance with the use of Latin music

**P R 132C Zumba 1 cr, 2 cl hrs**

The trademark name for Salsa Aerobics instruction emphasizing exercise and cardiovascular endurance with the use of Latin music

**P R 133C Indoor Cycling 1 cr, 2 cl hrs**

Designed to progressively build strength and endurance while improving cardio respiratory function

**P R 134C Spinning 1 cr, 2 cl hrs**

The trademark name for Indoor Cycling designed to progressively build strength and endurance while improving cardio respiratory function

**P R 140C Beginning Kung Fu 1 cr, 2 cl hrs**

Foundations of Chinese martial arts, self defense, and health systems with special emphasis on the Northern Longfist style.

**P R 141C Karate 1 cr, 2 cl hrs**

Instruction in the basic skills, blocks, strikes, and kicks of Japanese karate

**P R 142C Taijutsu 1 cr, 2 cl hrs**

Instruction in the basic techniques of punching, falling, rolling and kicking in Taijutsu

**P R 143C Tai Chi Chuan 1 cr, 2cl hrs**

Instruction and practice in techniques to enhance body awareness, reduces stress, improve balance and increase strength.

**P R 150C Beginning Belly Dance 1 cr, 2 cl hrs**

Instruction in the basic moving steps and rhythms of the belly dance

**P R 250C Intermediate Belly Dance 1 cr, 2 cl hrs**

Instruction on the isolation and slow movements of Middle Eastern dance, including use of the veil and improvisation

**P R 151C Irish Step Dance 1 cr, 2 cl hrs**

Introduction to the traditional Irish step dance

**P R 152C Ballroom Dance 1 cr, 2 cl hrs**

Introduction to ballroom dance such as the lindy, foxtrot, waltz, tango, cha-cha and rumba

**P R 153C Swing Dance 1 cr, 2 cl hrs**

Introduction to swing dancing including East Coast Swing, Lindy Hop and Charleston.

**P R 160C Outdoor Rec 1 cr, 2 cl hrs**

*Prerequisite: Good Physical Condition and able to hike several miles on rough terrain.*

Selected outdoor activities such as rappelling, rock climbing, paddling, caving, and hiking

**P R 161C Beginning Rock Climbing 1 cr, 2 cl hrs**

Introduction to basic climbing technique with an emphasis on safety, safe knot and belay

**P R 261C Intermediate Rock Climbing 1 cr, 2 cl hrs**

*Prerequisite: Beginning Rock Climbing or consent of instructor*  
Continuation of safety, rope set-up, belaying lead climb, rappelling and anchor set-up

**P R 170C Aquatic Fitness 1 cr, 2 cl hrs**

*Prerequisite: Swimsuits and Aqua shoes recommended*

Designed to enhance the level of muscular development, and cardiovascular endurance through exercise in water

# Physics

Professors Hofner, Minschwaner, Raymond, Romero,  
Westpfahl

Associate Professors Creech-Eakman, Eack (Chair of the Department), Morales,  
Sessions, Sonnenfeld, Young

Assistant Professors Arendt, Meier, Morales, Sessions

Adjunct Faculty: Avramidi, Balasubramaniam, Burcher, Colgate, Elvis, Fuchs,  
Goss, Haniff

Jurgenson, Klinglesmith, Lopez Carrillo, Manney, Meason, Myers, Pietrafß,  
Rison, Rupen, E. Ryan,

W. Ryan, Shepard, Taylor, Teare, Thomas,

Emeritus Professors Eilek, Hankins, Krehbiel, LeFebre, C. Moore, Schery, Winn

**Degrees Offered: B.S. in Physics and in Physics with options in Astrophysics, Atmospheric Physics, and Computer Science; M.S. in Physics; M.S. in Physics with Specialty in Instrumentation; Ph.D. in Physics; Ph.D. in Physics with dissertation in Astrophysics, Atmospheric Physics, or Mathematical Physics**

**Departmental web site:** <http://physics.nmt.edu>

Students in the Department of Physics are encouraged to pursue a broad scientific background and to master theory as well as experiment. The fundamental courses are offered in the principal areas of physics—atomic and nuclear physics, classical mechanics, electricity and magnetism, optics, quantum mechanics, statistical physics, and thermodynamics. The department also offers several laboratory classes. There is the opportunity for students to participate in research projects during the semesters and the summertime, over and above the class and lab work. Many undergraduate students become involved in faculty research and often co-author published papers.

There are three options to accompany the basic physics undergraduate degree: astrophysics, atmospheric physics, and computer science. The first two are designed around the main research interests of the faculty, so students can take advantage of the expertise of the faculty and the facilities that are offered on, or near, the campus. The latter option is present because computers play a crucial role in any application of physics. In addition, we encourage students to consider a minor in electrical engineering (page 231). Several of the faculty have expertise in these areas.

The areas of research in atmospheric physics include thunderstorm electricity, precipitation, cloud particles, cloud dynamics, large-scale atmospheric dynamics, the photochemistry of the middle to upper atmosphere and the dynamics of planetary atmospheres. The Langmuir Laboratory for Atmospheric Research, located on a mountaintop an hour's drive from the campus, offers an unparalleled opportunity for active undergraduate and graduate student participation in observation and research. The atmospheric physics group also operates a Beowulf cluster for atmospheric modeling, the Lightning Mapping Array, E-field-mill networks, and an active scientific

ballooning program focused on charge motion and X-rays produced during storms. In addition, faculty members, as well as undergraduate and graduate students, participate in field programs that use the aircraft and radars of the National Center for Atmospheric Research in Boulder, Colorado.

Research in astrophysics includes pulsar radio emission, the dynamics and kinematics of nearby galaxies, quasars, radio galaxies, plasma astrophysics, comets, stellar evolution, and star formation. The Very Large Array and Very Long Baseline Array radio telescopes, operated by the National Radio Astronomy Observatory, are headquartered on campus and offer unique opportunities for research in radio astronomy for faculty and undergraduate and graduate students alike. In addition, the 2.4-meter optical telescope at New Mexico Tech's Magdalena Ridge Observatory (MRO) is now in operation, and its optical interferometer is under construction. This facility is already involving students in research and development activities.

## Undergraduate Program

### Bachelor of Science in Physics

Minimum credit hours required—130

*In meeting the General Education Core Curriculum (page 100), physics majors must choose PHYS 221 and 222. In addition, the following courses are required:*

- PHYS 241 (3), 242 (4), 321 (3), 333 (3), 334 (3), 336L (1), 340 (3), 380 (1), 411 (3), 443 (3), 451 (2)
- MATH 231 (4), 254 (3), 332 (3), 335 (3), 336 (3), and three hours of approved upper-division courses
- Language—six hours
- Electives—to complete 130 credit hours; in some instances, additional elective credit hours may be desired.

### Sample Curriculum for the Bachelor of Science in Physics

#### Semester 1

5 PHYS 221 & 221L(general)  
4 MATH 131 (calculus)  
4 CHEM 121 & 121L (general)  
3 ENGL 111 (college English)  
16 Total credit hours

#### Semester 2

5 PHYS 222& 222L(general)  
4 MATH 132 (calculus)  
4 CHEM 122 & 122L (general)  
3 ENGL 112 (college English)  
16 Total credit hours

*Semester 3*

- 3 PHYS 241 (computational)
- 4 MATH 231 (calculus)
- 3 Social Science
- 3 Electives
- 3 Language
- 16 Total credit hours

*Semester 4*

- 4 PHYS 242 (waves)
- 3 MATH 332 (vector analysis)
- 3 MATH 335 (ordinary differential equations)
- 3 Humanities
- 3 Language
- 2 Electives
- 18 Total credit hours

*Semester 5*

- 3 PHYS 321 (mechanics)
- 3 PHYS 333 (electricity & magnetism)
- 3 MATH 254 (linear algebra)
- 4 Biology/Earth Science/Engineering with lab
- 3 ENGL 341 (technical writing)
- 16 Total credit hours

*Semester 6*

- 3 PHYS 334 (radiation and optics)
- 1 PHYS 336L (electrical & magnetic measurements lab)
- 3 PHYS 340 (quantum theory)
- 1 PHYS 380 (practicum in problem solving)
- 4 Biology/Earth Science/Engineering with lab
- 3 Social Science
- 1 Electives
- 16 Total credit hours

*Semester 7*

- 3 PHYS 411 (thermodynamics)
- 3 PHYS 443 (atomic and nuclear)
- 3 MATH 336 (applied analysis)
- 3 Humanities
- 3 Social Science
- 3 Electives
- 18 Total credit hours

*Semester 8*

- 2 PHYS 451 (senior lab)
- 3 Humanities/Social Science
- 6 Electives
- 3 MATH 382 (probability & statistics)
- 14 Total credit hours

**Bachelor of Science in Physics with Astrophysics Option**

*Minimum credit hours required—130*

*In meeting the General Education Core Curriculum (page 100), physics majors must choose PHYS 221 and 222. Requirements include the courses listed above for the Bachelor of Science Degree in Physics and the following courses:*

PHYS 325 (3), 326 (3), 327L (1), 328L (1), 425 (3), 426 (3)

**Sample Curriculum for the Bachelor of Science in Physics with Astrophysics Option***Semester 1*

- 5 PHYS 221 & 221L (general)
- 4 MATH 131 (calculus)
- 4 CHEM 121 & 121L (general)
- 3 ENGL 111 (college English)
- 16 Total credit hours

*Semester 2*

- 5 PHYS 222 & 222L (general)
- 4 MATH 132 (calculus)
- 4 CHEM 122 & 122L (general)
- 3 ENGL 112 (college English)
- 16 Total credit hours

*Semester 3*

- 3 PHYS 241 (computational)
- 4 MATH 231 (calculus)
- 3 Social Science
- 3 Language
- 1 Elective
- 14 Total credit hours

*Semester 4*

- 4 PHYS 242 (waves)
- 3 MATH 332 (vector analysis)
- 3 MATH 335 (ordinary differential equations)
- 3 Humanities
- 3 Language
- 16 Total credit hours

*Semester 5*

- 3 PHYS 321 (mechanics)
- 4 PHYS 325 & 327L (astrophysics)
- 3 PHYS 333 (electricity & magnetism)
- 3 MATH 254 (linear algebra)
- 4 Biology/Earth Science/Engineering with lab
- 17 Total credit hours

*Semester 6*

- 4 PHYS 326 & 328L (astrophysics)
- 3 PHYS 334 (radiation and optics)
- 1 PHYS 336L (electrical & magnetic measurements lab)
- 3 PHYS 340 (quantum theory)
- 1 PHYS 380 (practicum in problem solving)
- 3 Humanities
- 3 Social Science
- 18 Total credit hours

*Semester 7*

- 3 PHYS 411 (thermodynamics)
- 3 PHYS 425 (advanced astrophysics)
- 3 PHYS 443 (atomic and nuclear)
- 3 MATH 336 (intro partial differential equations)
- 4 Biology/Earth Science/Engineering with lab
- 16 Total credit hours

*Semester 8*

- 3 PHYS 426 (advanced astrophysics)
- 2 PHYS 451 (senior lab)
- 3 MATH 382 (probability & statistics)
- 3 ENGL 341 (technical writing)
- 3 Social Science
- 3 Humanities/Social Science
- 17 Total credit hours

## **Bachelor of Science in Physics with Atmospheric Physics Option**

*Minimum credit hours required—130*

*In meeting the General Education Core Curriculum (page 100), physics majors must choose PHYS 221 and 222. Requirements include the courses listed above for the Bachelor of Science Degree in Physics and the following courses:*

PHYS 331 (3), 332 (3), 432 (3), 433 (3)

Note: PHYS 331, 332, and 432 are offered in alternate years.

Students may take either of the following two sequences:

1. Junior year: PHYS 331 (fall); PHYS 332 (spring)  
Senior year: PHYS 432 (fall); PHYS 433 (spring)
2. Junior year: PHYS 432 (fall)  
Senior year: PHYS 331 (fall), PHYS 332, PHYS 433 (spring)

### **Sample Curriculum for the Bachelor of Science in Physics with Atmospheric Physics Option (Sequence 1)**

*Semester 1*

- 5 PHYS 221 & 221L (general)
- 3 ENGL 111 (college English)
- 4 CHEM 121 & 121L (general)
- 4 MATH 131 (calculus)
- 16 Total credit hours

*Semester 2*

- 5 PHYS 222 & 222L (general)
- 3 ENGL 112 (college English)
- 4 CHEM 122 & 122L (general)
- 4 MATH 132 (calculus)
- 16 Total credit hours

*Semester 3*

- 3 PHYS 241 (computational)
- 4 MATH 231 (calculus)
- 3 ENGL 341 (technical writing)
- 3 Social Science
- 3 Language
- 16 Total credit hours

*Semester 4*

- 4 PHYS 242 (waves)
- 3 MATH 332 (vectors)
- 3 MATH 335 (ordinary differential equations)
- 3 Humanities
- 3 Language
- 16 Total credit hours

*Semester 5*

- 3 PHYS 321 (mechanics)
- 3 PHYS 331 (weather and climate)
- 3 PHYS 333 (electricity and magnetism)
- 3 MATH 254 (linear algebra)
- 4 Biology/Earth Science/Engineering with lab
- 16 Total credit hours

*Semester 6*

- 3 PHYS 332 (weather and climate)
- 3 PHYS 334 (radiation/optics)
- 1 PHYS 336L (electricity and magnetism lab)
- 3 PHYS 340 (quantum)
- 1 PHYS 380 (practicum in problem solving)
- 3 Humanities
- 3 Social Science
- 17 Total credit hours

*Semester 7*

- 3 PHYS 411 (thermodynamics)
- 3 PHYS 432 (atmospheric remote sensing)
- 3 PHYS 443 (atomic and nuclear)
- 3 MATH 336 (intro partial differential equations)
- 4 Biology/Earth Science/Engineering with lab
- 16 Total credit hours

*Semester 8*

- 3 PHYS 433 (special atmospheric problems)
- 2 PHYS 451L (senior lab)
- 3 MATH 438 (partial differential equations)
- 3 Humanities/Social Science
- 3 Social Science
- 3 Electives
- 17 Total credit hours

**Sample Curriculum for the Bachelor of Science in Physics with Atmospheric Physics Option (Sequence 2)***Semester 1 through 4 are the same as for Sequence 1**Semester 5*

- 3 PHYS 321 (mechanics)
- 3 PHYS 333 (electricity and magnetism)
- 3 MATH 254 (linear algebra)
- 3 PHYS 432 (atmospheric remote sensing)
- 4 Biology/Earth Science/Engineering with lab
- 16 Total credit hours

*Semester 6*

- 3 PHYS 334 (radiation/optics)
- 1 PHYS 336L (electricity and magnetism lab)
- 3 PHYS 340 (quantum)
- 1 PHYS 380 (practicum in problem solving)
- 3 Humanities
- 3 Social Science
- 3 Electives
- 17 Total credit hours

*Semester 7*

- 3 PHYS 331 (weather and climate)
- 3 PHYS 411 (thermodynamics)
- 3 PHYS 443 (atomic and nuclear)
- 3 MATH 336 (intro partial differential equations)
- 4 Biology/Earth Science/Engineering with lab
- 16 Total credit hours

*Semester 8*

- 3 PHYS 332 (weather and climate)
- 3 PHYS 433 (special atmospheric problems)
- 2 PHYS 451 (senior lab)
- 3 MATH 438 (partial differential equations)
- 3 Humanities/Social Science
- 3 Social Science
- 17 Total credit hours

**Bachelor of Science in Physics with Computer Science Option***Minimum credit hours required—131**In meeting the General Education Core Curriculum (page 100), physics majors must choose PHYS 221 and 222. Requirements include the courses listed above for the Bachelor of Science Degree in Physics and the following courses:*

- CSE 113 (4), 122 (3), 221 (3)
- An additional six (6) hours of CSE courses numbered 300 or higher

Two particularly interesting sequences are:

1. CSE 344 and 451
2. CSE 410 and 411

**Sample Curriculum for the Bachelor of Science in Physics with Computer Science Option***Semester 1*

- 5 PHYS 221 & 221L (general)
- 4 MATH 131 (calculus)
- 4 CSE 113 (computer science)
- 3 ENGL 111 (college English)
- 16 Total credit hours

*Semester 2*

- 5 PHYS 222 & 222L (general)
- 4 MATH 132 (calculus)
- 3 CSE 122 (algorithms and data structures)
- 4 CHEM 121 & 121L (general)
- 16 Total credit hours

*Semester 3*

- 3 PHYS 241 (computational)
- 4 MATH 231 (calculus)
- 3 CSE 221 (system organization)
- 4 CHEM 122 & 122L (general)
- 3 Social Science
- 17 Total credit hours

*Semester 4*

- 4 PHYS 242 (waves)
- 3 MATH 332 (vector analysis)
- 3 MATH 335 (ordinary differential equations)
- 3 MATH 352 (basic concepts)
- 3 ENGL 112 (college English)
- 16 Total credit hours

*Semester 5*

- 3 PHYS 321 (mechanics)
- 3 PHYS 333 (electricity & magnetism)
- 3 MATH 254 (linear algebra)
- 3 CS 344 (design and analysis of algorithms)
- 3 ENGL 341 (technical writing)
- 15 Total credit hours

*Semester 6*

- 3 PHYS 334 (radiation and optics)
- 1 PHYS 336L (electrical & magnetic measurements lab)
- 3 PHYS 340 (quantum theory)
- 1 PHYS 380 (practicum in problem solving)
- 4 Biology/Earth Science/Engineering with lab
- 3 Humanities
- 15 Total credit hours

*Semester 7*

- 3 PHYS 411 (thermodynamics)
- 3 PHYS 443 (atomic and nuclear)
- 3 MATH 336 (intro partial differential equations)
- 3 CSE 451 (parallel processing)
- 3 Humanities/Social Science
- 3 Language
- 18 Total credit hours

*Semester 8*

- 2 PHYS 451 (senior lab)
- 4 Biology/Earth Science/Engineering with lab
- 3 Humanities
- 6 Social Science
- 3 Language
- 18 Total credit hours

See the Physics Department website at [www.physics.nmt.edu](http://www.physics.nmt.edu) for sample curricula for a B.S. in Physics with minors in electrical engineering and mathematics.

**Minor in Physics**

*Minimum credit hours required—19*

- PHYS 241 (3), 242 (4)
- Three of the following courses: PHYS 321 (3), 333 (3), 334 (3), 340 (3)
- Three (3) additional hours of upper-division physics

**Graduate Program****Master of Science in Physics**

The Master of Science degree in Physics may be earned under either of the following plans:

**With Thesis:**

The student's course of study must be approved by the student's advisory committee and must fulfill the general requirements for the master's degree with thesis and must include a minimum of nine credit hours selected from: PHYS 505, 508, 513, 514, 515, 516, 526.

All students must complete PHYS 501 and 502 in their first two semesters.

PHYS 579 (1), Graduate-Faculty Seminar, must be taken for the first four semesters.

The preliminary examination will cover courses in physics and mathematics normally included in the undergraduate physics curriculum. Thesis topics will be chosen in consultation with an advisory committee.

**Without Thesis:**

Courses approved by the student's advisor must fulfill the general requirements for the master's degree without thesis and must include the following:

- All students must complete PHYS 501 (1), and 502 (1) in their first two semesters
- PHYS 590 (3)
- a minimum of nine credit hours selected from: PHYS 505, 508, 513, 514, 515, 516, 526.
- PHYS 579 (1), Graduate-Faculty Seminar, must be taken for the first four semesters.

The preliminary examination will cover courses in physics and mathematics normally included in the undergraduate physics curriculum.

**Master of Science in Physics with Specialty in Instrumentation**

Students entering this M.S. program should have a bachelor's degree in engineering, one of the sciences, mathematics, or computer science. Students will also be expected to complete at Tech basic undergraduate physics and electronics courses they have not had. Given the varied backgrounds and interests of students in this specialty, the program of study is tailored to each student's needs. The flexibility needed to do this is evident in the following requirements:

*Credits*

- 9 Graduate physics courses approved by the student's advisory committee
- 3 EE 322, 322L (Advanced Electronics)
- 4 EE 451, 451L (Digital Signal Processing)
- 3 MATH 587 (Time Series)
- 6 At least two of the following:
  - EE 341, 342 (Linear Systems)
  - EE 443 (Control Theory)
  - EE 446 (Communications Theory)
  - CS 331, 432 (Computer Architecture, VLSI)
  - PHYS 565 (Astronomical Techniques)
- 3 Graduate course approved by the advisory committee
- 3 PHYS 590 (Independent Study)
- 32 Total credit hours

PHYS 579 (1), Graduate-Faculty Seminar, must be taken for the first four semesters. In addition to the above requirements, students must satisfy the general requirements for the M.S. degree and pass a preliminary examination on undergraduate physics and electronics.



## Doctoral Programs

Students of exceptional ability as demonstrated in previous courses in physics and mathematics, or in the preliminary examination, may pursue a program leading to the doctoral degree. All applicants to the physics doctoral degree program must submit GRE general and physics subject test scores.

The major doctoral programs of the Physics Department are in astrophysics and atmospheric physics. A degree in mathematical physics is offered in cooperation with the mathematics department. Students may also work in other areas of physics in which the department has expertise.

The following general requirements apply to all curricula: A minimum of 50 credit hours of graduate and upper-division courses approved by the student's committee should be taken, of which 12 credit hours must be mathematics beyond that required of an undergraduate physics major. PHYS 501 and 502 (where required below) may be waived for those students who have completed the equivalent through an experimental master's thesis. PHYS 579, Graduate-Faculty Seminar, must be taken for the first four semesters.

### Doctor of Philosophy in Physics with Dissertation in Astrophysics

Current areas of research in astrophysics include quasars, pulsars, and radio galaxies, X-ray astronomy, solar and stellar activity, plasma astrophysics, and comets. New Mexico Tech operates the Magdalena Ridge Observatory (MRO) and also takes advantage of the proximity of the facilities of the National Radio Astronomy Observatory (NRAO). Students may pursue dissertation work not only with regular faculty but also with a number of NRAO staff who have adjunct appointments at Tech.

The following courses must be completed: PHYS 501 (1), 502 (1), 505 or 526 (3), 513 (3), 514 (3), 515 (3), 516 (3), 562 (3), 563 (3), 564 (3), 565 or 566 (3), and 579. In addition, PHYS 426 (3) must be completed unless the student has had equivalent material in previous courses.

### Doctor of Philosophy in Physics with Dissertation in Atmospheric Physics

Current areas of research in atmospheric physics are the dynamics and microphysics of clouds and mesoscale weather systems, geophysical fluid dynamics, dynamics of planetary atmospheres, thunderstorm electrification and lightning, atmospheric radioactivity, physics of the middle and upper atmosphere, precipitation mechanisms, and radar meteorology. Research facilities include an instrumented aircraft for thunderstorm penetrations, several

meteorological radars, and Langmuir Laboratory, a mountaintop observing site. Also available are the observational and computer facilities of the National Center for Atmospheric Research in Boulder, Colorado.

The following core courses must be completed:

- PHYS 331 (3), 332 (3), 501 (1), 502 (1), 505 or 526 (3), 508 (3), 513 (3), 514 (3), 515 (3), 516 (3), and 579.
- An additional six (6) credit hours must be taken in areas pertinent to the student's program. This can be achieved by taking PHYS 532, PHYS 533, PHYS 535, PHYS 536, and/or other courses approved by the student's advisory committee.

### Doctor of Philosophy in Physics

The following courses must be completed: PHYS 501 (1), 502 (1), 505 (3), 508 (3), 513 (3), 514 (3), 515 (3), 516 (3), and 579. In addition, nine credit hours of graduate physics should be completed in the student's field of specialization.

### Doctor of Philosophy in Physics with Dissertation in Mathematical Physics

The mathematical physics program is operated in cooperation with the Mathematics Department. Dissertation supervision may be obtained in either department. Students normally pursue research based on faculty interest in one or both departments.

The following courses must be completed:

- PHYS 505 (3), 513 (3), 514 (3), 515 (3), 516 (3), 579
- MATH 435 (3), 438 (3), 442 (3), 471 (3), 535 (3)
- Additional approved graduate and upper-division courses, including at least six credit hours from mathematics and six credit hours from physics, should be elected to bring the total to a minimum of 51 credit hours beyond the bachelor's degree. The following courses have been approved:
- MATH 410 (3), 411 (3), 511 (3), 531 (3), 532 (3), 533 (3), 536 (3), 538 (3)
- PHYS 508 (3), 526 (3), 532 (3), 533 (3), 535 (3), 536 (3), 562 (3), 563 (3), 564 (3)

Additional courses may be approved at the discretion of the candidate's committee.

### Graduate Minor in Physics

A student seeking a graduate minor in physics must complete at least 6 hours from the following: PHYS 505, PHYS 508, PHYS 513, PHYS 514, PHYS 515, PHYS 516, or PHYS 523. The remaining physics courses must be graded, at least 300-level or above, and be approved by the minor advisor. A total of 12 credits hours in physics (minimum 6 hours at the 500-level) are required for a minor at the master's level, and 18 hours (minimum 12 hours at the 500-level) for the doctorate level minor.

## Physics Courses:

### PHYS 121, General Physics I, 4 cr, 3 cl hrs, 2 recitation hrs

*Corequisites: PHYS 121L; MATH 131*

Introductory concepts. Mechanics, including Newton's Laws of force, linear and angular momentum, energy, gravitation, heat and thermodynamics, and applications. [NMCCNS PHYS 1215: General Education Area III]

### PHYS 121L, General Physics Laboratory I, 1 cr, 3 lab hrs

*Corequisite: PHYS 121*

Experiments from the subject matter of PHYS 121. [NMCCNS PHYS 1215: General Education Area III]

### PHYS 122, General Physics II, 4 cr, 3 cl hrs, 2 recitation hrs

*Prerequisite: PHYS 121*

*Corequisites: MATH 132; PHYS 122L*

Continuation of PHYS 121 including electricity and magnetism, optics, and atomic and nuclear phenomena. [NMCCNS PHYS 1225: General Education Area III]

### PHYS 122L, General Physics Laboratory II, 1 cr, 3 lab hrs

*Corequisite: PHYS 122*

Experiments from the subject matter of PHYS 122. [NMCCNS PHYS 1225: General Education Area III]

### PHYS 221, Comprehensive Physics I, 4 cr, 3 cl hrs, 2 recitation hrs

*Prerequisites: PHYS 121; MATH 131*

*Corequisite: PHYS 221L*

A treatment of physics for science and engineering students from a modern point of view. The subject is logically developed starting with optics and the theory of relativity. Quantum and classical mechanics are then introduced. This course is required for physics majors. [NMCCNS PHYS 1215: General Education Area III]

### PHYS 221L, Comprehensive Physics Laboratory I, 1 cr, 2 lab hrs

*Corequisite: PHYS 221*

Laboratory experiments from the subject matter of PHYS 221. [NMCCNS PHYS 1215: General Education Area III]

### PHYS 222, Comprehensive Physics II, 4 cr, 3 cl hrs, 2 recitation hrs

*Prerequisites: PHYS 221; MATH 131*

*Corequisites: PHYS 222L; MATH 132*

Continuation of PHYS 221. Attempts to probe successively smaller scales are explored. The four forces of nature; practical applications of gravity and electromagnetism. Dynamics of large numbers of particles are introduced, resulting in applications to the everyday world. This course is required for physics majors. [NMCCNS PHYS 1225: General Education Area III]

### PHYS 222L, Comprehensive Physics Laboratory II, 1 cr, 2 lab hrs

*Corequisite: PHYS 132*

Laboratory experiments from the subject matter of PHYS 222. [NMCCNS PHYS 1225: General Education Area III]

### PHYS 241, Computational Physics, 3 cr, 3 cl hrs

*Prerequisites: PHYS 222; MATH 132*

This course goes into more depth than first-year college physics courses on key classical concepts such as force, acceleration, Newton's Laws, and conservation laws. New mathematics will include numerical solution of differential equations and statistical techniques for experimental scientists. The fundamental physics is reinforced by numerical simulations and calculations that the students write themselves. Along the way, students are taught to program in a scientific computing environment. Students should emerge with a firm grasp of classical mechanics and computational skills.

### PHYS 242, Vibrations and Waves, 4 cr, 3 cl hrs, 3 lab hrs

*Prerequisites: PHYS 122 or PHYS 222; MATH 231*

Vibrations and waves are examined from both theoretical and experimental standpoints. Theory describing simple vibrating systems, including coupled oscillators. Laboratory measurements on electrical analogs of vibrating systems. Wave theory for transverse and longitudinal waves. Experiments using electromagnetic radiation in the visible, microwave, and X-ray regions are used to illustrate the nature of waves.

### PHYS 301, Laboratory and Shop Techniques, 1 cr, 1 afternoon per week

Instruction in drill and tool bit sharpening, use of hand tools, drill press, lathe, milling machine, shaper, and sheet metal brake.

### PHYS 321, Intermediate Mechanics, 3 cr, 3 cl hrs

*Prerequisites: PHYS 241*

*Corequisite: MATH 335*

An intermediate course in the dynamics and statics of particles and rigid bodies. Introduction to Lagrangian and Hamiltonian mechanics.

### PHYS 325, Astrophysics I: Stars, 3 cr, 3 cl hrs

*Prerequisites: PHYS 242*

Astrophysics is the application of physics to the universe. This course begins with a review of relevant physics and then applies those concepts to the lives of stars. The subject matter includes stellar atmospheres, stellar interiors, star formation, stellar evolution, variable stars, and compact objects.

**PHYS 326, Astrophysics II: Planetary and Extragalactic Systems, 3 cr, 3 cl hrs**

*Prerequisites: PHYS 325*

This course continues the application of physics to the rest of the universe. Our own solar system and its formation and evolution, normal galaxies, active galaxies, the large-scale structure of the universe, and cosmology.

**PHYS 327L, 328L, Astronomy Laboratory, 1 cr, 3 lab hrs each semester**

*Prerequisites: PHYS 122, 122L or PHYS 222, 222L; or consent of instructor*

A self-paced introduction to astronomical observing and data reduction. Emphasis on techniques such as the operation of telescopes and their auxiliary equipment, astronomical photography, photometry, spectroscopy, and data handling. Exercises chosen from topics in solar system, stellar, galactic, and extragalactic astronomy.

**PHYS 331, Physics of Weather and Climate I, 3 cr, 3 cl hrs**

*Prerequisite: PHYS 122 or 222*

*Offered alternate years*

The flows of energy and water in the atmosphere, ocean, and land surface work together to form the environment in which we live. Short-term variations in these flows give rise to weather, while longer term averages are related to the Earth's climate. This course explores the physical and chemical processes which are important for understanding weather and climate— atmospheric and oceanic thermodynamics, cloud formation and precipitation, solar and thermal radiation, and the photo-chemistry of the atmosphere.

**PHYS 332, Physics of Weather and Climate II, 3 cr, 3 cl hrs**

*Prerequisites: PHYS 331; MATH 332 and 335*

*Offered alternate years*

This course, a continuation of PHYS 331, introduces the principles of geophysical fluid dynamics and investigates the factors controlling winds and ocean currents, floods, drought, and temperature change, as well as climate phenomena such as El Niño, the Greenhouse Effect, and the ice ages.

**PHYS 333, Electricity and Magnetism, 3 cr, 3 cl hrs**

*Prerequisites: PHYS 122 or PHYS 222; PHYS 242; MATH 332*  
*Corequisite: MATH 335*

This subject is one of the cornerstones for understanding a huge variety of phenomena — electronic and optical devices, communication by telephone, radio waves, optical fibers, and the behavior of atoms and molecules. It is remarkable that so much insight comes from Maxwell's four equations and the Lorentz force law. This course develops these equations in detail and applies them to a variety of problems. It also helps students develop an understanding of the applications of more advanced mathematics in a physical context.

**PHYS 334, Radiation and Optics, 3 cr, 3 cl hrs**

*Prerequisites: PHYS 333; MATH 335*

This course explores the behavior of electromagnetic waves, including optical waves, using Maxwell's equations and the Lorentz force law. Included in the course are the topics of radiation, conservation laws, relativistic and non-relativistic electrodynamics, basic geometrical optics and aberration theory, and specific phenomena such as polarization, diffraction and interference. The class will include demonstrations and discussions of these phenomena and modern optical devices.

**PHYS 336L, Electrical and Magnetic Measurements Lab, 1 cr, 3 lab hrs**

*Prerequisite: PHYS 333*

Experiments in electricity and magnetism, emphasizing applications to measurements in physics and geophysics.

**PHYS 340, Introduction to Quantum Theory, 3 cr, 3 cl hrs**

*Prerequisites: PHYS 321; MATH 254, 335, or consent of instructor*

Electrons, atoms, and radiation. Wave-particle experiments, introductory quantum mechanics, atomic structure and spectra, the hydrogen atom, exclusion principle, electronic structure of atoms, and diatomic molecules.

**PHYS 362, Image Processing, 2 cr, 2 cl hrs**

*Prerequisite: PHYS 122 or 222*

An introduction to image processing and computational physics designed for scientists and engineers. Topics will include properties of imaging devices and systems, image construction, analysis, and display. Data will come from satellites and terrestrial sources. Examples will come from current research whenever possible.

**PHYS 380, Practicum in Problem Solving, 1 cr, 2 cl hrs**

*Prerequisite: PHYS 321, or consent of instructor*

Methods of problem solving, including dimensional and scale analysis, rapid estimation, and combining knowledge from various disciplines. Class time will be spent analyzing and solving problems posed by the instructor and students. Students will normally be graded S/U, and sections will be strictly limited in size to facilitate active participation of all students.

**PHYS 389, Pilot Course, topic, hrs, and cr to be arranged**

**PHYS 391, Directed Study, hrs and cr to be arranged**

**PHYS 408, Cooperative Education**

On-the-job training to supplement the academic program. Students alternate periods (usually six months long) of full-time semiprofessional employment in their chosen field with periods of full-time academic study.

**PHYS 411, Thermodynamics and Statistical Physics, 3 cr, 3 cl hrs**

*Prerequisite:* PHYS 122 or PHYS 222; PHYS 340

*Corequisite:* MATH 335

A course dealing with the effects of heat and work on gases, liquids, and solids. The equations of state and the first and second laws of thermodynamics are presented with applications to heat engines and chemical processes. An introduction is given to kinetic theory and statistical mechanics.

**PHYS 421, Continuum Mechanics, 3 cr, 3 cl hrs**

*Prerequisites:* PHYS 121 or PHYS 221; MATH 332, 335

*Offered on demand*

Statics and dynamics of fluids and elastic bodies.

**PHYS 425, Astrophysics III: Plasma Astrophysics, 3 cr, 3 cl hrs**

*Prerequisites:* PHYS 325, 326, 333

Plasma and fluid physics govern most of the luminous matter in the universe. This course surveys the many aspects of plasma physics, from microphysics (single particle motions, waves and oscillations, collisions) to macrophysics (the fluid description and magnetohydrodynamic effects). Applications will include a wide variety of astrophysical objects, from the earth's magnetosphere and the solar wind, to accretion disks and radio jets.

**PHYS 426, Astrophysics IV: High Energy Astrophysics, 3 cr, 3 cl hrs**

*Prerequisites:* PHYS 333 and 425; or consent of instructor

This course continues the application of fluid and plasma physics to astrophysics. Radiation processes and diagnostics, shock physics, high energy plasmas, and cosmic ray acceleration. Many applications will come from our galaxy, including the interstellar medium, star formation, supernovae, black holes, and pulsars. We will go beyond the boundaries of our galaxy to study active galactic nuclei and their connection to galaxy formation.

**PHYS 432, Atmospheric Remote Sensing, 3 cr, 3 cl hrs**

*Prerequisite:* PHYS 122 or 222

Remote sensing from space and ground-based instruments is a useful technique for monitoring the physical and chemical state of the atmosphere. This course will examine the physics of remote sensing using radio, microwave, infrared, visible, and ultraviolet instruments. Topics will include both active and passive systems for measuring atmospheric temperature, composition, and dynamics.

**PHYS 433, Special Problems in Atmospheric Physics, 3 cr, 3 cl hrs**

*Prerequisite:* PHYS 331

*Offered spring semesters*

Project in which student works with a member of the atmospheric physics group on current research. This project is expected to lead to a report, conference presentation, or contribution to a published paper. The student should contact an appropriate faculty member within the first two weeks of the fall semester to organize a project.

**PHYS 443, Atomic and Nuclear Physics, 3 cr, 3 cl hrs**

*Prerequisite:* PHYS 340

Continuation of PHYS 340. Further topics in atomic and molecular structure. Quantum statistics with applications to degenerate Fermi and Bose Fluids. Radioactivity, elements of nuclear structure, nuclear energy sources. Mesons, hyperons, and resonances.

**PHYS 444, Solid-State Physics, 3 cr, 3 cl hrs**

*Prerequisite:* PHYS 340 or consent of instructor

*Offered on demand*

Theory and application of solid-state devices; binding in molecules and crystals; energy bands; electrons in metals; imperfections in solids; electrical, thermal, and magnetic properties of solids; and semiconductor theory.

**PHYS 449, Astrobiology, 3 cr, 3 cl hrs**

*Prerequisite:* CHEM 121 & 122, PHYS 121 & 122, one other science course and consent of instructor.

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. (Same as BOL 449 and EARTH 449)

**PHYS 451, Senior Laboratory, 1 or 2 cr, 3 or 6 lab hrs**

*Prerequisites:* Senior status or consent of instructor

Experiments in atomic, nuclear, and solid-state physics.

**PHYS 489, Pilot course, topic, hrs, and cr to be arranged****PHYS 491, Directed Study, hrs and cr to be arranged**

**PHYS 500, Directed Research, cr to be arranged**

*This course may not be used to fulfill graduate degree requirements.*

Research under the guidance of a faculty member.

**PHYS 501, 502, Graduate Project, 1 cr, 3 lab hrs each semester**

This course involves beginning graduate students in a modest project, usually related to ongoing research in the department. While the work will be supervised by a faculty member, the emphasis is on independent work by the student. Possible types of projects include data analysis, software development, theoretical modeling, a literature survey, and design and/or construction of research or teaching equipment.

**PHYS 505, Advanced Dynamics, 3 cr, 3 cl hrs**

*Offered Fall 2009 and alternate years*

Introduction to classical mechanics: Lagrangian and Hamiltonian formalism, rigid body motion, normal modes. Hamilton-Jacobi Theory, and problems in relativistic mechanics.

**PHYS 508, Statistical Mechanics, 3 cr, 3 cl hrs**

*Offered Spring 2010 and alternate years*

Entropy, randomness, the Boltzmann distribution, and the chemical potential. Translational, rotational, vibrational, and electronic contributions to the partition function. Calculation of mean energies, heat capacities, and equilibrium constants. Stability. The influence of wave function symmetry: Bose-Einstein and Fermi-Dirac statistics. The quantum statistical operator. Coherence and the Pauli principle. (Same as CHEM 524)

**PHYS 513, 514, Electromagnetics I & II, 3 cr, 3 cl hrs each semester**

*Offered 2009-2010 and alternate years*

The electromagnetic field equations; boundary value problems in electrostatics and magnetostatics; plane, cylindrical, and spherical waves, wave guides; the Hertz Vectors, retarded potentials and simple radiating systems; relativistic electrodynamics; radiation from moving charges.

**PHYS 515, 516, Quantum Mechanics I and II, 3 cr, 3 cl hrs each semester**

*Offered 2008-09 and alternate years*

Review of experiments leading to quantum theory: Schrodinger's Equation, operators and eigenvalues, perturbation theory, and applications to simple physical systems. The second semester includes introduction to scattering theory, the theory of angular momentum, and Dirac Theory.

**PHYS 526, Fluid Dynamics, 3 cr, 3 cl hrs**

*Offered 2010 and alternate years*

Basic equations, potential and viscous flow, scaling. Compressible flow including characteristics and shock waves. Magnetohydrodynamics, including MHD waves, shocks, and confinement. Fluid and MHD instabilities. Turbulence.

**PHYS 532, Atmospheric Remote Sensing, 3 cr, 3 cl hrs**

Physics of remote sensing using radio, microwave, infrared, visible, and ultraviolet instruments. Topics will include both passive and active systems for measuring atmospheric temperature, composition, and dynamics. Shares lectures with PHYS 432, but is graded separately and additional graduate-level work is required.

**PHYS 533, Advanced Topics in Atmospheric Physics, 1-3 cr, 1-3 cl hrs**

Specialized coursework in the student's areas of interest. Advanced topics in the area of atmospheric physics. Selection of topics changes from semester to semester. Current faculty interests can be found at the department web site: [www.physics.nmt.edu](http://www.physics.nmt.edu). This course may be repeated for credit if the material covered in each instance is different.

**PHYS 535, Physics of Lightning, 3 cr, 3 cl hrs**

*Offered Fall 2009 and alternate years*

Theory and experimental techniques concerning cloud charging mechanisms. Remote and in-situ sensing of lightning. Lightning phases and properties. Properties of the long spark and leaders in the lab and in the sky. Simple numerical models of cloud charging, lightning initiation, and propagation.

**PHYS 536, Atmospheric Convection, 3 cr, 3 cl hrs**

Governing equations, turbulence, thermodynamics, and microphysics of moist convection. Models for convection ranging from plumes and thermals through numerical simulations are discussed, as well as interactions of convection with the atmospheric environment.

**PHYS 546L, Electrical and Magnetic Measurements Graduate Lab, 1 cr, 3 lab hrs**

*Prerequisite: Graduate standing or consent of instructor*

Experiments in electricity and magnetism, emphasizing applications to measurements in physics and geophysics. Topics include DC and AC circuits, complex impedance, transformers, magnetic hysteresis, transistors, operational amplifiers, superconductivity, and student selected projects. Shares lab with Physics 336L but graduate students will face a higher standard on lab reports and be required to do some additional formal study of electronics. The course is recommended for graduate students lacking practical electronics experience.

**PHYS 549, Astrobiology, 3 cr, 3 cl hrs**

*Prerequisites: Graduate standing or consent of instructor.*

*Offered on demand.*

An in-depth and interdisciplinary study of astrobiology, including interactions between living and non-living systems at multiple scales: stellar, planetary, meso, and microscopic. Addresses fundamental questions regarding the origin of life, and the possible extent and distribution of life in the universe. Combines principles of astrophysics, geosciences, planetary science, chemistry, and biology. Innovative interactive exercises and projects working in interdisciplinary groups and individually. Shares lecture with PHYS 449 but is graded separately and additional graduate-level work is required. (Same as BIOL 549 and GEOL 549)

**PHYS 562, Stellar Astrophysics, 3 cr, 3 cl hrs**

*Prerequisites: PHYS 425, 426 or equivalent or consent of the instructor.*

*Offered Spring 2007 and alternate years.*

This course covers in-depth the physics of stars, their structure and evolution. Topics include energy generation and transport, nucleosynthesis, equations of state, stellar modelling, asteroseismology, and stellar pulsation and rotation — all studied in the context of the evolution of a star. There are detailed discussions and derivations of the various stages in star formation and evolution, and the end states of stars (e.g. white dwarfs, planetary nebulae, black holes). The course stresses current refereed literature and has occasional guest speakers on various topics.

**PHYS 563, Extragalactic Astrophysics, 3 cr, 3 cl hrs**

*Prerequisites: PHYS 425, 426 or equivalent or consent of instructor*

*Offered Fall 2009 and alternate years*

The structure and dynamics of galaxies. Distribution of galaxy types. Potential and orbit theory. Spheroidal galaxies as self-gravitating systems. Instabilities in disk galaxies. Constraints on dark matter and on galaxy formation.

**PHYS 564, Relativity and Cosmology, 3 cr, 3 cl hrs**

*Prerequisites: PHYS 425, 426 or equivalent or consent of instructor*

*Offered Spring 2009 and alternate years*

General relativity with application to cosmology. Basic principles of relativity. Applications to orbits, gravitational radiation, and black holes. Relativistic cosmography and cosmology. The early universe, galaxy formation, and active galaxies.

**PHYS 565, Astronomical Techniques, 3 cr, 3 cl hrs**

*Offered alternate years*

Optical, IR, X-ray and gamma-ray astronomical telescopes and detectors. Throughput, detector quantum efficiency, the modulation transfer function, noise and estimation error. Photometers and photometric systems, CCD imaging, slit and objective grating spectrometry, Fourier spectroscopy. Astrometry, orbit determination. Computer analysis and astronomical databases. Class work will be augmented by extensive optical observing using local facilities.

**PHYS 566, Advanced Radio Astronomy, 3 cr, 3 cl hrs**

*Offered Spring 2009 and alternate years*

The design and operational characteristics of radio telescopes and interferometers. Properties of antennas, telescope optics, feeds, waveguides, receivers, and amplifiers. Spectrometers and spectroscopy. Sensitivity and noise. Amplitude and phase calibration, faint signal detection, astrometry, and mapping. Factors that affect radio data, including instrumental characteristics, atmospheric limitations, and propagation phenomena. The VLA and VLBA and the techniques of radio imaging by aperture synthesis. Hands-on astrophysical exercises to be solved by imaging.

**PHYS 567, Advanced Topics in Astrophysics, 2–3 cr, 2–3 cl hrs**

*Offered on demand*

A one-semester tutorial may be selected from any one of the following: our solar system, comets, solar and stellar activity, galactic structure and kinematics, active galaxies and quasars, astrophysical plasmas, accretion disks, black holes, stellar spectroscopy, stellar photometry and astrometry.

**PHYS 571, Advanced Topics in Physics, 3 cr, 3 cl hrs**

*Offered on demand*

Study of a special topic not otherwise treated, normally one related to a field of research interest at Tech.

**PHYS 579, Graduate-Faculty Seminar, 1 cr, 1 cl hr**

*Offered every semester*

A seminar in which current research topics are discussed by faculty, students, and outside speakers. Graded S/U, where satisfactory performance consists of regular attendance and participation. Credit earned may not be applied towards the 30 credits required for the M.S. degree.

**PHYS 581, Directed Study, cr to be arranged**

Study under the guidance of a member of the graduate faculty. In general, subject matter will supplement that available in other graduate course offerings.

**PHYS 590, Independent Study, cr to be arranged****PHYS 591, Thesis (master's program), cr to be arranged****PHYS 595, Dissertation (doctoral degree program), cr to be arranged**

*Prerequisite: CHEM.595*

**Physics Faculty Research Interests**

Avramidi—Mathematical Physics, Analysis on Manifolds, Quantum Field Theory

Balasubramaniam—Spectroscopy and Polarized Radiative Transfer Dynamics of Solar Active Regions, Vector Magnetometry

Buscher—Optical/IR Interferometry, Atmospheric Seeing Measurement, Adaptive Optics, Early and Late Stages of Stellar Evolution

Colgate—Astrophysics, Plasma Physics, Atmospheric Physics

Creech-Eakman—Stellar Astrophysics, Mass-loss, Optical/IR Interferometry, IR Instrumentation

Eack—Production of Energetic Particles and Gamma Rays in Thunderstorms

Eilek—Plasma Astrophysics, Quasars, Radio Galaxies, Pulsars

Elvis—Quasars and Active Galactic Nuclei, X-ray Astronomy

Fuchs—Atmospheric Dynamics

Goss—Radio Astronomy, Interstellar Medium

Haniff—Spatial Interferometry at Optical and Near-Infrared Wavelengths, Atmospheric Turbulence, Imaging Theory, Evolved Stars

Hankins—Radio Astronomy of Pulsars, Instrumentation, Signal Processing

Hofner—Star Formation, Interstellar Medium, X-ray Astronomy, Extragalactic Interstellar

Klinglesmith—Asteroids, Robotic Telescope Operations

Krehbiel—Lightning studies; radar meteorology; thunderstorm electrification

LeFebre—Statistical Physics and Thermodynamics

Lopez Carrillo—Doppler Radar and Data Analysis, Tropical Dynamics

Manney—Atmospheric Science, Stratospheric Dynamics/

Transport, Stratospheric Polar Processes and Ozone Loss

Meason—Nuclear Physics, Nuclear & Space Radiation Effects, Electromagnetic Radiation Effects & Directed Energy

Meyers—Cosmology, Extragalactic Radio Astronomy, Interferometric Imaging Algorithms

Minschwaner—Radiative Transfer and Climate, Physics of the Middle and Upper Atmosphere

C. Moore—Weather Radar, Precipitation Mechanisms  
Morales—Outer planets observations and atmospheric dynamics

Myers—Cosmology, Extragalactic Radio Astronomy, Interferometric Imaging Algorithms

Pietraß—Organic Chemistry, Organic Synthesis, Physical Organic Chemistry

Raymond—Geophysical Fluid Dynamics, Cloud Physics, Clouds and Climate

Rison—Atmospheric Electricity, Radar Meteorology, Instrumentation

Romero—Energetic Materials, Shock Phenomena, High Energy Physics

Rupen—Gas and Dust in Galaxies, Radio Transients

E. Ryan—Asteroid Collisional Physics, Observational and Theoretical Studies

W. Ryan—Asteroid Astronomy, High Energy Physics

Schery—Environmental Radioactivity

Sessions—Field Theoretic Approaches to Atmospheric Physics

Sheperd—Star Formation

Sonnenfeld—charge Transport by lightning, Embedded systems and instrumentation, Tribocharging of ice

Taylor—Very Long Baseline Radio Astronomy, Active Galactic Nuclei

Teare—Experimental Adaptive Optics, Radiation Effects and Directed Energy

Thomas—Atmospheric Physics, Instrumentation

Westpfahl—Dynamics of Spiral and Dwarf Galaxies

Winn—Atmospheric physics; electrical discharges in gases; instrumentation

Young—Star Formation and the Interstellar Medium, Dwarf and Elliptical Galaxies

# Preprofessional Programs

Specific requirements for admission to professional schools vary. With the help of an advisor, each preprofessional student should plan a course of study that will meet the specific entrance requirements of the school in which the student is interested. The following statements outline the usual requirements for programs which may be completed with course offerings available at Tech. Preprofessional students who complete the requirements for the Bachelor of Science degree in Basic Sciences with appropriate selection of electives will qualify for admission to most professional schools.

Preprofessional training in the biological and medical allied sciences consists of a thorough background in basic sciences. Hence, the first two years will be essentially the same for all specialties. Courses during the first two years should include ENGL (two semesters); BIOL 111, 112, 331, 333; CHEM 121, 122, 333, 334; MATH 131, 132; PHYS 121, 122; PSY 121; and social science (two semesters).

## Predental, Prephysical Therapy, and Preoptometry Programs

Most accredited schools of these specialties require a minimum of two years of college work. However, most schools give preference to students with three or four years of preparation. Courses should include those listed above for the first two years.

## Premedical Program

Students interested in preparing for admission to medical school should meet frequently with their advisors, beginning with their first semester at New Mexico Tech. Accredited medical schools require a minimum of three years of college work, with a minimum grade-point average of 3.0. However, most students complete a bachelor's degree before entering medical school.

Students are advised to consult the requirements of individual medical schools in choosing coursework. Upper division courses in New Mexico Tech's curriculum that may aid in medical school preparation include BIOL 311, 341, 351, 352, 355, and 437; CHEM 311, 331, 332, 441, and 442. Most premedical students major in biology, however, any bachelors degree is acceptable. Premedical students should be aware that the Medical College Admissions Test is required for admission to medical school.

## Premedical Technology Program

Students interested in preparing for admission to veterinary school should meet frequently with their advisors, beginning with their first semester at New Mexico Tech. Schools of medical technology require a minimum of three years of undergraduate study; however, the degreed student

has a distinct advantage because of the extra year of preprofessional training. Recommended courses in addition to those described above for the first two years include BIOL 311, 341, 351, 355; and CHEM 311.

## Preveterinary Medicine Program

A minimum of two years of acceptable college work is required for admission to a college of veterinary medicine. However, most students complete a bachelor's degree before entering veterinary school. Courses to be included in a two-year program should be those described above. Students should add as many additional courses from those listed under the premedical program. A four-year program should include the remaining biology and chemistry courses of the premedical program and be planned to meet the degree requirements for the Bachelor of Science degree in biology, chemistry, or basic sciences.

## Prenursing Program

An increasing number of schools of nursing now require one year of general liberal arts courses for admission. Courses recommended for such nursing curricula are English (two semesters); BIOL 111, 112, 341; general chemistry; general psychology; and general physics (one semester each).

## Prepharmacy Program

Most accredited colleges of pharmacy offer a five-year program, including prepharmacy training, leading to a Bachelor of Science in Pharmacy degree. All such colleges of pharmacy require at least one year of prepharmacy study and some colleges will accept two years. The University of New Mexico has an accredited College of Pharmacy which accepts one year of prepharmacy study. Recommended courses in the prepharmacy curriculum are ENGL 111 and 112; CHEM 121 and 122; BIOL 111; and MATH 131 (MATH 132 recommended).

## Prelaw Program

The usual requirement for admission to an accredited school of law is a baccalaureate degree from an accredited college.

Law schools often look for successful completion of English and writing courses as evidence of writing ability, and successful completion of mathematics and science courses as evidence of logical reasoning ability.

Many Tech degrees are suitable background for the field of patent law. Students interested in patent law should consult with an advisor early in their college career, to ensure they take appropriate courses. Contact Academic Affairs for further information and academic advising.



# Psychology

*Professor Cormack*

*Associate Professor Samuels (Chair of the Department)*

*Adjunct Professor Thomas*

*Emeritus Professors Etscorn, Holson*

**Degree Offered: B.S. in Psychology**

The program in psychology is designed to provide students with a scientific foundation in the methods and basic data in psychology and to prepare students for further work in all specializations within the field. Students acquire the fundamentals of learning and memory, intelligence, perception, feelings and emotions, attention, thought, language and communication, the development of all these processes and their pathology, the application of psychology to other fields, as well as techniques for measuring and studying psychological variables. Students conduct laboratory experiments on the psychological and physiological bases of behavior. The department has a modern animal care facility for laboratory classes and research. There are many opportunities for independent research.

## Undergraduate Program

### Bachelor of Science in Psychology

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

- PSY 121 (3); 205 (4), 472 (1)
- Two courses (with associated labs) chosen from among PSY 301 (4), 305 (4), 309 (4)
- 15 additional credit hours in psychology
- BIOL 111 (4), 112 (4), and at least six (6) upper-division credits in Biology, exclusive of BIOL 471 or 472
- MATH 283 (3) or 483 (3)
- At least four (4) additional credit hours beyond the General Education Core Curriculum and above the Psychology requirements selected from among Biology, Computer Science, Chemistry, Mathematics, and Physics.
- Electives to complete 130 credit hours

Students intending to major in psychology should complete PSY 121 and 205 by the end of their sophomore year. They are advised to complete the biology and mathematics requirements as early as possible since material from these courses will be used in upper-division courses.

### Sample Curriculum for the Bachelor of Science in Psychology

#### Semester 1

3 PSY 121 (general)  
 3 ENGL 111 (college English)  
 4 MATH 131 (calculus)  
 4 CHEM 121 & 121L (general)  
 14 Total credit hours

#### Semester 2

4 PSY 205 (experimental)  
 3 ENGL 112 (college English)  
 4 MATH 132 (calculus)  
 4 CHEM 122 & 122L (general)  
 15 Total credit hours

#### Semester 3

3 PSY 212 (drugs and behavior)  
 3 PSY 323 (developmental)  
 5 PHYS 121 & 121L (general)  
 4 BIOL 111 (general)  
 3 MUS 105 (fundamentals)  
 18 Total credit hours

#### Semester 4

3 PSY 209 (social)  
 3 MATH 283 (statistics)  
 5 PHYS 122 & 122L (general)  
 4 BIOL 112 (general)  
 3 Elective  
 18 Total credit hours

#### Semester 5

4 PSY 301 (perception)  
 3 HIST 151 (world history I)  
 3 BIOL 331 (cell biology)  
 3 PHIL 231 (introduction)  
 4 CSE 113 (introduction)  
 17 Total credit hours

#### Semester 6

4 PSY 305 (learning, memory, and cognition)  
 3 HIST 152 (world history II)  
 4 BIOL 351 (physiology)  
 3 ENGL 341 (technical writing)  
 3 Elective  
 17 Total credit hours

*Semester 7*

- 4 PSY 309 (physiological)  
 3 PSY 330 (abnormal)  
 9 Electives  
 16 Total credit hours

*Semester 8*

- 1 PSY 472 (seminar)  
 3 PSY 400 (history)  
 11 Electives  
 15 Total credit hours

## Minor in Psychology

Minimum credit hours required—20

The following courses are required:

- PSY 121 (3), 205 (4)
- PSY 301 (4) or PSY 305 (4) or PSY 309 (4)
- Additional nine (9) credit hours in psychology

## Psychology Courses

The following courses may be used to fulfill Area 4: Social Sciences portion of the General Education Core Curriculum, page 100.

### PSY 121, General Psychology, 3 cr, 3 cl hrs

The study of behavior. Includes perception, motivation, learning, personality, social processes, and physiological processes. [NMCCNS PSYC 1113: General Education Area IV]

### PSY 205, Experimental Psychology, 4 cr, 3 cl hrs, 2 lab hrs

*Prerequisite: PSY 121; a lab usage fee is charged*

Basic concepts and research methodology in the study of behavior; emphasis on experimental design, control, and laboratory methods.

### PSY 209, Social Psychology, 3 cr, 3 cl hrs

*Prerequisite: PSY 121*

Study of the manner by which the behavior of one individual is influenced by the behavior and other characteristics of others. Includes social perception and cognition, attitudes, prejudice, interpersonal attraction, cooperation, group behavior, and aggression.

### PSY 212, Drugs and Behavior, 3 cr, 3 cl hrs

*Prerequisite: PSY 121*

An overview of the design and interpretation of psychopharmacological research; emphasis on self-administered drugs as well as addictions and treatment.

### PSY 301, Perception, 4 cr, 3 cl hrs, 2 lab hrs

*Prerequisites: PSY 205; a lab usage fee is charged*

Experimental and theoretical study of sensory mechanisms and perceptual processes.

### PSY 305, Cognitive Psychology, 4 cr, 3 cl hrs, 2 lab hrs

*Prerequisites: Psychology 205 passed with a C- or better; a lab usage fee is charged.*

A study of research findings, major issues and theories of mental processes. Topics include attention, learning, memory, imagery, concept formation, language and its development, thinking, problem solving and decision making. The laboratory is designed to give students the opportunity to explore the experimental bases of cognitive processes.

### PSY 309, Behavioral Neuroscience, 4 cr, 3 cl hrs, 2 lab hrs

*Prerequisites: Psychology 205 passed with a C- or better; Biology 111, 112; a lab usage fee is charged*

Study of the neural and other physiological bases of behavior. Functional neuroanatomy of sensory and motor systems, motivation and drives, learning and emotion. Clinical correlates of neurological abnormalities are emphasized. Laboratory concentrates on the neuroanatomy of sheep, rat and human brain.

### PSY 310, Science and Pseudoscience, 3 cr, 3 cl hrs

*Prerequisites: PSY 121 or consent of instructor*

This course examines methods for determining whether given claims are science or pseudoscience. Several controversial topics will be explored, with emphasis on coming to objective decisions about such claims. Topics include logical fallacies, the Scientific Method, creationism, global warming and climate change, hidden codes in the Bible, Relativity theory, 9/11 truth conspiracy claims, Dark Matter, UFO sightings, Perpetual Motion Devices, Quantum Mechanics, and more.

### PSY 311, Tests and Measurements, 3 cr, 3 cl hrs

*Prerequisite: PSY 121*

Design, administration, interpretation, and evaluation of psychological and educational tests. Includes measurement theory as well as practical techniques.

### PSY 312, Psychopharmacology, 3 cr, 3 cl hrs

*Prerequisites: PSY 212; BIOL 111, 112*

Behavioral and pharmacological techniques for the study of drugs acting on the nervous system. Topics include sites of drug action, CNS toxicity, psychotherapeutics, and experimental designs employed in psychopharmacological research.

**PSY 323, Psychology of Child and Adolescent Development, 3 cr, 3 cl hrs**

*Prerequisite: PSY 121*

The development of human behavior from conception to adolescence. Includes cognitive, social, behavioral, and physical development.

**PSY 323L, Psychology of Child and Adolescent Development Lab, 1 cr, 2 cl hrs**

*Corequisite: PSY 323 and consent of instructor*

This course is intended to help students understand, through firsthand observation, theories and ideas taught in Child and Adolescent Development (PSY 323). The class will focus on the biological, perceptual, cognitive, behavioral, linguistic and socialemotional development of preschoolers at the NMT Children's Center.

**PSY 324, Psychology of Adult Development and Aging, 3 cr, 3 cl hrs**

*Prerequisite: PSY 121*

The development of human behavior from early adulthood to old age. Cognitive, social, behavioral, emotional, and physical development. Life tasks, careers, physical and emotional health, leisure, dying, and death.

**PSY 330, Abnormal Psychology, 3 cr, 3 cl hrs**

*Prerequisite: PSY 121*

An introduction to psychopathology. Includes the etiology, diagnosis, treatment, and prognosis of behavioral disorders.

**PSY 350, Psychobiology of Sex, 3 cr, 3 cl hrs**

*Prerequisite: PSY 121 or consent of instructor*

Sexual reproduction in a broad evolutionary context. Topics include sexual and asexual reproduction, sexual selection, the endocrinology of mammalian reproduction, development of the reproductive system and sexually differentiated behaviors, sex differences in the brain, and human behavioral sex differences.

**PSY 362, Animal Behavior, 3 cr, 3 cl hrs**

*Prerequisites: PSY 121 or consent of instructor*

General overview of ethological and physiological approaches to the study of animal behavior. (Same as BIOL 362)

**PSY 376, Mass Violence and Aggression, 3 cr, 3 cl hrs**

*Prerequisite: Upper-division standing or consent of the instructor*

This course examines the nature and dynamics of mass violence and aggression, and their impact on politics and societies. Through lectures and readings the students explore and compare political, sociological and psychological dimensions of genocides, state terror, and ethnic cleansing. (Same as HIST 376)

**PSY 389, Special Topics in Psychology, cr and hrs to be arranged**

**PSY 391, Directed Study, hrs and cr to be arranged**

*Prerequisite: Upper-division standing in psychology*

Supervised individual work in psychology. May be repeated for more than one semester's work.

**PSY 400, History of Psychology, 3 cr, 3 cl hrs**

*Prerequisite: Nine hours in psychology*

Study of central questions and concepts of psychology from their origins in classical philosophy and medicine to modern times.

**PSY 472, Senior Seminar, 1 cr, 1 cl hr each semester**

*Prerequisite: Upper-division standing or consent of instructor*

Review and discussion of current research in psychology.

## Faculty Research Interests

Cormack—Psychophysics, Visual Perception, Sensory Mechanisms

Samuels—Cognitive Development, Reasoning and Problem Solving, Memory, Brain Injury and Rehabilitation

# Master of Science for Teachers (MST)

## Interdepartmental Program within the Department of Psychology and Education (Samuels, Department Chair)

### Interdepartmental Program within the Department of Psychology and Education (Samuels, Department Chair)

*Advisory Committee:* Altig (Chemistry), Chávez (Mineral Engineering), Bonnekessen (Communication, Liberal Arts, and Social Sciences), Westpfahl (Physics), Harrison (Earth and Environmental Science), Mazumdar (Computer Science), Ostergren (Mechanical Engineering), Reiss (Biology), Stone (Mathematics), Topliff (TCC), Becker (Coordinator); *Ex-Officio:* Iver Davidson (Distance Education), Mary Dezember (Associate Vice President of Academic Affairs), Peter Gerity (Vice President of Academic Affairs), Sara Grijalva (Registrar), Lorie Liebrock (Graduate Dean), Michelle Osowski (Director of Alternative Licensure Program).

*Adjunct Faculty:* Ray Collins, Lynn Deming, Dee Friesen, Rob Hepler, Deidre Hirschfeld, Ian Jenness, Dan Klinglesmith, Lynne Kurilovitch, Eileen Ryan, Elisabeth Stone, Dave Thomas, Mike Topliff, and Don Wolberg

**Degree Offered:** *Master of Science for Teachers*

#### Program Description

The MST program is designed to provide graduate-level classroom and laboratory instruction for teachers of science, mathematics, engineering, and/or technology. The emphasis of the courses is on content, rather than pedagogy. MST students are encouraged to develop laboratory exercises, demonstrations, and teaching methods from the course content and apply these as projects in their own classrooms during the academic year. Courses for the participants are offered in a variety of disciplines and are taught by New Mexico Tech faculty. Classes build on fundamental principles and offer new concepts and novel teaching methods. Courses are offered throughout the year via distance instruction and as live courses on the New Mexico Tech campus and around the state.

#### Program Prerequisites

An individual with at least one year of teaching experience may apply for admittance into the MST Program. The Program encourages individuals to hold a valid teaching certificate when appropriate.

#### Transfer Credit Policy

A maximum of 12 credit hours of course work with grade B or better, earned at another accredited institution, may be approved by the student's advisory committee for transfer to the MST program. To be approved, credits must not have been used to satisfy the requirements for a previous degree. Transfer credits can include upper-division undergraduate or graduate credit in science, mathematics, engineering, and/or technology. Transferred credits may include up to six credit hours of professional education courses in areas generally appropriate to this program. Requests for evaluation of transfer credit hours must be made in writing to the program coordinator and must include the transfer credit form and official transcripts.

#### Application for Admission

Application forms may be obtained from the internet at [www.nmt.edu/~grad/](http://www.nmt.edu/~grad/). Printed forms or more information can be requested by e-mail from [graduate@nmt.edu](mailto:graduate@nmt.edu) or by mail from:

Master of Science for Teachers  
Graduate Office  
801 Leroy Place, New Mexico Tech,  
Socorro, NM 87801

For information on Tech's Education Department and alternate licensure, see page 143.

#### MST Fellowships

The MST Office maintains a list of available fellowships.

#### Endorsement Policy

Information regarding certification endorsements may be obtained from the New Mexico Department of Education, Santa Fe, New Mexico.

#### Placement Exams

MST students may take placement exams for ST: 523, 524, 525, 526, or 550. Upon successful completion of the exam(s), this requisite for the program will be waived and the student will not be required to take the course(s). The exams consist of questions covering basic concepts of science and mathematics.

#### Use of Tech Facilities

If an MST student is utilizing New Mexico Tech facilities or faculty (i.e., computer center, advisor, or graduate committee), the student must be registered for at least one Tech upper-division or graduate course.

### Thesis or Independent Study Requirement

The candidate for the MST degree must select either a thesis or a non-thesis program under the guidance of the student's advisor and advisory committee. The thesis program involves the preparation of a thesis through experimental, theoretical, or applied research (ST 591), under the supervision of a faculty member. The candidate must satisfy the thesis requirements of the department of his/her advisor. Six credit hours will be allowed for the thesis. The Independent Study (IS) provides the candidate with an opportunity to engage in a plan of study under the supervision of NMT Faculty to (a) explore in more depth or detail an area to which the student has been introduced in previous courses or in the field of science-based education and (b) contribute to the knowledge content and/or application of the knowledge content of the selected area. An IS is intended to be a project initiated by the student and designed in conjunction with his/her advisory committee. Three credit hours will be allowed for the IS (ST 590).

### Graduate Advisory Committee

Each MST student will be assigned a temporary advisor at the time of first registration. The student will select an advisor and an advisory committee by the completion of 12 credits or within one year of first enrollment (whichever comes first). The student's academic advisor must be a regular faculty member of the Institute. The advisory committee consists of at least the academic advisor and two other members with regular faculty members not being a minority. The academic advisor serves as chair of the advisory committee. The Psychology and Education Chair and the Graduate Dean must approve the advisor and members of the advisory committee. The student should have contact with his/her advisory committee at least once a year.

### Course Program

Courses to be used towards each of the graduate degrees at New Mexico Tech must meet with the prior approval of the student's advisory committee. These courses constitute the student's Course Program. The approved Course Program must be on file in the Graduate Office for full-time students no later than the end of the second semester of residency. Part-time and distance education students must formalize their course program by the time they complete 12 credits. The course program is reported on the committee report form, available online and from the Graduate Office.

### Program Requirements

All incoming MST students must demonstrate competence in science and mathematics by either:

1. Completing the introductory courses:
  - ST 523, Survey of Biology
  - ST 524, Survey of Chemistry
  - ST 525, Survey of Geology
  - ST 526, Survey of Physics
  - ST 550, Mathematics for Teachers

*Credits are awarded for these courses but these credits DO NOT count towards the 30 credits needed for a MST Degree.*

2. Passing the appropriate placement exams (see above). No credits are awarded for passing a placement exam.

These courses or the appropriate placement exams are prerequisites for most other ST courses.

Master of Science for Teacher students must take the following core of 21 credit hours that will give breadth and depth to the program:

1. All incoming students must take a technical communication course and a computer literacy course.
  - ST 530, Technical Communication for Teachers (2)
  - ST 556, Computers and Science Teaching (1)
2. For comprehensiveness, MST students must take one course in each of the following distribution areas, for a total of twelve credit hours:
  - Math (2)
  - Physics (2)
  - Chemistry (2)
  - Geology (2)
  - Biology (2)
  - Engineering/Computer Science/Economics (2)
3. For depth, MST students must take an additional three courses (six credit hours) within one of the above distribution areas of the student's choice.

In addition to the core requirements above, MST students must complete:

- ST 590, Independent Study (3), or ST 591, Thesis (6)
- Additional courses to complete 30 credit hours. These courses may be chosen from MST courses or other Tech courses numbered 300 or above.

### MST Courses:

All MST courses that satisfy a distribution area requirement have at least one survey course as a prerequisite. MST courses that do not apply to a distribution area require competence in basic

courses in subject matter area or consent of instructor.

MST courses may not be used to fulfill the requirements of any other undergraduate or graduate degree offered by New Mexico Tech without prior approval by the chair of the department offering the degree.

Students may receive an additional credit of directed study for each course with the submission of an accepted project and paper to the professor of the respective course.

### **Waiver of Prerequisites and/or Distribution Area Requirement:**

The MST Department Chair and the Department Chairman (or his/her designee) representing a distribution area on the MST Advisory Committee must approve a request to waive a prerequisite or distribution area requirement. This request is submitted by the student and must be recommended by the advisor before consideration.

### **ST 501 Special Topics**

*Prerequisite: consent of the Instructor*

These courses are offered on a request basis: Charles Darwin, "The Origin of Species", and Evolution, Vertebrate Paleontology, Educational Testing, Materials Science and Nanomaterials Workshop, Growth of the North American Continent, Timescapes: The Field Course, Computer Basics and MS Office

### **ST 502D Archaeology for Teachers, 2cr**

*Prerequisites: ST 525/525D or consent of the Instructor*

A general introduction to the study of the past through material remains and the relationship of archaeology to the sciences. Four major topics are covered: archaeological field and lab method and theory; human evolution; the basic structure of world prehistory; archaeological careers and application of archaeology in the public sphere. Assignments include papers, archaeological analysis problems and classroom lesson plans.

### **ST 503D Ancestor's Tale, 2cr**

*Prerequisites: ST 523/523D and ST 525/525D or consent of the Instructor*

Evolution is a theory, a process and a narrative of biological and geological science that elucidates the history of life and its amazing diversity and abundance on Earth. *The Ancestor's Tale* is a course that takes its name from the book (used as the text), written by noted evolutionary biologist Richard Dawkins, and is at once metaphor and narrative of life's journey through almost 4 billion years. The journey of these evolutionary pilgrims begins now, in the present, with our own species *Homo sapiens*, and moves ever deeper back through the evolutionary branchings of organisms in time. The course investigates the unity of all life on Earth through all of time.

### **ST 505/505D, Human Evolution, 2 cr**

*Prerequisites: ST 523/523D; or consent of instructor*

We live on a planet populated by several billion members of a single species, *Homo sapiens*, different from all other species by a unique set of characters and behaviors not seen in any other animal species. This course is concerned with the origin and evolution of who we are and how we got here. The course will trace the origin of the great group to which we belong, the Primates, as well as our distant and not too distant cousins. We will review those traits that make us Primates, along with such interesting animals as the lemurs of Madagascar, the Old World Monkeys, and the Great Apes of Africa.

### **ST 506D, Dinosaurs and Their World, 2 cr**

*Prerequisites: ST 523/523D and ST 525/525D; or consent of the instructor*

This course means to do what its title advertises. Together, we will go on an adventure to look at dinosaurs and their world, a world at once with similarities to our own, and many differences. We will explore a world about which we know a great deal, but also a world that still has many more unanswered questions. We will take a journey back through so much time that the reality of time's distance is reduced to numbers without a sense of the actual enormity of the journey. And yet even that journey is but a small fraction of a still greater timescale of our planet and the universe.

**ST 508D Worms, Bugs, and Shells, 2cr**

*Prerequisite: ST 523/523D or consent of the instructor*

This course provides an introduction to the major groups of living invertebrate animals. The vast majority of living organisms are animals and fewer than 5% of these are animals with backbones; the majority of the rest are invertebrates, the “worms, bugs and shells” of this course. This course will acquaint students with the main ideas about the classification, anatomy, evolutionary relationships, ecology, behavior, geographical distribution and other aspects of the natural history of the major groups of living invertebrates. Special emphasis will be placed on species found in New Mexico and the Southwest. Technical terminology will be kept to a minimum and the primary focus will be on big ideas.

**ST 509D Human Genetics, 2cr**

*Prerequisites: ST 523/523D and ST550/550D or consent of the Instructor*

Human genetics covers the basic principles of transmission and molecular genetics and the application of genetics to human health and reproduction. Lecture topics include forensic DNA analysis, genetic testing for diseases, cancer pre-disposition, *in vitro* fertilization, pre-implantation genetics, evolutionary medicine, and epigenetics. Bioethical issues raised by the development of new genetic tests, including whole-genome sequencing are considered. Participants are required to develop educational modules that can be used in their classes

**ST 510/510D Vertebrate Zoology: An Introduction to Animals with Backbones, 2cr**

*Prerequisites: ST 523/523D or consent of the Instructor*

Vertebrate Zoology provides an introduction to the major groups of living vertebrate animals: fishes, amphibians, reptiles, birds and mammals. Vertebrates comprise a small fraction of all the animals that now exist on Earth, but are the most familiar and attract the most interest, in part because we ourselves are vertebrates. Vertebrates are diverse and abundant, although an increasing number of species are endangered. This course includes the classification, anatomy, evolutionary relationships, ecology, behavior, geographical distribution and other aspects of the natural history of the world’s living vertebrates. Special emphasis will be placed on species found in New Mexico and issues of threatened and endangered species, habitat destruction and protection.

**ST 513, Molecular Biology Laboratory for Teachers, 2 cr**

*Prerequisites: ST 523/523D and ST 550/550D; or consent of instructor*

An introduction to the techniques used in molecular biology, including spectrophotometry, electrophoresis, gel filtration, chromatography, hydrolysis, and the analysis of biological polymers.

**ST 517, Environmental Studies, 2 cr**

*Prerequisites: ST 523/523D and ST 550/550D; or consent of instructor*

This course is a study of the interrelationships of organisms with their physical and chemical environment including the biological interactions among populations, communities, ecosystems, and pollutants.

**ST 518D Water as a Resource, 2cr**

*Prerequisites: ST 523/523D and ST 524/524D or consent of the instructor*

This asynchronous web course covers one of our most precious resources in New Mexico and beyond. This course covers interesting and timely topics such as drinking water quality and supplies, water-generated energy, water conservation, desalination, ocean currents, weather patterns, water reservoirs, the hydrologic cycle, climate change, and drought, in the same flexible online format as Renewable Energy ST577d. Students view course material in weekly modules, participate in online discussions, complete two projects, and view virtual field trips. The web format allows you to view the course material whenever you want to during that module week. The scope of this course encompasses both local and global water issues and politics plus the biology and chemistry of water systems and supplies. The goal is to give a good understanding of the way water systems work and how they are connected to the other Earth systems, and to prepare students to teach water resources in their classrooms.

**ST 519, Modern Genetics, 2 cr**

*Prerequisites: ST 523/523D and ST 550/550D ST 509 recommended; or consent of instructor*

This lab course is an introduction to techniques used to study Mendelian and molecular genetics, including forensic DNA.

**ST 523/523D, Survey of Biology, 1 cr**

A survey of life functions at the cellular level including the structure of organic molecules, membrane structure and function, energy metabolism, cellular reproduction, and gene action. Also includes an introduction to evolution and phylogenetic survey of the kingdoms of life.

**ST 524/524D, Survey of Chemistry, 1 cr**

This course is an introduction to basic chemical terminology and nomenclature, modern atomic and molecular theory, periodicities of chemical behavior, and the physical characteristics and isotopic stability of the elements. The student will learn how to read and write properly balanced chemical equations, make meaningful predictions based on stoichiometric relationships, identify and quantify the participants in electron and proton transfer reactions and establish a foundation for pursuing more advanced studies in the chemical, physical, material, life, earth and environmental sciences.

**ST 525/525D, Survey of Geology, 1 cr**

This course covers the fundamentals of geosciences, including field-based training in how and why geology "works." Mandatory field trips will introduce participants to the essentials of the study of Earth materials, with classroom sessions discussing the origin of the Earth, its landforms, and materials.

**ST 526/526D, Survey of Physics, 1 cr**

Explore Newton's three Laws of Motion in this laboratory course. Hands-on, class time experiments are supplemented with assigned readings. This course is not mathematically intensive.

**ST 529/529D, Research and Documentation, 2 cr**

*Prerequisites: None*

This course covers the various kinds of research (both primary and secondary) and documentation, particularly in the fields of science, including gathering and analyzing data, writing (literature reviews, reports, articles, bibliographies), and documenting correctly.

**ST 530/530D, Technical Communication for Teachers, 2 cr**

*Prerequisites: None*

The theory and practice of writing for technology and science: lab reports, proposals, abstracts, and scientific articles. Emphasis will be on audience awareness, editing, writing, and documenting information.

**ST 534D Engineering Economic Analysis, 2cr**

*Prerequisites: ST 550/550D or consent of the instructor*

Economic principles applied to decision-making problems in mineral engineering and engineering in general. Compound interest, present worth, rate of return, depreciation, depletion, before and after tax analysis pertinent to project evaluation. *Same as ME 320.*

**ST 535/535D Green Construction for Teachers, 2cr**

*Prerequisites: ST 550/550D or consent of the Instructor*

The course covers the concepts behind sustainable construction, the history of the green construction movement, materials and processes used, regulatory and certification standards, and presents design examples. A final design project incorporates the cumulative knowledge gained in the course.

**ST 536D Fundamentals of Information Technology, 2cr**

*Prerequisites: ST 556 or consent of the instructor*

This is an introductory course aimed at presenting state-of-the art information on technology and technological issues in a broad rather than detailed manner. Major issues affecting all of us and specifically the Information Technology Professionals will be discussed. Although this course is not intended to make us all experts in Information Technology (IT) it will help us understand why IT works the way it does, and give us the groundwork to be more useful IT users and partners. This course will give the student the basic understanding of IT which will help them be more comfortable with the technology around us and use it more efficiently. The student will also have a basic proficiency in an operating system and basic software applications (e.g. word processing, spreadsheets, presentation graphics, and databases).

**ST 537 Supercomputer Challenge, 3cr**

*Prerequisite: consent of the Instructor*

Teachers will learn how to sponsor a Supercomputing Challenge team and how to help students complete an appropriate computational science project in keeping with the Challenge mission statement (described at <http://www.challenge.nm.org/>). The computational project incorporates four components, Project Management, Structured Programming and Design, Mathematical and Agent Based Modeling, and Internet Research and Resources This is a twelve month project and terminates with the final competition at LANL in May.



**ST 540, Rockin' Around New Mexico, 1 cr**

*Prerequisite: ST 525/525D or consent of the Instructor*

Explore local geology, including volcanic rocks and hazards, seismic hazards, mountain-building processes, and mineral resources. Two days of the three-day course will be spent in the field, following an introductory day comprising geologic exercises and lecture presentations. Each year, a different New Mexico community hosts this course, co-sponsored by the New Mexico Bureau of Geology.

**ST 541, Geology and Mining Engineering for Teachers I, 2 cr**

*Prerequisites: ST 525/525D and ST 550/550D; or consent of instructor*

This course is a study of the principles and technology of mineral occurrence, extraction, and refining. Field trips complement lectures and laboratory experiments. Emphasis is on New Mexico base metal deposits.

**ST 542D, Timescapes: Momentous, World Altering Events, 2 cr**

*Prerequisites: ST 525/525D; or consent of the instructor*

This course is designed for science majors interested in discovering the great events occurring over the last 4.5 billion years of Earth history. Churchill said, "History is just one thing after another," but the history of planet Earth can be viewed as having been shaped by momentous, world-altering events, millions of years apart. These will form the basis of this course. The course will meet distribution requirements for science majors.

**ST 543D, Forensic Geology, 2 cr**

*Prerequisites: ST 525/525D; or consent of the instructor*

Forensic Geology is a discipline with an ever-expanding role in criminology, environment concerns, and even the war against global terror – geologists have made claims they can tell the locations of terrorist leaders by studying the rocks visible behind them in videotapes. This discipline, a specialty of the geosciences, collects and studies earth materials and their associations, including rocks, sediments, soils, water, and any man-made products that they contain, with attention toward their significance in regulatory and legal areas. The margins of Forensic Geology overlap with other sciences, including biology, chemistry, physics, anthropology, and archeology.

**ST 547, Field Techniques in Geology for Teachers, 2 cr**

*Prerequisites: ST 525/525D and ST 550/550D; or consent of instructor*

This course covers rock and mineral identification, geochronology, stratigraphic succession, and practical field mapping in the San Juan Basin. Be prepared for rigorous activity and primitive camping. Enrollment limited.

**ST 548, Geology of the Southwest—National Parks and Natural Resources, 2 cr**

*Prerequisites: ST 525/525D and ST 550/550D; or consent of instructor*

This is a field geology course focusing on regional geologic settings of the arid Southwest, including identification of rocks and minerals, geologic environments, and interpretation of geologic field data.

**ST 550AD, Mathematics for Teachers, 1 cr**

This course is a basic survey of the principles of contemporary mathematics. The course will emphasize the algebra of sets and numbers, exponentials and logarithms, complex numbers, vectors and matrices, and applications in science for each.

**ST 550BD, Mathematics for Teachers, 1 cr**

This course is a basic survey of the principles of contemporary mathematics. The course will emphasize the algebra of sets and numbers, exponentials and logarithms, complex numbers, vectors and matrices, and applications in science for each.

**ST 550, Mathematics for Teachers, 2 cr**

This course is a basic survey of the principles of contemporary mathematics. The course will emphasize the algebra of sets and numbers, exponentials and logarithms, complex numbers, vectors and matrices, and applications in science for each.

**ST 551AD, Concepts in Mathematics for Teachers, 1 cr**

*Prerequisites: ST 550/550D; or consent of instructor*

The development of some of the great ideas in Mathematics through history, from the concept of number to abstract mathematics, is discussed. Students develop class projects using the covered concepts and history in their own classes.

**ST 551BD, Concepts in Mathematics for Teachers, 1 cr**

*Prerequisites: ST 550/550D; or consent of instructor*

The development of some of the great ideas in Mathematics through history, from the concept of number to abstract mathematics, is discussed. Students develop class projects using the covered concepts and history in their own classes.

**ST 552AD, Calculus on a Computer, 1 cr**

*Prerequisites: ST 550/550D; or consent of instructor*

Students learn to use computer software to do single variable calculus. Applications and geometric understanding are emphasized. No previous calculus is required. Student versions of the software are available for purchase.

**ST 552BD, Calculus on a Computer, 1 cr**

*Prerequisites: ST 550/550D; or consent of instructor*

Students learn to use computer software to do single variable calculus. Applications and geometric understanding are emphasized. No previous calculus is required. Student versions of the software are available for purchase.

**ST 553, Problem Solving and Recreational Mathematics, 2 cr**

*Prerequisites: ST 550/550D; or consent of the instructor*

This course covers problem solving techniques, logic and mathematical arguments, logic puzzles, word problems in algebra, games of strategy for two players, geometrical dissections, tiling puzzles, and basic combinatorics.

**ST 554, Mathematical Modeling, 2 cr**

*Prerequisites: ST 550/550D; or consent of instructor*

Students learn the process of going from a real world problem to a mathematical model and back to an interpretation of results. Students will work in small groups on a wide variety of applications. Projects suitable for classroom use will be developed.

**ST 556, Computers and Science Teaching, 2 cr**

This course covers the general techniques of computer maintenance and upgrading, including hardware and software. Basic use of the World Wide Web, including sites and techniques of special interest to teachers is also covered.

**ST 557, Fractals and Chaos, 2 cr**

*Prerequisites: ST 550/550D; or consent of instructor*

This course covers the development of the basic geometry of fractals, using both deterministic and random methods, the mathematical ideas behind chaos, the connections between the ideas of chaos and fractals, and applications.

**ST 558/558D, Probability and Statistics, 2 cr**

*Prerequisites: ST 550/550D; or consent of instructor*

This course covers techniques for the visual presentation of numerical data; descriptive statistics; introduction of sampling and statistical inference, illustrated by examples from a variety of fields.

**ST 560 Space Science: Hazardous Asteroids, 2 cr**

*Prerequisites: ST 526/526D and ST 550/550D or consent of the Instructor*

This course introduces concepts relevant to understanding small bodies in the Solar System and their effect on the near-Earth space environment. The emphasis is on processes that can threaten life on Earth, specifically, a potential asteroid collision. The goal is to expose the student to some of the basic principles of space science (gravity, kinetic energy, astronomical measurement) while using hazardous asteroids as a fun and non-intimidating context for refreshing simple math skills. The format will include lectures, laboratory exercises, and hands-on use of an optical telescope.

**ST 561, Weather and Climate, 2cr**

*Prerequisites: ST 526/526D; or consent of the instructor*

In this course, students will study the physical and chemical processes that are important for understanding weather and climate: thermodynamics and the flow of energy in the atmosphere, cloud formation and precipitation, solar and thermal radiation, the greenhouse effect, and the photochemistry of ozone.

**ST 562, Radio Astronomy for Teachers, 2 cr**

*Prerequisites: ST 526/526D and ST 550/550D; or consent of instructor*

This course is an introduction to observational radio astronomy. It covers some general concepts of astronomy including electromagnetic radiation, motions of astronomical bodies, coordinate systems, as well as small radio telescope operation and data collection. The format will include lectures, field trips, hands on use of optical and radio telescopes, independent team research, documentation, and research presentations. Students must be willing to explore independently and work in teams. Class hours vary during the week to accommodate observing sessions.

**ST 563, Optical Astronomy for Teachers, 2 cr**

*Prerequisites: ST 526/526D and ST 550/550D; or consent of the instructor*

This course exposes the student to the techniques of optical observational astronomy. The emphasis is on correct use of digital cameras and analysis of digital images. In addition, the course covers basic aspects of finding celestial objects in the night sky. Students must be willing to explore independently and work in teams. Class hours vary during the week to accommodate observing sessions.

**ST 564/564D, Great Concepts in Physics, 2 cr**

*Prerequisites: ST 526/526D and ST 550/550D; or consent of instructor*

This course covers the concepts of physics from the Greeks to the present, the triumphs and questionable philosophical assumptions of the scientific method, revolutions of relativity and quantum theory. Extensive mathematical background and laboratory work are not required.

**ST 565, Physics of Aviation, 2 cr**

*Prerequisites: ST 526/526D and ST 550/550D; or consent of the instructor*

This course is a basic survey of aerodynamics with emphasis on the principles of physics that apply to flight. There is a limited use of mathematics, but nothing beyond basic algebra. The course uses the method of discovery learning to introduce the principles of physics to flight. The course is a combination of lecture, in-class exercises and take-home activities. There is one short in-class examination and a required in class presentation.

**ST 567, Mission to Mars, 2cr**

*Prerequisites: ST 526/526D and ST 550/550D; or consent of the instructor*

The STARBASE® La Luz Academy Mars Missions Flight, for fifth graders, involves students in planning and preparing for a simulated manned mission to Mars. Teachers guide their students through a series of Base Operations (including creating a mission patch, writing a saga, learning Mars facts, and designing a life support system) in the classroom and then bring students to the culminating Link-Up Day activity in the spring. The goal of the Mars Missions Flight is to increase student interest and motivation for studying science, technology, engineering, and mathematics. Participating teachers can earn graduate credit by submitting the following items: complete lesson plans developed for implementing each of the Base Operation activities in their classroom; a list of resources used in the classroom to accomplish the required Base Operations; and a lessons-learned report based on their participation in this activity.

**ST 568 AFRL La Luz Summer Teacher Institute, 1cr**

*Prerequisites: ST526/526D and ST 550/550D; or consent of the instructor*

This is a hands-on, inquiry-based course that focuses on science, technology, engineering, and mathematics (STEM) activities from the AFRL La Luz Academy. Students will earn one credit hour by completing a specified team STEM project, using a systems engineering approach, during the weeklong course. Opportunities to collaborate with scientists and engineers, as well as tours of AFRL facilities, will be incorporated into the course, as available. An additional credit hour is available the following summer for those students who develop and implement STEM lesson plans as Teacher Institute Fellows during the school year and present these lesson plans at the AFRL La Luz Academy Teacher Institute Symposium.

**ST 569 Optics for Teachers, 2cr**

*Prerequisites: ST 526/526D and ST 550/550D or consent of the Instructor*

This course considers the characteristics and behavior of light. Drawings and a few algebraic equations provide complementary means – concrete and abstract – for predicting the position, orientation, size and type of images created in a variety of optical instruments and natural circumstances. Participants receive an Introductory Optics System kit, and individual projects and class activities insure familiarity and the ability to adapt the kit for a range of classroom levels. The study of light introduces various “action at a distance” phenomena. While this course affirms that many observed phenomena require a considerably more sophisticated model for optics, a solid grounding in geometric optics is sufficient for the design of state of the art instruments.

**ST 572D, New Mexico Science and Scientists I, II, III, 2 cr each**

*Prerequisites: none*

New Mexico is unique in the U.S. in its concentration of scientists and in the range of science being done here. Much of the research is on the cutting edge, be it deep-space radio astronomy, New World archeology, or the newest computer chips. New Mexico scientists are at work in universities, colleges, museums, institutes, national laboratories, the state and federal government, regional entities such as the Middle Rio Grande Conservancy, and in mining and other private industries. The course will introduce students to many of these scientists in an informal, conversational setting. This course is designed for both science and non-science majors.

Section I: Earth, Mars, and Meteors

Section II: Biology and Evolution

Section III: Energy, Environment and Materials

**ST 577 Renewable Energy (extensive use of field trips), 2 cr**

*Prerequisites: ST 524/524D and ST 526/526D; or consent of the instructor*

This is a survey course that explores the state of energy use, production, economics and environmental issues by field trips, lectures and readings. Topics explored in this course include sources of energy, impacts of energy production and use, methods of production and delivery as well as environmental, economic and political issues. Field trips will allow students to see firsthand alternative energy facilities, sites where alternative energy is in use, traditional mines and power plants. Students will meet with personnel at these facilities. A goal of the course is to enable teachers to present information in their classroom from the perspective of real experience.

**ST 577D Renewable Energy (web based, no field trips), 2 cr**

*Prerequisites: ST 524/524D and ST 526/526D; or consent of the instructor*

Energy and the energy crisis and their association with non-renewable sources are covered and renewable sources and new technologies are then covered for a contrasting perspective. Weekly course modules explain fossil fuel origins, uses, and abuses, plus the renewable energy sources wind, solar, biomass, hydroelectric, ocean/tidal, and geothermal plus virtual field trips. The scope of this course encompasses both local and global energy issues and politics plus new technology and innovations. The goal is to give a good understanding of the alternatives to fossil fuel use and ways to reuse and conserve resources. Taking this course will prepare the student to teach energy generation and conservation in his or her own classroom.

**ST 578D The Chemistry of Natural Products, 2cr**

*Prerequisites: ST 524/524D or consent of the Instructor*

This course begins with an overview of organic compounds; examining each of the major functional groups. A number of different classes of naturally derived organic compounds are then considered. These include the sugars, alkaloids (opiates, nicotine, etc.), essential oils, taxanes and cannabinoids. Sulfur based compounds are also discussed. In particular, we are interested in understanding the natural sources for these compounds and methods of isolation. Additionally, we would like to understand their physiological effects, mode of action and metabolism.

**ST 579D Concepts in Chemistry: Development of Atomic Theory, 2cr**

*Prerequisites: ST 524/524D or consent of the Instructor*

This course examines the classic experiments in chemistry and physics that underpin our current understanding of atomic structure. We begin by examining the classification of matter, the fundamental laws of chemical combination and the development of a workable atomic theory. Then, we consider the discovery and characterization of the subatomic particles; the electron, proton and neutron. The structure of the atom is next discussed. We look at the experimental evidence for quantum physics and how it can be used to understand the electronic structure of the atom. Finally, simple bonding theories are presented.

**ST 581, Directed Study, cr to be arranged**

Study under the guidance of a member of the graduate faculty. In general, subject matter will supplement that available in other graduate course offerings.

**ST 590, Independent Study, 3 cr**

An IS provides the student with an opportunity to engage in a plan of study under the supervision of NMT Faculty to (a) explore in more depth or detail an area to which the student has been introduced in previous courses or in the field of science-based education and (b) contribute to the knowledge content and/or the application of the knowledge content of the selected area. An IS is intended to be a project initiated by the student and designed in conjunction with his/her advisory committee.

**ST 591, Thesis (master's program), 6 cr**

A Thesis is similar to an IS except that it normally involves research over an extended period of time and follows the guidelines of the Academic Advisor's or Research Advisor's Department. In general, the requirements for a Masters of Science for Teachers student completing a thesis are no different from the requirements for any other graduate student completing a thesis within the same department.

# Engineering

## Accreditation

The bachelor's programs in chemical engineering, civil engineering, electrical engineering, mechanical engineering, environmental engineering, materials engineering, mineral engineering and petroleum engineering are accredited by the Engineering Accreditation Commission of ABET, <http://www.abet.org>.

## Professional Examinations

All engineering majors are required to take the Fundamentals in Engineering (FE) [previously known as the Engineer in Training or EIT] examination as a requirement for graduation. This examination is the entry-level requirement for those individuals who intend to attain a professional engineer status. The FE examination is given in the fall and spring each year at New Mexico Tech. The FE examination is a national examination; therefore, the results are transferable to any state or territory of the United States.

## Minors

- Aerospace Engineering
- Biomedical Engineering
- Civil Engineering
- Electrical Engineering
- Environmental Engineering
- Explosives Engineering
- Materials Engineering
- Mechanical Engineering
- Mineral Engineering
- Petroleum Engineering
- Polymer Science Engineering

# Engineering Science

The Engineering Science courses provide the fundamentals engineering topics for all engineering programs. No specific degree is offered. For further information contact the Dean of Engineering, Dr. Thomas W. Engler.

## Engineering Science Courses:

*The major content of these courses is directed toward the fundamental core subjects of engineering.*

### ES 110, Introduction to Engineering, 2 cr, 1 cl hr, 3 lab hrs

*Corequisite: MATH 103*

Introduction to structure and ethics in the engineering profession. The concept of problem solving. Introduction to engineering analysis and design, graphical communication, basic computer skills. Manual and CAD engineering graphics.

### ES 111, Computer Programming for Engineers, 3 cr, 2 cl hrs, 3 lab hrs

*Corequisite: MATH 131*

Engineering computer problem solving using a high-level programming language. Algorithm and program development and documentation. Emphasis is placed on programming logical and concise solutions to a variety of problems drawing from engineering disciplines of mechanics, civil, electrical, industrial, and economics.

### ES 201, Statics, 3 cr, 3 cl hrs

*Prerequisites: PHYS 121*

*Corequisite: MATH 231*

Forces and moments acting on rigid bodies in equilibrium, distributed forces including hydrostatic forces, friction, moment of inertia, and problem solution by computer.

### ES 216, Engineering Fluid Mechanics, 3 cr, 3 cl hrs

*Prerequisite: ES 201*

*Corequisite: MATH 231*

Fundamentals of fluid mechanics including fluid statics, velocity of continuous media, continuity, and momentum balance. Introduction of laminar and turbulent flows, similitude, dimensionless analysis, Bernoulli's equation, friction factor, introduction to pump and compressor selection.

### ES 302, Mechanics of Materials, 3 cr, 3 cl hrs

*Prerequisite: ES 111 or CS 111; ES 201 passed with grade C or better; MATH 231*

Relationships between external forces acting on deformable bodies and the stresses and strains produced; tension, compression, torsion, shear, bending, and problem solution by computer. Failure criteria. Design of members and systems.

**ES 303, Engineering Dynamics, 3 cr, 3 cl hrs**

*Prerequisite:* ES 111 or CS 111; ES 201 passed with grade C or better; MATH 335

Kinematics and kinetics of particles, systems of particles, and rigid bodies; momentum and energy methods; and problem solution by computer.

**ES 305, Engineering Analysis, 3 cr, 3 cl hrs**

*Prerequisites:* ES 216, 302; MATH 335; or consent of instructor

Solution of linear systems of equations using Gaussian elimination and matrix methods. Scalar and vector fields; gradient; divergence; curl; line, surface and volume integrals; Green's theorem and Stokes' theorem. Solutions to partial differential equations from heat transfer, mechanical vibrations, and fluid mechanics using separation of variables, series and Laplace transforms. (Same as MENG 305)

**ES 316, Engineering Economics, 3 cr, 3 cl hrs**

*Prerequisite:* ES 111

Professional ethics. Economic decision-making for engineering alternatives. Use of compound interest and depreciation calculations to compare the relative economy of investments and procedures. The application of economic principles such as return on investment, leverage, and present worth to engineering problems. Use of PC computer programs. This course is not available for social science credit.

**ES 332, Electrical Engineering, 3 cr, 3 cl hrs**

*Prerequisites:* PHYS 122; MATH 335

Analysis of steady state linear circuits, balanced three-phase power, transformers. Electromechanical energy conversion. Semiconductor devices and applications.

**ES 347, Thermodynamics, 3 cr, 3 cl hrs**

*Prerequisites:* CHEM 122; MATH 132; ES 111

*Corequisites:* ES 216; PHYS 122; MATH 231

Introduction of the first and second laws of thermodynamics and their applications to engineering power cycles. Carnot cycle, Rankine cycle, refrigeration cycle, Otto cycle, and Diesel cycle.

**ES 350, Heat and Mass Transfer, 3 cr, 3 cl hrs**

*Prerequisite:* ES 216

*Corequisite:* MATH 335

Fundamentals of heat transfer, steady- and unsteady-state conduction, convection and radiation. Fundamentals of mass transfer, steady and unsteady state, diffusion, and convection. Dimensionless analysis, equipment.

**ES 405L, Instrumentation, Measurement, and Process Control Laboratory, 1 cr, 3 lab hrs**

*Prerequisite:* ES 111; PHYS 122

Laboratory exercises involving instrumentation and design of basic control systems.

**ES 489, Special Topics in Engineering Science, 3 cr, 3 cl hrs****ES 491, Directed Study, cr to be arranged**

# Chemical Engineering

([www.nmt.edu/~cheme](http://www.nmt.edu/~cheme))

*Associate Professor Bretz, LeClerc (Associate Chair), Tartis  
Assistant Professor Riley  
Adjunct Faculty Bickel, Cal, Dunston, Hasan, Lee, McCoy  
Laboratory Associate Price*

## **Degree Offered: B.S. in Chemical Engineering**

Chemical Engineering is considered one of the base engineering disciplines with applications in nearly every facet of life. The development and production of food, pharmaceuticals, fuels, semiconductors, detergents, fertilizers, plastics, and paper have all been driven by the ingenuity of chemical engineers. Current frontiers being explored by Chemical Engineers include biofuels, renewable energy, new batteries, nanotechnology, fuel cells, microsensors, explosives, and other critical technologies important to the 21st century. Chemical engineering graduates find challenging careers in a broad spectrum of fields including petroleum, chemical, plastics, paper, semiconductor, pharmaceutical, and biotechnology. At the same time, the breadth of a chemical engineering background helps graduates flourish in careers such as medicine, patent law, and technical marketing.

Throughout the Chemical Engineering curriculum, we focus on the development of complete engineers who can foster innovation through know-how and champion ideas through effective communication. We deliver a thorough education with insightful teaching, an innovative curriculum, research opportunities, summer job experiences, and channels for permanent, successful careers. Each year, our program is reviewed by an outside advisory board of professionals, who help ensure that our graduates are well prepared for lifelong successful careers in the exciting array of fields open to chemical engineers.

An important part of the chemical engineering experience at New Mexico Tech is the abundance of opportunities to participate in cutting edge research projects of our faculty and staff. Virtually all of our graduates engage in significant research projects and/or internships while working toward B.S. degrees in Chemical Engineering. Examples of areas of research open to Tech chemical engineering undergraduates include energetic materials, fuel cells, nano-composite materials, membrane separations, computer simulation, bioenergy, and thin film plasma processing. Numerous opportunities exist for summer research internships, including employment at the nearby Sandia and Los Alamos national labs as well as the research divisions on campus.

To learn more, the Student Handbook section of the

Chemical Engineering website ([www.nmt.edu/~cheme](http://www.nmt.edu/~cheme)) is an excellent resource with quick links and great insights to taking advantage of the outstanding educational opportunities at New Mexico Tech.

## **Program Educational Objectives**

The following objectives have been established by the program faculty in conjunction with our students and advisors from industry. They describe the characteristics and expected accomplishments of our future alumni.

1. Our graduates will be engaged in careers covering the spectrum of fields, which require a command of the principles of Chemical Engineering, or in pursuit of/complete post graduate degrees in fields such as engineering, the sciences, business, law, or medicine.
2. Our graduates will be active in the professional community by participating in professional societies, obtaining licensure, and other related activities.

## **Undergraduate Program**

### **Bachelor of Science in Chemical Engineering**

Minimum credit hours required—136

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

- ChE 110 (1), 110L (1), ChE 326 (3), 345L (1), 349 (3), 351 (3), 352 (3), 443 & 443L (3), 445L (1), 461 (3), 462 (3), 485 (1)
- CHEM 311 & 311L (4), 331 & 331L (4), 333 & 333L (4)
- ES 111 (3), 201 (3), 216 (3), 302 (3), 316 (3), 347(3), 350 (3), 405L (1)
- EE 211 (3) or ES 332 (3)
- MATH 231 (4), 335 (3)
- MATE 202 & 202L or 235 & 235L (4)
- Chemistry/Biology Elective (3) Any upper-division chemistry or biology course approved by the advisor
- Engineering/Technical Electives (6) Upper-division engineering or other approved courses. These electives should generally be Chemical Engineering or other engineering program courses at the 300-, 400- or 500-level. Advanced courses in chemistry, biology, mathematics, and computer science are encouraged. Chemical Engineering technical elective courses include ChE 463, 464, 470, 472, 473, 474, 475, and 489. Consult the semester schedule and your advisor for the availability of other technical electives of interest.

Chemical engineering majors must maintain a minimum GPA of 2.0 in required courses in order to graduate. Courses used for degree, including general degree requirements, may not be taken on an S/U basis.

All engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.



## Sample Curriculum for the Bachelor of Science in Chemical Engineering

To help plan your course of study, be sure to use the degree flowchart found in the Student Handbook at [www.nmt.edu/~cheme](http://www.nmt.edu/~cheme)

### Semester 1

- 2 ChE 110 & 110L (intro to chemical engineering)
- 3 ENGL 111 (college English)
- 4 MATH 131 (calculus I)
- 4 CHEM 121 & 121L (general)
- 3 Social Science
- 16 Total credit hours

### Semester 2

- 3 ES 111 (computer programming)
- 4 MATH 132 (calculus II)
- 4 CHEM 122 & 122L (general)
- 5 PHYS 121 & 121L (general)
- 16 Total credit hours

### Semester 3

- 3 ChE 326 (principles of chemical engineering)
- 4 MATH 231 (calculus III)
- 3 ES 201 (statics)
- 4 CHEM 311 & 311L (analytical)
- 3 ENGL 112 (college English II)
- 17 Total credit hours

### Semester 4

- 3 ES 216 (fluid mechanics)
- 3 ES 347 (engineering thermodynamics)
- 3 MATH 335 (ordinary differential equations)
- 5 PHYS 122 & 122L (general)
- 3 Humanities
- 17 Total credit hours

### Semester 5

- 3 ChE 349 (ChE thermodynamics)
- 3 EE 211 (circuits) or ES 332 (electrical engineering)
- 3 ES 350 (heat and mass transfer)
- 1 ES 405L (instrumentation)
- 4 CHEM 331 & 331L (physical)
- 3 Social Science
- 17 Total credit hours

### Semester 6

- 1 ChE 345L (junior design)
- 3 ChE 351 (kinetics)
- 3 ChE 352 (separation processes)
- 3 ES 316 (engineering economics)
- 3 ENGL 341 (technical writing)
- 4 MATE 202 & 202L or 235 & 235L (materials engineering)
- 17 Total credit hours

### Semester 7

- 1 ChE 445L (unit operations lab)
- 3 ChE 461 (plant design I)
- 1 ChE 485 (senior seminar)
- 3 ES 302 (strength of materials)
- 4 CHEM 333 & 333L (organic)
- 3 Engineering/Technical Elective
- 3 Humanities/Social Science
- 18 Total credit hours

### Semester 8

- 2 ChE 443 (process control)
- 1 ChE 443L (process control lab)
- 3 ChE 462 (plant design II)
- 3 Chemistry/Biology Elective
- 3 Engineering/Technical Elective
- 3 Humanities
- 3 Social Science
- 18 Total credit hours

## Minor in Polymer Science

Minimum credit hours required—19

The following courses are required:

- CHEM 334 (3), 446 (3)
- MATE 202 & 202L (4) or 235 & 235L (4)
- MATE 351 (3), 474 (3)
- ChE 473 (3)

## Chemical Engineering Courses:

### ChE 110, Introduction to Chemical Engineering, 1 cr, 1 cl hrs

Students will gain fundamental engineering skills that apply to all engineering disciplines through problem and cooperative based learning exercises and attain a clear understanding of what chemical engineers practice versus other engineering disciplines, in both traditional and contemporary work environments and careers. This course will introduce engineering calculations such as material and energy balances, cost analysis, and engineering software programs.

### ChE 110L, Introduction to Chemical Engineering Lab, 1 cr, 1 lab hr

This lab focuses on first hand experience of engineering design, calculations, and simulations using ChemCAD, Lab VIEW, and Excel. Additionally, data acquisition and analysis will be introduced. Small teams will design, build, and test a system, resulting in a written report, oral presentation, and design competition.

**ChE 326, Principles of Chemical Engineering, 3 cr, 3 cl hrs***Prerequisite: CHEM 121**Corequisite: MATH 132**Offered fall semester*

Introduction to stoichiometric computations. Calculations of energy and material balance. Elementary process analysis and reactor design. Single and multi-phase systems. (Same as METE 326)

**ChE 345L, Chemical Engineering Design Lab, 1 cr, 3 lab hrs***Prerequisites: ES 347, 350, ChE 326**Offered spring semester*

Team-oriented project design. Introduction to design fundamentals and creative problem-solving techniques. Written and oral presentations summarizing team progress.

**ChE 349, Chemical Engineering Thermodynamics, 3 cr, 3 cl hrs***Prerequisites: MATH 231; CHEM 121, PHYS 121; ES 347 is recommended**Offered fall semester*

The theory and engineering applications of the properties of mixtures, phase and chemical reaction equilibria. (Same as MATE 350)

**ChE 351, Chemical Process Kinetics, 3 cr, 3 cl hrs***Prerequisites: ChE 326, 349, ES 350**Offered spring semester*

Fundamentals of chemical reaction kinetics and chemical reactor design. Development of rate equations for both homogeneous and heterogeneous reactions, catalysis, diffusion-controlled reactions, and transport processes. (Previously offered as ChE 451)

**ChE 352, Separation Processes, 3 cr, 3 cl hrs***Prerequisites: ChE 326, 349, ES 350**Offered spring semester*

The process approach to solving problems that involve equilibrium in binary and multicomponent mixtures. Phase equilibrium, absorption, distillation (binary and multicomponent), liquid-liquid extraction, leaching. Design of staged operations for separating gas-liquid, liquid-liquid, solid-liquid, and gas-solid mixtures. (Previously offered as ChE 442)

**ChE 443, Process Dynamics and Control, 2 cr, 2 cl hrs***Prerequisites: MATH 335, ChE 326*

Process dynamics and control theory applied to chemical, mechanical, and other engineering processes. Design of control systems.

**ChE 443L, Chemical Process Dynamics & Control Lab, 1 cr, 3 lab hrs***Corequisite: ChE 443*

Computer modeling of system dynamics. Design, implementation, and tuning of process control systems for chemical processes.

**ChE 445L, Unit Operations Lab, 1 cr, 3 lab hrs***Prerequisite: ChE 351, 352**Offered fall semester*

Laboratory exercises to illustrate heat exchange, fluid flow, and mass transport phenomena in common unit operations found in the chemical process industries.

**ChE 461, Chemical Plant Design, Economics, and Management I, 3 cr, 1 cl hr, 6 lab hrs***Prerequisites: ES 316 or consent of instructor**Offered fall semester*

A two-semester sequence of courses in which a design project is used to illustrate principles and processes of chemical plant design, economics, and management. Lecture topics include intellectual property, capital and operating cost estimation, energy conservation, design optimization and scaling of chemical processes. Use of commercially available process simulation software emphasized.

**ChE 462, Chemical Plant Design, Economics, and Management II, 3 cr, 1 cl hr, 6 lab hrs***Prerequisite: ChE 461**Offered spring semester*

Continuation of ChE 461.

**Elective Courses****ChE 463, Design and Analysis of Experiments, 3 cr, 3 cl hrs***Prerequisite: Senior standing*

Methods of statistics and modeling important to many problems in materials science and engineering. Examples are chosen from a number of actual experiences. Safety considerations and experiment design including analysis of risk, how risks may be integrated, and how formal procedures should be established. The use of information sources, such as materials safety data sheets (MSDS). (Same as MATE 430)

**ChE 464, Natural Gas Engineering, 3 cr, 3 cl hrs***Prerequisite: PETR 245 or ChE 349**Offered fall semester*

Composition and properties of natural gas. Gas separator design. Recovery of liquefiable products from gas. Conditioning, transmission, and compression, measurement of gas, gas pipeline design, and gas storage. (Same as PETR 464)

**ChE 465, Catalyst Characterization Techniques, 3 cr, 3 cl hrs**

*Prerequisite:* ChE 349 or MATE 350 or CHEM 332 or instructor's consent

The course provides an overview of techniques used to characterize catalytic materials including data analysis and linking physical and chemical properties to catalytic activity at the laboratory and process level. Topics include x-ray methods, neutron scattering methods, physical adsorption, chemical adsorption, temperature programmed techniques, photoelectron spectroscopy, vibrational spectroscopy, and electron microscopy.

**ChE 470, Fuel Cell Technology, 3 cr, 3 cl hrs**

*Prerequisite:* Consent of instructor

The principles of fuel cell technology, including classification of fuel cells and operating mechanisms. Analysis of the underlying thermodynamics and physical factors which govern fuel cell performance and efficiency. Cell components and integrative cell design.

**ChE 472, Advanced Transport Phenomena, 3 cr, 3 cl hrs**

*Prerequisite:* ES 216 and 350 or MATE 314 or consent of instructor

Advanced topics in momentum, heat, and mass transfer. Newtonian and non-Newtonian fluid behavior and laminar flow problems, elementary turbulent flow concepts, energy balance applications in incompressible fluid flow, flow and vacuum production. Fourier's law and thermal conductivity of materials, steady state and time dependent heat conduction, application in solidification, elementary convective heat transfer. Diffusivity of materials, diffusion in gases, liquids and solids and through porous media, time dependent diffusion, and interphase mass transfer.

**ChE 473, Polymer Materials Engineering, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 202 or consent of instructor  
*Offered every fall semester*

Introduction to classes and performance properties of polymeric materials. Methods of polymer synthesis and processing. Special emphasis on structure, viscoelasticity, and mechanical properties.

**ChE 474, Polymer Processing and Characterization, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* MATE 202 or consent of instructor

A practical and "hands-on" course covering the essentials of polymer processing and polymer materials characterization. A survey of polymer processing techniques with emphasis on the fundamentals of extrusion. Lab topics include: extruder operation, compounding, scanning calorimetry, rheometry, and mechanical testing. Field trips to manufacturing facilities. (Same as MATE 474)

**ChE 475, Explosives Surety, 3 cr, 3 cl hrs**

*Prerequisite:* Upper-class standing or consent of instructor  
*Offered spring semester*

An introduction to explosives and other energetic materials. The basic chemical compositions, properties and environmental effects of commercial, military, and improvised (terrorist) explosives and some pyrotechnics will be compared. The basic physics of shock waves and detonation. Explosive effects, blast detection, tagging and environmental issues. Case studies or recent bombings will be used to describe a variety of terrorist approaches. Safety in handling of explosive materials and classifications for transportation and storage. (Same as EXPL 414.)

**ChE 476 Drug Delivery Techniques, 3 cr, 3 cl hrs**

*Prerequisite:* Senior standing or consent of instructor

Focus is on current developments in drug delivery techniques, with only a brief discussion of common clinical techniques. The first portion of the class focuses on various delivery mechanisms and the tools needed to validate successful targeted drug delivery (both in vitro, in vivo and diagnostic tools). The second part of the course focuses on current developments in drug delivery based on published research articles. Students will read, digest, and critically analyze scientific work from leading research laboratories. Students will also gain valuable communication tools, as each student will present an article of interest to the class. Finally, the third part of the course focuses on important materials characterization methods such as biological sample prep, SEM, TEM, DSC, Flow Cytometry, Fluorescence Microscopy, ELISA Assays. Shares lecture with MATE 576 but is graded separately and additional work is required at the graduate level.

**ChE 485, Senior Seminar, 1 cr, 3 lab hrs**

*Prerequisite:* Senior standing or consent of instructor  
*Offered fall semester*

Student and outside speaker presentations of topics of current interest. Peer and video review of each student's work. Career planning.

**ChE 491, Independent Study, hrs and crs to be arranged**

*Prerequisite:* Consent of instructor

Individual study of chemical engineering problems of special interest.

## Faculty Research Interests

Bretz—Transport Phenomena, Phase Behavior, Natural Gas Processing

Leclerc—Catalysis, Reactor Design, Alternative Fuels

Riley—Electrochemical Engineering, transport

Phenomena, Colloidal-Based Nanocomposites

Tartis - Biomedical Engineering, Targeted Drug Delivery

## Civil Engineering

*Professor Cal (Chair of Department), Richardson*

*Associate Professor Wilson*

*Assistant Professors Dong*

*Adjunct Faculty Ghosh, Hendrickx, McCord, McMullin, Kuhn*

***Degree Offered: B.S. in Civil Engineering; Areas of Specialization: Geotechnical, Water Resources, and Structural***

### Department Mission Statement

The primary objective of this program is to produce well-balanced civil engineers capable of entering the civil engineering profession or continuing their studies at the graduate level. Graduates will be well-prepared to solve current civil engineering problems, and they will have the ability to adapt to problems of the future.

The achievements of civil engineers are well-known to the general public, because civil engineers build the world's infrastructure. In doing so, they can shape the history of nations. Projects that civil engineers work on include: airports, bridges, buildings, dams and waterways, drainage and sewer systems, city roads, and highways.

The undergraduate program offers a balanced approach to civil engineering education. Students take a common core of civil engineering courses, and they can specialize in the areas of geotechnical, water resources, or structural engineering. The program is also designed to give students a solid foundation in engineering and science. Students take courses in chemistry, physics, and math, in addition to a core set of engineering courses common to most engineering disciplines. The civil engineering courses teach students the fundamentals of engineering design, as well as potential applications. Students are taught how to use computer software to expedite the design process, and they are also taught how to balance engineering designs with economic constraints. During their senior year, undergraduate students work with a professor on a design project.

### Program Educational Objectives

1. To develop graduates that function successfully in the fundamental areas of civil engineering, and within a specialty, such as structural, geotechnical or water resources engineering.
2. To prepare graduates for advanced education in civil engineering and related fields, and for professional licensure.

## Undergraduate Program

### Bachelor of Science in Civil Engineering

Minimum credit hours required—132

In addition to the General Education Core Curriculum (page 100), the following courses are required:

- CE 101 (1), 201 (3), 301 (3), 302 (3), 401 (3), 402 (3), CE 406 (3), CE 407 (3), 413 (3), 423(3), 481 (3)
- ES 316 (3)
- ES 110 (2), 111 (3), 201 (3), 216 (3), 302 (3)
- MATH 231 (4), 283 (3), 335 (3)
- ME 220 (3), 420(3)
- Basic Science Elective— 3 credits from the following: BIOL 111, EARTH 101, EARTH 120, EARTH 130, EARTH 140, EARTH 150. Students are not required to take the accompanying lab unless it is required by the Biology/Earth Science department.
- Technical Electives (12): Minimum of 12 credit hours from the list of approved civil engineering electives. Students may take approved elective courses from more than one specialty area to satisfy the B.S. degree without prior approval from their advisor or the Department Chair. Courses are grouped by specialty to assist students who may want to specialize in a particular area.

Civil engineering approved electives include:

- **Geotechnical** (12): CE 420 (3), CE 422 (3), ME 360 (3), ME 409 (3), ME 422 (3), ME 427 (3), ME 434 (3), ME 442 (4), EXPL XXX (3)
- **Water Resources** (12): ENVE 201 (3), ENVE 301 (3), ENVE 303(3), ENVE 304 (3), ENVE 406 (3), EARTH 440 (4), EARTH 441 (1), EARTH 442 (1), EARTH 443 (1), ES 347 (3), ES 350 (3)
- **Structural** (12): CE 410 (3), CE 412 (3), CE 414 (3), CE 418 (3), CE 420 (3), MATE 470 (3), MENG 304 (3), MENG 441 (3), ME 409 (3), ME 434 (3) , EXPL XXX (3)

#### Additional technical electives must be approved by the Department Chair.

Students pursuing a B.S. in Civil Engineering must take all engineering courses for a letter grade.

Civil engineering majors must maintain a minimum GPA of 2.0 in required courses in order to graduate. All engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

### Sample Curriculum for the Bachelor of Science Degree in Civil Engineering

#### Semester 1

- 1 CE 101 (civil engineering seminar)
- 4 CHEM 121 & 121L (general)
- 3 ENGL 111 (college English)
- 2 ES 110 (drafting)
- 4 MATH 131 (calculus)

3 Basic Science\*

17 Total credit hours

\* Basic Science Elective from one of the following:

BIOL 111, EARTH 101, EARTH 120, EARTH 140, EARTH 150

#### Semester 2

- 3 ENGL 112 (college English)
- 3 ES 111 (computer programming)
- 4 MATH 132 (calculus)

5 PHYS 121 & 121L (general)

15 Total credit hours

#### Semester 3

- 4 CHEM 122 & 122L (general)
- 3 ES 201 (statics)
- 4 MATH 231 (calculus)

5 PHYS 122 & 122L (general)

16 Total credit hours

#### Semester 4

- 3 ES 216 (fluid mechanics)
- 3 ES 302 (mechanics of materials)
- 3 MATH 335 (ordinary differential equations)
- 3 ME 220 (surveying and map preparation)

6 Humanities / Social Science

18 Total credit hours

#### Semester 5

- 3 CE 201 (materials, properties, and testing)
- 3 CE 301 (construction engineering)
- 3 ME 420 (soil mechanics)
- 3 ENGL 341 (technical writing)
- 3 MATH 283 (statistics)

3 Social Science

18 Total credit hours

#### Semester 6

- 3 CE 302 (structural engineering)
- 3 CE 401 (finite element analysis)
- 3 ME 422 (rock mechanics)
- 3 ES 316 (engineering practice and economics)

3 Humanities

15 Total credit hours

*Semester 7*

- 3 CE 406 (steel)
- 3 CE 407 (concrete)
- 6 CE Electives
- 3 Humanities
- 15 Total credit hours

*Semester 8*

- 3 CE 402 (transportation engineering)
- 3 CE 413 (foundation design & analysis)
- 3 CE 423 (open channel hydraulics)
- 3 CE 481 (senior design)
- 6 CE Elective
- 18 Total credit hours

**Approved Civil Engineering Electives**

CE students must take a minimum of 12 elective credit hours. Students may take approved elective courses from more than one specialty area to satisfy the B.S. degree without prior approval from their advisor or the Department Chair. Courses are grouped by specialty to assist students who may want to specialize in a particular area.

**Water Resources Engineering**

- 3 ENVE 201 (environmental engineering)
- 3 ENVE 301 (applied principles of environmental engineering)
- 3 ENVE 303 (water treatment process design)
- 3 ENVE 304 (wastewater treatment process design)
- 3 ENVE 406 (environmental engineering unit operations)
- 4 EARTH 440 (hydrological theory and field methods)
- 1 EARTH 441 (aquifer mechanics)
- 1 EARTH 442 (vadose zone processes)
- 1 EARTH 443 (atmospheric dynamics and rainfall processes)
- 3 ES 347 (engineering thermodynamics)
- 3 ES 350 (heat and mass transfer)

**Geotechnical Engineering**

- 3 CE 420 (pavement design)
- 3 CE 422 (geotechnical waste containment design)
- 3 ME 360 (exploration and field mapping)
- 3 ME 409 (design of structures)
- 3 ME 427 (site investigation)
- 3 ME 434 (drilling & blasting)
- 4 ME 442 (applied geomechanics)
- 3 Some explosives (EXPL) courses – check with Department Chair

**Structural Engineering**

- 3 CE 410 (reinforced masonry and timber design)
- 3 CE 412 (advanced design of steel structures)
- 3 CE 414 (advanced design of concrete structures)
- 3 CE 418 (structural dynamics)
- 3 CE 420 (pavement design)
- 3 MATE 470 (corrosion phenomena)
- 3 MENG 304 (advanced strength of materials)
- 3 MENG 441 (dynamics and vibrations in structural design)
- 3 ME 409 (design of structures)
- 3 ME 434 (drilling & blasting)
- 3 Some explosives (EXPL) courses – check with Department Chair

**Additional technical electives must be approved by the Department Chair.**

**Minor in Civil Engineering**

*Minimum credit hours required – 18*

*The following courses are required:*

- 18 total credit hours of CE courses, ME 420, or ME 422

**Civil Engineering Courses****CE 101, Civil Engineering Seminar, 1 cr, 1 cl hrs**

Brief overview of civil engineering topics, including structures, water resources, geotechnical and transportation engineering in the form of seminars by faculty, and guest speakers from industry, consulting, and government.

**CE 201, Construction Materials, Properties, and Testing, 3 cr, 3 cl hrs**

*Prerequisite: CHEM 122*

Mechanical behavior of engineering materials, including metals, ceramics, polymers, concrete, wood, bitumens, and asphaltic concretes; explanations of macroscopic behavior in terms of phenomena at the microscopic level.

**CE 301, Introduction to Construction Engineering, 3 cr, 3 cl hrs**

Topics covered include: contracting and bonding, planning and scheduling, estimating, project control, and productivity models.

**CE 302, Introduction to Structural Engineering, 3 cr, 3 cl hrs**

*Prerequisites: ES 201, 302 or consent of instructor*

Basic topics in the analysis, behavior, and design of trusses and framed structures under static loads; analysis topics include member forces in trusses, shear and moment diagrams, deflections, simple applications of the force method and slope-deflection; and an introduction to computer applications by means of a general purpose structural analysis program.

**CE 401 – Finite Element Analysis for Civil Engineers, 3 cr, 3 cl hrs**

*Prerequisite: CE 302 or consent of instructor*

Introduction to finite element analysis (FEA) for Civil Engineering students. Students will learn the fundamentals of FEA, and they will learn to use software packages to analyze complex structures. Topics include: 1-D systems, trusses, 2-D problems, axis-symmetric solids, beams, frames, and some types of 3-D problems.

**CE 402, Introduction to Transportation Engineering, 3 cr, 3 cl hrs**

Introduction to the design, planning, operation, management, and maintenance of transportation systems. Principles for planning integrated multi-modal transportation systems (highways, air, rail, etc.). Introduction to the layout of highways, airports, and railroads with traffic flow models, capacity analysis, and safety. Functional design concepts for both the facilities and systems areas of study with life cycle costing procedures and criteria for optimization.

**CE 406, Design of Steel Structures, 3 cr, 3 cl hrs**

*Prerequisite: CE 302 or consent of instructor*

Behavior and design of steel members subjected to tension, compression and flexural loads, according to AISC specifications. Topics covered include: elastic and inelastic design, buckling of beams and columns, and structural connections.

**CE 407, Design of Concrete Structures, 3 cr, 3 cl hrs**

*Prerequisite: CE 302 or consent of instructor*

Study of the strength, behavior and design of reinforced concrete members, including beams, columns and slabs. Topics covered will include serviceability of beams and slabs, control of deflections and cracking, shear design, and bonding.

**CE 410, Reinforced Masonry and Timber Design, 3 cr, 3 cl hrs**

*Prerequisite: CE 302 or consent of instructor*

Reinforced masonry design topics covered include: the properties and performance of masonry materials; design criteria and methods in reinforced masonry; and design examples including reinforced masonry walls, masonry columns and pilasters, and rectangular beams. Timber topics covered include: design of beams, columns, trusses, and diaphragms in wood; design of gluelaminated beams; design of wood connections; use of timber design codes and the International Building Code (IBC).

**CE 412, Advanced Design of Steel Structures, 3 cr, 3 cl hrs**

*Prerequisite: CE 406 or consent of instructor*

Behavior and design of structural steel beams, columns, frames, and connections. Topics include: elastic and inelastic design, composite beam design, stability of beams and columns, behavior of steel frame structures, design of bolted and welded connections, metallurgical and mechanical properties of welds, braced frame and moment frame design for lateral loads. Extensive use of the current AISC-LRFD design code.

**CE 413, Foundation Design and Analysis, 3 cr, 3 cl hrs**

*Prerequisite: ME 420*

Principles of soil mechanics and foundation engineering. Immediate and time dependent settlements, service loads, lateral loads, loading, approximate analysis methods, performance requirements, shallow foundations, lateral earth pressure, design of retaining walls, deep foundations, special footings, slope stability, and computer modeling of foundations. (Same as ME 413).

**CE 414, Advanced Design of Concrete Structures, 3 cr, 3 cl hrs**

*Prerequisite: CE 407 or consent of instructor*

Topics covered include: strut and tie models, footings, retaining walls, principles of prestressed concrete, materials and techniques used in these systems, advantages and disadvantages of prestressing methods over regular reinforced concrete, and the design of prestressed concrete structures, such as axially loaded members, beams (for flexure and shear), and slabs.

**CE 418, Structural Dynamics, 3 cr, 3 cl hrs**

*Prerequisites: Math 335 and CE 302 or consent of instructor*

Fundamentals of structural dynamics. Analysis of single and multi-degree-of-freedom structures subjected to various types of vibrations. Topics covered will include structural responses to free, harmonic and periodic excitations, step and pulse excitations, and earthquake loads.

**CE 420, Pavement Materials and Design, 3 cr, 3 cl hrs**

*Prerequisites: CE 201 or ES 302*

Analysis, behavior, performance, and structural design of pavements for highways, bridges and airfields. Topics include: climatic factors, maintenance strategies and life cycle design economics, traffic loadings, recycled pavement materials, evaluation by nondestructive testing (roughness, skid resistance, structural capacity), destructive testing, and rehabilitation of pavement systems.

**CE 422, Geotechnical Waste Containment Design, 3 cr, 3 cl hrs**

*Prerequisites: ME 420; MATH 335*

Design procedures consisting of waste disposal methods, various containment systems, and associated remediation techniques. Waste characterization and soil-waste interactions, contaminant transport in low permeability soils, geosynthetics and soil materials use in waste containment, remedial issues of solidification and stabilization and barrier design, and landfill- and surface impoundment-related design, including liners, leachate and gas collection and removal, final covers, static and seismic slope stability, and settlement analysis. Geotechnical problem definition, application of field and laboratory test data, use of computer models for analysis and design.

**CE 423, Open Channel Hydraulics, 3 cr, 3 cl hrs**

*Prerequisites: ES 216*

Analysis and characteristics of flow in natural and artificial open channel systems using energy, continuity, and momentum equations as applied to steady-state uniform, gradually varied, and rapidly varied flow profiles with emphasis on design of hydraulic structures. The students will use their knowledge of fluid mechanics, calculus, numerical analysis, and computer science to solve practical open channel flow problems. A variety of hydraulic conveyance and structures are covered, including rigid and flexible boundary channels, culverts, sluice gates, fumes, weirs, spillways, stilling basins, and bridges.

**CE 481, Senior Engineering Design , 3 cr, 3 cl hrs**

*Prerequisite: Senior standing*

A semester-long civil engineering design project organized and directed by a faculty member.

**CE 491, Special Topics in Civil Engineering, 2-3 cr**

*Prerequisite: Senior standing or consent of instructor*

New and developing areas of knowledge in civil engineering offered to augment the formal course offerings.

**CE 518, Structural Dynamics, 3 cr, 3 cl hrs**

*Prerequisite: MATH 335 and CE 302 or consent of instructor*

Fundamentals of structural dynamics. Analysis of single and multi-degree-of-freedom structures subjected to various types of vibrations. Topics covered will include structural responses to free, harmonic and periodic excitations, step and pulse excitations, and earthquake loads. Graduate students complete an additional project and a classroom presentation. Graduate work is graded separately. Lectures shared with CE 418.

**Faculty Research Interests**

Cal— Air quality engineering, chemical fate and transport, transportation engineering, water resources engineering

Ghosh— Macro behavior of composites, structural health monitoring and restoration

Hendrickx— Vadose zone hydrology, water and salt balance of natural and irrigated systems, evapotranspiration, remote sensing, soil physics, electromagnetic induction

Kuhn— Geotechnical engineering

McCord— Water resources engineering

McMullin— Structural engineering

Richardson— Biological wastewater treatment, groundwater contamination, site remediation

Wilson— Structural vibration control, fuzzy control, earthquake engineering



# Computer Science and Engineering

*Professors Liebrock, Soliman, Sung  
Associate Professor Mazumdar (Chair of the Department), Shin  
Assistant Professor Zheng  
Adjunct Faculty Anselmo, Lassez, Mukkamala  
Emeritus Faculty Stavelly*

## **Degrees Offered: B.S., M.S., and Ph.D. in Computer Science, and M.S. with Information Technology Option**

The Department of Computer Science and Engineering is focused on an exciting and rapidly growing body of knowledge with constantly changing emphasis.

The curriculum of the department includes courses in both theory and application. It prepares students to apply the principles of logic and mathematics to the design and construction of hardware and software systems using current engineering paradigms and also exposes them to major applications of computing.

The *Bachelor of Science in Computer Science* is accredited by the Computer Science Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore MD 21202-4012, telephone (410) 347-7700. The program emphasizes fundamental principles while striking a careful balance between the applications of computer technology and the theory of computing. In addition to the required fundamental computer science courses, students must also take technical electives to broaden their knowledge in major computer science application areas. Graduates of this program will be well prepared for both industry employment and graduate study.

The *Master of Science in Computer Science* program is designed for students who wish to further broaden or deepen their knowledge of computer science and applications. Both thesis and non-thesis options are offered; an independent study report is required for the non-thesis option. Master's students usually participate in faculty research projects to complete their thesis or independent study.

New Mexico Tech's Department of Computer Science and Engineering also offers a *Ph.D. in Computer Science* program. This program gives students the opportunity to take courses, to select committee members, to use the resources of the department, and to pursue research in a fairly large number of areas of computer science and its applications.

The department has been certified, since 2002, by the National Security Agency and the Department of Homeland Security as a National Center of Academic Excellence in Information Assurance Education. Since 2009, the department has also been certified as a National Center of Academic Excellence in Information Assurance Research.

The department has its own network of computers and servers plus a variety of other equipment in several laboratories. The Tech Computer Center supports a larger network that is also available to the department. Computing equipment at the research labs associated with Tech includes both symmetric multiprocessors and special purpose massively parallel computers. The department also has access to massively parallel machines at national laboratories and supercomputing centers.

## **Mission**

The mission of the Computer Science and Engineering Program is to produce computer science graduates who, trained in the design, implementation, and analysis of computational systems and skilled in technical communication, will contribute towards the advancement of computing science and technology.

## **Program Educational Objectives**

Within a few years of graduating with a B.S. degree in Computer Science, our students will demonstrate that they have:

1. the ability to design, implement, and analyze computational systems;
2. the capability to tackle complex computer science and engineering related problems in the real world;
3. contributed towards the advancement of computing science and technology
4. the capacity to work effectively with peers in computational tasks; and
5. cognizance of ethical, social, and legal issues pertaining to computer science and engineering.

## **Program Outcomes**

The undergraduate academic program in Computer Science will enable our graduates to acquire by the time of their graduation:

1. the ability to design, implement, and test small software programs, as well as large programming projects;
2. knowledge of the theoretical concepts of computing and of the fundamental principles of programming languages, systems, and machine architectures;
3. exposure to one or more application areas within computer science;
4. technical communication skills in written and oral form;
5. the capability to work as part of a team; and
6. awareness of the ethical and societal impact of developments in the field of computer science.

## **Undergraduate Program**

### **Bachelor of Science in Computer Science**

*Minimum credit hours required—130*

In addition to the General Education Core Curriculum (page 100), the following courses are required:

- CSE 101 (2), 113 (4), 122 (3), 213 (3), 221 (3), 222 (3), 324 (3), 325 (4), 326 (3), 331 (3), 342 (3), 344 (3), 353 (3), 382 (3), 423 (4)
- MATH 221 (3), 382 (3), 382L (1)
- Breadth Requirement: 3 hours of electives to broaden background from Education, Fine Arts, Humanities, Management, Philosophy, Social Science, or Technical Communication.

- Technical Electives: A sequence of 12 hours of Computer Science and Engineering courses numbered 300 or higher, pre-approved by the student's advisor and the CS Department Undergraduate Advisor. Students are encouraged to select a coherent set of courses as technical electives that will prepare them for a specific focus in their career.
- Each of the above courses must be completed with a grade of C or better.
- Electives to complete 130 credit hours.

### *Sample Curriculum for the Bachelor of Science in Computer Science*

#### Semester 1

- 4 MATH 131 (calculus)
- 1 CSE 101 (introduction to comp science & info tech)
- 4 CSE 113 (introduction to programming)
- 3 ENGL 111 (college English)
- 4 CHEM 121 & 121L (general)
- 16 Total credit hours

#### Semester 2

- 4 MATH 132 (calculus)
- 3 CSE 122 (algorithms and data structures)
- 4 CHEM 122 & 122L (general)
- 3 ENGL 112 (college English)
- 3 Social Science
- 17 Total credit hours

#### Semester 3

- 3 CSE 221 (computer systems)
- 3 Humanities
- 5 PHYS 121 & 121L (general)
- 3 MATH 382 (probability and statistics)
- 3 MATH 382L (probability and statistics)
- 15 Total credit hours

#### Semester 4

- 3 CSE 213 (intro to object oriented programming)
- 3 CSE 222 (systems programming)
- 3 CSE 324 (programming languages)
- 5 PHYS 122 & 122L (general)
- 3 Humanities
- 3 MATH 221 (discrete mathematics)
- 17 Total credit hours

#### Semester 5

- 3 CSE 331 (computer architecture)
- 3 CSE 344 (algorithms)
- 3 CSE 353 (data and computer communications)
- 3 ENGL 341 (technical writing)
- 3 Technical Elective
- 2 Electives
- 17 Total credit hours

#### Semester 6

- 3 CSE 326 (software engineering)
- 3 CSE 342 (formal languages)
- 3 CSE 382 (social issues)
- 3 Social Science
- 3 Technical Elective
- 2 Electives
- 17 Total credit hours

#### Semester 7

- 4 CSE 423 (compiler writing)
- 3 Humanities
- 3 Technical Elective
- 3 Breadth Elective
- 13 Total credit hours

#### Semester 8

- 4 CSE 325 (operating systems)
- 3 Humanities/Social Science
- 3 Social Science
- 3 Technical Elective
- 2 Electives
- 15 Total credit hours

## Graduate Program Master of Science

Students may earn a Master of Science degree in Computer Science or a Master of Science Degree in Computer Science with the Information Technology Option through cooperation with the Information Technology faculty.

### Master of Science Degree in Computer Science Without Thesis:

- 1.) Students must have demonstrated proficiency in the core undergraduate curriculum including the topics normally covered by CSE 324, 325, 331, 342, 344, and 423. Proof of proficiency usually requires grades of B or better in these courses or in equivalent courses approved by the department.
- 2.) Course work approved by the student's advisory committee fulfilling the general requirements of 27 credit hours for the master's degree. At least 15 credit hours must be in computer science courses numbered 500 or above, not including CSE 590

(Independent Study) or 591 (Thesis). Three of these hours must be CSE 585 (Graduate Seminar).

3.) CSE 590: 3 credit hours.

#### **With Thesis:**

- 1.) Students must have demonstrated proficiency in the core undergraduate curriculum including the topics normally covered by CSE 324, 325, 331, 342, 344, and 423. Proof of proficiency usually requires grades of B or better in these courses or in equivalent courses approved by the department.
- 2.) Course work approved by the student's advisory committee fulfilling the general requirements of 24 credit hours for the master's degree. At least 15 credit hours must be in computer science courses numbered 500 or above, not including 590 (Independent Study) or 591 (Thesis). Three of these hours must be CSE 585 (Graduate Seminar).
- 3.) CSE 591 (Thesis): 6 credit hours.

#### **Master of Science Degree in Computer Science with Information Technology Option**

Students earning a Master of Science degree in Computer Science can choose the Information Technology Option. The requirements for the Information Technology Option are the same as those for a Master of Science in Computer Science, except that:

Students must demonstrate proficiency in the topics normally covered by CSE 324, CSE 331, CSE 344, IT 321, IT 326, and IT 373. Proof of proficiency usually requires grades of B or better in these courses or in equivalent courses approved by the department.

Course work approved by the student's advisory committee fulfilling the general requirements of 24 credit hours (with thesis) or 27 credit hours (without thesis) for the master's degree. At least 15 credit hours must be in computer science courses numbered 500 or above, not including 590 (Independent Study) or 591 (Thesis). Three of these hours must be CSE 585 (Graduate Seminar). A minimum of 9 credit hours must be in a sequence of upper-division information technology courses approved by the student's advisory committee.

CSE 590 (Independent Study): 3 credit hours; or CSE 591 (Thesis): 6 credit hours.

There is no foreign language requirement for the Master of Science degree in Computer Science or the Master of Science degree in Computer Science with the Information Technology Option. The independent study or thesis topic may be selected, subject to approval from the student's advisory committee and the computer science chair (or information technology program coordinators), from any area of computer science or information technology.

#### **Doctor of Philosophy in Computer Science**

Students of exceptional ability as demonstrated in previous course work are encouraged to pursue a doctor of philosophy degree; individuals with substantial experience in industrial research and development may also apply to the doctoral program. The current research programs of the department include parallel computation, information assurance, high speed networks, neural networks, software engineering, verification, genetic algorithms, databases and knowledge-base systems, and computational intelligence. The department also encourages interdisciplinary work with other departments and divisions at Tech and in cooperation with researchers at Los Alamos and Sandia national laboratories.

As computer science and engineering is a diverse and rapidly changing discipline, the program of study of a Ph.D. student will depend on the area of specialization and on prior experience and education. All Ph.D. students will be required to demonstrate master's-level knowledge of the core areas of computer science, as well as a thorough understanding of the intended area of specialization. The core areas include systems (operating systems and computer architectures), programming (programming languages, compilers, data structures, and formal semantics), and theory (automata theory, algorithms, and computational complexity). In addition, all Ph.D. students are required to take three credit hours of CSE 585 (Graduate Seminar). The specific course requirements are determined with the consultation and approval of the student's advisory committee and the chair of the department.

The student must pass a preliminary examination in each of the core areas. A detailed list of topics to be covered is available from the department. The student must also pass a candidacy examination in his or her specific area of specialization. See the description of the Graduate Program, page 47, for further details.

#### **Computer Science Courses:**

##### **CSE 101, Introduction to Computer Science and Information Technology, 2 cr, 2 cl hrs**

Brief overview of the discipline of computer science and information technology topics including computer architecture, operating systems and networks, automata and models of computation, programming languages and compilers, algorithms, databases, security and information assurance, artificial intelligence, graphics, and social/ethical issues of computing. (Same as IT 101)

**CSE 113, Introduction to Programming, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite: MATH 103 or equivalent*

Introduction to programming in a structured language (e.g., C): problem solving, algorithm development, top-down design, modular programming, debugging, testing, control structures including selection, iteration and recursion, number systems, data representation, data types including arrays, strings, pointers, and dynamic structures. Concepts implemented through extensive programming using good programming style. (Same as IT 113).

**CSE 122, Algorithms and Data Structures, 3 cr, 3 cl hrs**

*Prerequisite: CSE 113*

*Corequisite: MATH 132*

Fundamental data structures including linked lists, trees, hash tables, and graphs. Algorithms for sorting, searching, and other fundamental operations. Introduction to mathematical foundations for analysis of iterative and recursive algorithms and for basic correctness proofs. Analysis of algorithms. Implementation of selected algorithms using sound programming methodologies. (Same as IT 122)

**CSE 209, Programming Language Practicum, 1 cr, 3 lab hrs**

*Prerequisite: Knowledge of elementary programming*

A practical course teaching the use of a programming language of current interest. May be repeated for credit with different languages.

**CSE 213, Introduction to Object Oriented Programming, 3 cr, 3 cl hrs**

*Prerequisite: CSE 113, 122*

Introduction to programming in an object oriented language (e.g., Java): review of problem solving, algorithm development, top-down design, modular programming, debugging, testing, control structures including selection, iteration and recursion, data types including arrays, strings, pointers, and dynamic structures. Object oriented concepts will include: objects, classes, inheritance, instances, methods, interfaces, packages, encapsulation, and polymorphism. Concepts implemented through extensive programming using good programming style. (Same as IT 213)

**CSE 221, Computer System Organization, 3 cr, 3 cl hrs**

*Prerequisite: CSE 122*

The hardware/software interface. Basic organization of hardware and operating systems. Memories, buses, interrupts, input and output, and instruction set architecture. Programming in assembly language. (Same as IT 221)

**CSE 222, Systems Programming, 3 cr, 3 cl hrs**

*Prerequisite: CSE 113, 221*

This course provides an introductory overview of operating systems and system programming, mainly focusing on system-level programming based on OS services and other APIs. Topics include system calls, file I/O, files and directories, memory management, process control, inter-process communication (IPC), socket-based network programming, remote procedure call (RPC) programming, and basic security mechanisms. Course work includes substantial programming homework and team-based projects.

**CSE 321, Internet and Web Programming, 3 cr, 3 cl hrs**

*Prerequisite: CSE 213, 221*

This course has a practical emphasis on the design and techniques for developing internet-based applications, mainly focusing on web programming. Topics include HTML, client-side scripting language (JavaScript), server-side programming (Servlets, JSP, and J2EE), and XML/web services (Java and .NET). This course will also cover some important topics needed for internet-based application developments, such as Internet architectures, basic object-oriented programming (OOP) concepts, and web security. Course work includes substantial programming homework and team-based projects. (Same as IT 321)

**CSE 324, Principles of Programming Languages, 3 cr, 3 cl hrs**

*Prerequisite: CSE 122, 213*

Introduction to the definition of syntax and semantics. Data types, control structures, concurrency, declarations, procedures. Recursion and recursive definitions. Procedural and data abstraction. Examples from current programming languages.

**CSE 325, Principles of Operating Systems, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: CSE 221 and 222*

Software I/O buffering. Discussion of concurrent processes, including mutual exclusion, synchronization, and deadlock. Processor scheduling, memory management, and resource control. Hoare's monitors. File systems. Each student is expected to design and implement a small operating system as a substantial portion of the course grade.

**CSE 326, Software Engineering, 3 cr, 3 cl hrs***Prerequisites: CSE 122, 213*

This course provides the introductory overview of software engineering, concentrating on large-scale software system design and implementation. Topics include software life cycle, UML-based design language, design tools and techniques, design documentation, software testing, and software project management. Course work includes a team-based project. (Same as IT 326)

**CSE 328, Secure Software Construction, 3 cr, 2 cl hrs, 1 lab hr***Prerequisite: CSE 222, CSE 213*

Formal methods and practical techniques for the specification, design, implementation, and validation of computer software. Current software engineering and management practices, with emphasis on ensuring software reliability, safety, and security. Course work includes a team project to develop a sizeable, real-world application software. (Same as IT 328)

**CSE 331, Computer Architecture, 3 cr, 3 cl hrs***Prerequisite: CSE 221*

Computer design fundamentals and hardware components: instruction set design, memory hierarchies, ALU's, control units, bus architectures, input and output, system design. Performance modeling and measurement.

**CSE 342, Formal Languages and Automata, 3 cr, 3 cl hrs***Prerequisite: MATH 221 with a grade of C or better*

Regular expressions. Regular, context-free, context-sensitive and unrestricted grammars and languages. Finite and pushdown automata. Turing machines, recursive and recursively enumerable languages. Decidability and the halting problem.

**CSE 344, Design and Analysis of Algorithms, 3 cr, 3 cl hrs***Prerequisites: CSE 122; MATH 221 with grade of C or better*

Interplay of data structures and algorithms. Time and space complexity of algorithms. Design paradigms and analysis techniques. Fundamental algorithms; combinatorial and graph algorithms; numerical algorithms. Introduction to the theory of NP-completeness.

**CSE 351, Modeling and Simulation Technologies for Information Systems, 3 cr, 3cl hrs***Prerequisites: CSE 122; MATH 221*

Fundamentals and techniques for designing and using simulation, modeling, and optimization algorithms with applications in system performance modeling, business infrastructure modeling, and distributed and parallel computing. An introduction to advanced complex systems models. (Same as IT 351)

**CSE 353, Data and Computer Communication, 3 cr, 3 cl hrs***Prerequisites: CSE 222*

Basic concepts of data communication. Transmission media (wireline and wireless) characteristics and utilization. Digital and analog data signaling, modulation, and coding. Signal and channel analysis. Concepts from information theory. Data multiplexing and switching. Connection-oriented vs. connectionless networking. Synchronous and asynchronous carriers (ATM, SONET/ SDH). Overview of the OSI vs. TCP/IP protocol stacks. The Internet protocol structure- "subnet" and interfaces. Channel access and allocation. Examples of LAN, MAN, and WAN. Data link control, design issues, link management, error and flow control. Principles of internetworking: relays and protocols. (Same as IT 353)

**CSE 373, Introduction to Database Systems, 3 cr, 3 cl hrs***Prerequisite: CSE 122*

Conceptual modeling and database design using the entity-relationship model. The relational model; relational algebra and relational query languages; design theory for relational databases. Database integrity. Physical data organization. Introduction to problems of concurrency control, recovery, security, and distributed databases. Course work includes a project using SQL and the Oracle Database Management System. (Same as IT 373)

**CSE 382, Legal, Ethical, and Social Issues of Information Technology, 3 cr, 3 cl hrs***Prerequisite: CSE 326 or consent of instructor*

A survey of current legal IT (and general business and management) issues. Social and ethical issues associated with IT and management of secure information systems. (Same as IT 382)

**CSE 391, Directed Study, cr and topics arranged****CSE 423, Compiler Writing, 4 cr, 3 cl hrs, 3 lab hrs***Prerequisites: CSE 324, 326, 342, 344**Corequisite: CSE 331*

Implementation of compilers for higher level computer languages including: parsing, symbol table management, code emission, and code optimization. Each student implements a small compiler and designs an optimizing compiler as a substantial portion of the course grade. Individual and group projects. Practice in developing software requirement, specification, design, and test plan documents.

**CSE 441, Cryptography and Applications, 3 cr, 3 cl hrs**  
(Same as IT 441)

*Prerequisites: CSE 122; MATH 221*

Basic theory of encryption and decryption. The RSA algorithm and the public/private key system. Cryptography systems in use for Internet and business applications. (Same as IT 441)

**CSE 451, Introduction to Parallel Processing, 3 cr, 3 cl hrs**

*Prerequisites: CSE 122 or IT 122*

Introduction to supercomputers and massively-parallel machine architecture, models of parallel computation, parallel algorithms, synchronization, parallel languages, data and functional parallelism, parallel performance analysis, popular interfaces, and parallel debugging. Students will gain experience in parallelization of sequential algorithms and implementation of parallel algorithms. (Same as IT 451)

**CSE 452, Introduction to Sensor Networks, 4 cr, 3 cl hrs, 2 lab hrs**

*Prerequisites: CSE 325 and CSE 353, or consent of instructor*

Introduction to sensory technology with special focus on networking applications. Topics include sensor networks deployment, sensed data manipulation, mobile ad-hoc wireless communication, security. Students will get familiar with sensors' hardware and programming via a set of practical experiments that covers sensor networks deployment and data collection/analysis.

**CSE 453, Computer Networks and the Internet, 3 cr, 3 cl hrs**

*Prerequisite: CSE 353*

Layering of protocols (ISO, ITU and TCP/IP stacks) and network architectures. Fiber optics technology and high speed networks. Internetworking: global addresses/names and translation, virtual networks and tunnels, routing, subnetting, IPv6, multicasting. Mobile IP. End-to-end protocols, TCP and UDP. Congestion control and resource allocation. Socket interfacing, client-server and API. The QoS mechanism integrated/differentiated), ATM QoS. Network security: information and link security, encryption, internetworking security, IPsec, firewalls, VPN, wireless security. (Same as IT 453)

**CSE 454, Computer Graphics, 3 cr, 3 cl hrs**

*Prerequisites: CSE 213, 222; MATH 254*

Design and implementation of visual interfaces. Graphics input and output hardware, display programming, 2-D transformations, approximation techniques for curve and surface representation. Introduction to the creation of 3-D computer-generated images, color theory, lighting and shading.

**CSE 463, Information Assurance, 3 cr, 3 cl hrs**

*Prerequisite: Senior standing*

Defense and offensive information warfare. Information system security. Computer break-ins, hacking, and other attack methods. Vulnerability and risk analysis. Theory and applications of cryptography. Intrusion detection and incident response. Security planning and management. (Same as IT 463)

**CSE 464, Introduction to Soft Computing, 3 cr, 3 cl hrs**

*Prerequisites: CSE 344; MATH 382*

Major types of artificial neural networks. Fuzzy logic theory and fuzzy systems construction. Genetic algorithms and evolutionary computing. Intelligent systems and engineering applications. Comparative study of the soft computing paradigm as a problem solving methodology.

**CSE 476, Visualization, 3 cr, 3 cl hrs**

*Prerequisite: CSE 122 or consent of instructor*

This course presents application of graphical visualization to current problems, with a focus on extracting and representing information in multidimensional data sets using 2D and 3D graphics. Topics include visualization tools and techniques, human vision and perception, color mapping, sound, data representation for insight extraction, time visualization, visual analytics, volume rendering, surface extraction and rendering. Students will develop visualizations of real world problems. (Same as IT 476)

**CSE 489, Special Topics in Computer Science, 3 cr, 3 cl hrs**

*Prerequisites: CSE 213, 222 and consent of instructor*

Undergraduate special topics in computer science.

**CSE 491, Directed Study, cr and topics arranged**

*Can not be used toward graduation.*

**CSE 500, Directed Research, cr and topics arranged**

*This course may not be used to fulfill graduate degree requirements. Research under the guidance of a faculty member.*

**CSE 523, Advanced Compiler Writing, 3 cr, 3 cl hrs**

*Prerequisite: CSE 423*

Advanced topics in compilation, such as theory of parsing, error recovery, optimization, semantics-directed translation, and hardware-independent and hardware-specific code generation.

**CSE 525, Advanced Operating Systems, 3 cr, 3 cl hrs**

*Prerequisites: CSE 325 and 331; or consent of instructor*

Advanced topics in operating systems such as real-time, distributed systems, fault-tolerance, parallel I/O, performance, safety-critical systems, and verification.

**CSE 528, Formal Methods in Software Development, 3 cr, 3 cl hrs**

*Prerequisites:* CSE 342; CSE 325 or 328 or 423 or equivalent experience

Use of mathematics, logic, and computer science theory in software development. Formal specifications; systematic development of programs from specifications. Correctness proofs and other analysis techniques.

**CSE 531, Advanced Computer Architecture, 3 cr, 3 cl hrs**

*Prerequisite:* CSE 331

Advanced topics in computer architecture.

**CSE 532, Fault-Tolerant Computing, 3 cr, 3 cl hrs**

*Prerequisite:* CSE 331; or consent of instructor

Techniques for design of fault-tolerant digital devices with on-line self-error-detection and self-error-correction. Fault-tolerant PLAs, gate arrays, and computer memories. Fault-tolerant computer architectures. Application of error-detecting and error-correcting codes for design of reliable devices with self-error detection/correction. Design of self-checking checkers. Combining on-line and off-line error-detecting techniques. Reliability analysis of fault-tolerant devices. Self-error detection/correction for multiprocessors.

**CSE 542, Advanced Formal Language Theory, 3 cr, 3 cl hrs**

*Prerequisite:* CSE 342

Extensive study of context-sensitive and recursively enumerable languages; closure properties, decidability, and ambiguity of various language classes. Special topics as time permits.

**CSE 544, Analysis of Algorithms, 3 cr, 3 cl hrs**

*Prerequisite:* CSE 344

Analysis of correctness and complexity of asymptotically efficient algorithms. Set partitioning, dominators of dags (with applications in code optimization), Strassen's matrix multiplication algorithm, FFT, Schonage-Strassen integer multiplication algorithm, pattern matching, NP complete problems (both time and space), lower bounds. Discussion of problems for which no efficient algorithms exist.

**CSE 546, Theory of Computation, 3 cr, 3 cl hrs**

*Prerequisite:* CSE 342

Effective computability of functions and sets in terms of Turing machines and other computational models. Universal machines and examples of unsolvable problems. The Church-Turing thesis and formal proofs of the equivalence of Turing machines, systems of recursion equations, and other models of computation. Mathematical properties of the classes of recursive functions. Recursive and recursively enumerable sets.

**CSE 551, Advanced Parallel Processing, 3 cr, 3 cl hrs**

*Prerequisite:* CSE 451; or consent of instructor

This course focuses on the application of models of parallel computation, parallel algorithms, synchronization, parallel languages, parallel performance analysis, and parallel debugging to large problems and complex systems. Topics include: integrating data and shared memory parallelism, multilevel domain decompositions, portability, and scalability. Student will parallelize and analyze the performance of a complex system or application.

**CSE 553, Advanced Computer Networks, 3 cr, 3 cl hrs**

*Prerequisite:* CSE 453

Models of computer networks. Design and analysis issues. Abstract syntax notation, data compression, security and authentication. Recent developments in the field.

**CSE 565, Neural Nets, 3 cr, 3 cl hrs**

*Prerequisites:* CSE 344; MATH 254 and 382; or consent of instructor

Neuron modeling. The perceptron and multilayer perceptrons. Learning algorithms. The Kohonen model, the Grossberg model, the Hopfield model. Associative memory. Applications. Recent developments in the field.

**CSE 567, Soft Computing, 3 cr, 3 cl hrs**

*Prerequisites:* MATH 254, 382; CSE 344 or equivalent, or consent of instructor

Artificial neural networks, with emphasis on multiplayer feedback networks, self-organizing networks, and Hopfield-style networks. Learning algorithms. Introduction to fuzzy systems and evolutionary computing. Engineering applications of soft computing. (Same as MENG 567: Smart Engineering Systems)

**CSE 568, Intelligent Systems, 3 cr, 3 cl hrs**

*Prerequisites:* MATH 254, 382; CSE 344 or equivalent, or consent of instructor

Overview of the major paradigms of soft computing: neural networks, fuzzy systems, and evolutionary computing. In-depth coverage of selected topics in each area as relevant to intelligent systems. Recent advances in the field, and case studies of intelligent systems. Coursework includes a large-scale project. (Same as MENG 568: Smart Engineering Systems II)

**CSE 569, Embedded Systems Design, 3 cr, 3 cl hrs**

*Prerequisite: consent of instructor*

Hardware/software systems and codesign. Embedded processor architecture and programming. Models of computation for embedded systems. Behavioral design. OS primitives for concurrency, timeouts, scheduling, communication and synchronization. Architecture selection. Simulation, synthesis, and verification. Hardware/software implementation. Performance analysis and optimization. Application-level embedded system design concepts such as basic signal processing and feedback control. Design methodologies and tools. Design examples and case studies.

**CSE 570, Real-Time Systems, 3 cr, 3 cl hrs**

*Prerequisite: consent of instructor*

Classification of real-time systems. Fundamental theorems and corollaries of deadline and fixed priority real-time scheduling techniques. Schedulability analysis. Scheduling techniques to guarantee an array of timing requirements. Implementation of a set of tasks with periodic and aperiodic timing requirements. Execution time estimation of a piece of code. Modification of scheduling algorithms in a real-time kernel. Performance evaluation of an operating system for real-time applications.

**CSE 573, Database and Knowledge-base Systems, 3 cr, 3 cl hrs**

*Prerequisites: CSE 373; MATH 221*

Databases, object bases, and knowledge bases. Data models. Logical foundations of database and knowledge-base systems. Query optimization. Selected topics from current research.

**CSE 576, Advanced Visualization, 3 cr, 3 cl hrs**

*Prerequisite: consent of instructor*

This course presents application of graphical visualization to large problems and complex systems, with a focus on extracting and representing information in multidimensional data sets using 2D and 3D graphics. Topics include visualization tools and techniques, human vision and perception, color mapping, sound, data representation for insight extraction, time visualization, visual analytics, volume rendering, surface extraction and rendering. Students will perform visual analytics research for large problems and/or complex systems.

**CSE 581, Directed Study, cr to be arranged****CSE 585, Graduate Seminar, 3 cr****CSE 589, Special Topics in Computer Science, 3 cr, 3 cl hrs**

*Prerequisites: Two semesters of upper division courses in computer science and consent of instructor.*

Graduate special topics in computer science.

**CSE 590, Independent Study, cr to be arranged**

Under the direction of a faculty member appointed by the department, the student shall prepare a paper making use of standard reference sources on some topics not covered by other course work.

**CSE 591, Thesis (master's program), cr to be arranged****CSE 595, Dissertation (doctoral degree program), cr to be arranged**

*Prerequisite: CHEM 595*

**Faculty Research Interests**

Anselmo—Strategic Management, Decision Theory, Risk Analysis

Lassez—Constraint and Logic Programs, Dynamical Systems, Bioinformatics

Liebrock—Computer Forensics, Information Assurance, Parallel Processing, Well Posedness Analysis, Visualization

Mazumdar—Databases, Information Systems, Software Integrity

Mukkamala—Information Assurance, Digital Forensics, Knowledge Mining, Applied Soft Computing Techniques, Bioinformatics, Information and Network Security Practices

Shin—Access Control, Identity Management, Security Engineering, Software Engineering

Soliman—Computer Networks, Programming Languages, Neural Networks

Stavely—Formal Methods in Software Engineering, Programming Languages, Computational Logic

Sung—Computational Intelligence, Information Security, Bioinformatics

Zheng—Computer Architecture, Wireless Networking, Image Processing



# Electrical Engineering

*Professors Rison, Teare, Wedeward (Chair of the Department)  
Associate Professors Arechiga, R. Bond, El-Osery, Erives,  
Jorgensen*

*Adjunct Faculty Andrews, Calloni, Krehbiel, Mansfield,  
Meason, Parameswariah, Reicher, Restaino, Wick, Xiao*

**Degrees Offered: B.S. in Electrical Engineering; M.S. in Electrical Engineering**

## Mission

The mission of the New Mexico Tech Electrical Engineering Department is two-fold: (1) to develop and maintain a program of excellence in teaching which ensures that our graduates have technical knowledge and professional skills they need to become effective engineers in the rapidly-changing technical environment of today's society, so that these graduates will contribute to the growth and development of New Mexico and our nation, and (2) to develop and maintain state-of-the-art research programs which are responsive to the needs of industry and government, which provide excellent educational opportunities for students, and which provide an environment for intellectual growth and excitement.

## Program Educational Objectives

The objective the B.S. in Electrical Engineering degree program is to prepare graduates who will be successful in their chosen career paths. Specifically, graduates of this program will be capable of achieving

1. success in post-undergraduate studies as evidenced by
  - satisfaction with the decision to further their education,
  - advanced degrees earned,
  - professional visibility (e.g. publications, presentations, awards, etc.), and
  - international activities (e.g., participation in international conferences and societies, collaborative research, study abroad, etc.);
2. success in their chosen profession as evidenced by
  - career satisfaction,
  - professional visibility (e.g., publications, presentations, patents, inventions, awards, etc.),
  - professional development (e.g., continuing education, professional registration, etc.),
  - entrepreneurial activities, and
  - international activities (e.g., participation in international conferences and societies, collaborative projects, employment abroad, etc.)

## Undergraduate Program

The Department of Electrical Engineering concentrates on a high-quality undergraduate program in electronics and design, combined with a firm intellectual foundation in the fundamentals of circuits, signals, and systems. As with other degree programs at Tech, students are also provided with a breadth of knowledge in the basic sciences, mathematics, humanities, and social sciences.

Laboratories constitute an important part of the electrical engineering program. The laboratories are closely coupled with the lecture parts of courses and utilize modern, state-of-the-art equipment. Personal computer-based instruments and software packages provide students with up-to-date engineering and design techniques.

Design is integrated into all aspects of the curriculum. Students take an "Introduction to Design" course in the second semester of their junior year. This and their other course work prepare students for two Senior Design Project courses, in which students apply material learned in the classroom to real-world problems. Projects are available from the greater Tech community, including Tech research labs, Langmuir Laboratory for Atmospheric Research, the Energetic Materials Research and Testing Center, and the VLA and VLBA facilities of the National Radio Astronomy Observatory.

Graduates of Tech's electrical engineering program will be well equipped with the practical skills necessary for immediate employment, as well as with the intellectual base for graduate studies and lifelong learning.

## Bachelor of Science in Electrical Engineering

*Minimum credit hours required—130*

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

Electrical Engineering core: EE 101 & 101L (2), 211 (3), 212 & 212L (4), 231 & 231L (4), 308 & 308L (4), 321 & 321L (4), 333 (3), 341 (3), 382 (3), 434 (3), 451 & 451L (4), 481 & 481L (3), 482 & 482L (3)

Introduction to problem-solving and computer skills: CSE 113 (4)

Mathematics core: MATH 231 (4), 254 (3), 332 (3), 382 (3)

Electrical Engineering electives: a minimum of seven credit hours, including at least one lab credit hour, from Electrical Engineering 300- and 400-level courses, excluding the Electrical Engineering core classes listed above.

Engineering/Computer Science electives. Six hours from the following:

Electrical Engineering courses numbered 200 and above (excluding EE core and elective classes)

Computer Science courses except CSE 101, CSE 113 and 122

Other engineering dept. courses numbered 200 and above

Engineering Science courses numbered 200 and above, except ES 316 and 332

At least three credit hours must be from outside the Electrical Engineering Department.

Electives to complete 130 credit hours. Without prior departmental approval, the following cannot be used for these electives: ENGL 103; MATH 101, 103, 104, 105; PR courses; or New Mexico Tech Community College courses.

To enroll in an Electrical Engineering Department class, a student must have passed the prerequisites of the course. In addition, a student must be in good academic standing and have declared electrical engineering as a major to enroll in EE 382 and EE 481.

Students pursuing a B.S. degree in Electrical Engineering must take all Electrical Engineering courses for a letter grade.

All engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

While fulfilling the General Education Core Curriculum (page 100), Electrical Engineering students must also satisfy a depth requirement in the humanities and social sciences. Each Electrical Engineering student is required to take at least nine credit hours in a single area with three of the credit hours at the 300-level or above and be chosen from one of the following areas:

1. Political Science
2. Philosophy
3. History
4. Psychology

Courses from other Humanities and Social Science areas may be used to complete the general education core curriculum, but cannot be used to satisfy the Electrical Engineering Department's depth requirement.

### Sample Curriculum for the Bachelor of Science in Electrical Engineering

#### Semester 1

4 MATH 131 (calculus)  
 5 PHYS 121 & 121L (general)  
 2 EE 101 & 101L (introduction to electrical engineering)  
3 ENGL 111 (college English)  
 14 Total credit hours

#### Semester 2

4 MATH 132 (calculus)  
 5 PHYS 122 & 122L (general)  
 4 CHEM 121 & 121L (general)  
4 CSE 113 (programming)  
 17 Total credit hours

#### Semester 3

4 MATH 231 (calculus)  
 4 CHEM 122 & 122L (general)  
 3 EE 211 (circuits)  
 4 EE 231 & 231L (digital electronics)  
3 ENGL 112 (college English)  
 18 Total credit hours

#### Semester 4

3 MATH 254 (linear algebra)  
 3 MATH 332 (vector analysis)  
 4 EE 212 & 212L (circuits)  
 4 EE 308 & 308L (microcontrollers)  
3 Social Science  
 17 Total credit hours

#### Semester 5

4 EE 321 & 321L (analog electronics)  
 3 EE 333 (electricity and magnetism)  
 3 EE 341 (signals and linear systems)  
 3 ENGL 341 (technical writing)  
3 Humanities  
 16 Total credit hours

#### Semester 6

3 EE 382 (introduction to design)  
 3 MATH 382 (probability)  
 4 Electrical Engineering Elective with lab  
 3 Humanities  
3 Social Science  
 16 Total credit hours

#### Semester 7

3 EE 481 & 481L (senior design project)  
 4 EE 451 & 451L (digital signal processing)  
 3 Electrical Engineering Elective  
 3 Social Science  
3 Humanities or Social Science  
 16 Total credit hours

#### Semester 8

3 EE 434 (electromagnetic wave transmission and radiation)  
 3 EE 482 & 482L (senior design project)  
 6 Engineering/Computer Science Elective  
4 Free Elective  
 16 Total credit hours

## Minor in Electrical Engineering

Minimum credit hours required—19

The following courses are required:

- EE 101 & 101L (2), 211 (3), 212 & 212L (4), 231& 231L (4)
- Six (6) additional credit hours of Electrical Engineering courses selected from: 308 & 308L (4), 321 & 321L (4), 322 & 322L (4), 324 (3), 333(3), 341 (3).

## Graduate Program

### Master of Science in Electrical Engineering

The Electrical Engineering graduate program provides students with unique research opportunities, thanks to its close association with many research facilities. These facilities include Energetic Materials Research and Testing Center, Langmuir Laboratory, Magdalena Ridge Observatory, National Radio Astronomy Observatory, Incorporated Research Institutions for Seismology, and Institute for Complex Additive Systems Analysis; all easily accessible from campus. These facilities can provide opportunities for students to participate in research related to leading scientific and engineering projects and allow them to achieve highly desirable educational and research experiences.

The student's course of study must be approved by the student's advisory committee, must fulfill the general requirements for the master's degree (page 56), and must include any two of the following courses:

- EE 521, Measurement and Instrumentation
- EE 531, Advanced Digital Design
- EE 544, Modern Control Systems
- EE 554, Embedded Control Systems
- EE 570, Advanced Topics in Electrical Engineering

At least 12 semester hours must be approved Electrical Engineering courses. No more than six (6) semester hours of advanced undergraduate course work may be used to satisfy the degree requirements. Students are required to take at least six (6) credit hours from outside the Electrical Engineering department. Students may choose between an M.S. with thesis (24 credit hours of courses plus six (6) thesis hours) or an M.S. with independent study (27 credit hours of courses plus three (3) independent study hours). Students may be required to take an appropriate software course if they don't have an appropriate programming background.

A five-year B.S./M.S. Electrical Engineering degree can be achieved by fulfilling the separate requirements of both an undergraduate degree and a graduate degree in Electrical Engineering in a five-year period. A combined minimum of 158 credit hours with at least 19 credit hours of 500-level courses and Independent Study (EE 590) is required. Students in the Electrical Engineering five-year program must normally apply for graduate standing at the end of their seventh semester. Graduate admission will be contingent

upon adherence to the approved program of studies. Graduate status will be granted on fulfillment of the requirements for the B.S. Degree.

### Sample Curriculum for the Master of Science in Electrical Engineering with Thesis

#### Semester 1

4 EE 521 (measurement and instrumentation)

4 EE 554 (embedded control systems)

3 Non-EE Course

11 Total credit hours

#### Semester 2

4 EE 570 (advanced topics)

3 EE 581 (directed study)

3 Non-EE Course

11 Total credit hours

#### Semester 3

6 EE 591 (thesis)

3 Graduate Elective

9 Total credit hours

### Graduate Certificate in Electrical Engineering

The Electrical Engineering graduate certificate program is aimed at practicing engineers wanting to increase their exposure to electrical engineering at the graduate level while not being tied to a degree program. The program is designed to provide a rigorous upgrade to the student's skills in electrical engineering while focusing on topics of interest to the student.

The certificate program requires a minimum of 16 credit hours of graduate course work. The course requirements are:

EE521 Measurement and Instrumentation (4 credits)

One 4 credit electrical engineering graduate course

One 3 credit or higher electrical engineering course at either graduate or upper undergraduate level.

One 3 credit or higher graduate course in either mathematics, physics, engineering or computer science.

EE590 Independent Study (2 credits) supervised by a member of the electrical engineering department.

## Electrical Engineering Courses:

The Department of Electrical Engineering encourages students from other majors to take electrical engineering courses. Students from other disciplines who are interested in taking electrical engineering courses should inquire at the department office.

### EE 101, 101L, Introduction to Electrical Engineering 2 cr, 1 cl hr, 3 lab hrs

*Corequisites:* MATH 103; EE 101 and 101L are corequisites of each other

A broad overview of electrical engineering, including an introduction to analog and digital circuitry. Practical exercises using the EE department's computer-based applications software and lab equipment.

### EE 211, Circuits and Signals I, 3 cr, 3 cl hrs

*Prerequisites:* MATH 132; EE 101 or junior standing  
*Normally offered fall semester*

Principles of electrical circuit analysis. Kirchhoff's laws, equivalent circuits, dependent sources, node and mesh analyses, signals, RLC components. Introductory circuits and operational amplifier circuits as examples.

### EE 212, 212L, Circuits and Signals II, 4 cr, 3 cl hrs, 3 lab hrs

*Prerequisite:* EE 211  
*Corequisites:* EE 212 and 212L are corequisites of each other.  
*Normally offered spring semester*

Continuation of EE 211, Laplace transform techniques, transient response, steady-state sinusoidal response, and frequency response of RLC circuits.

### EE 231, 231L, Digital Electronics, 4 cr, 3 cl hrs, 3 lab hrs

*Corequisites:* CSE 113, EE 231 and 231L are corequisites of each other.  
*Normally offered fall semester*

Foundation of combinational digital system analysis and design; including Boolean algebra, logic gates, and truth tables. Sequential digital design via finite state machines. Lab provides exposure to computer-aided design software and programmable logic hardware.

### EE 308, 308L, Microcontrollers, 4 cr, 3 cl hrs, 3 lab hrs

*Prerequisites:* CS 113; EE 231 and 231L  
*Corequisites:* EE 308 and 308L are corequisites of each other.  
*Normally offered spring semester*

Introduction to microcontrollers. Elementary assembly- and C-language programming, bus structures, parallel and serial interfaces, support devices. Using logic analyzers and disassemblers in circuit testing. Using microcontrollers in measurement and control applications.

### EE 321, 321L, Analog Electronics, 4 cr, 3 cl hrs, 3 lab hrs

*Prerequisites:* EE 212 and 212L  
*Corequisites:* EE 321 and 321L are corequisites of each other.  
*Normally offered fall semester*

Basic principles and use of operational amplifiers, diodes, field-effect transistors, and bipolar junction transistors in electronic circuits.

### EE 322, 322L, Advanced Electronics, 4 cr, 3 cl hrs, 3 lab hrs

*Prerequisites:* EE 321 and 321L, and 341  
*Corequisites:* EE 322 and 322L are corequisites of each other.

Applications in analog electronics. Topics include timing and switching circuits, power supply techniques, active filters, switched capacitor circuits, oscillators, and phase-locked loops.

### EE 324, Semiconductor Theory and Devices, 3 cr, 3 cl hrs

*Prerequisite:* PHYS 122  
Fundamentals of semiconductor materials and devices. Topics include introduction to quantum mechanics and electrical conduction in conductors, insulators, and semiconductors. The theory is applied to pn junctions, bipolar and field-effect transistors and opto-electronic devices.

### EE 333, Electricity and Magnetism, 3 cr, 3 cl hrs

*Prerequisite:* PHYS 122  
*Corequisite:* MATH 332  
Electric and magnetic fields in free space and in matter. Energy storage as a function of field quantities and the relation of this to capacitance and inductance. Maxwell's equations applied to simple electrostatic and magnetostatic problems, plane waves, and transmission lines. Transient and sinusoidal steady state solutions of uniform transmission line problems modeled in terms of circuit parameters.

### EE 341, Signals and Linear Systems, 3 cr, 3 cl hrs

*Prerequisites:* EE 212; MATH 254  
Principles of linear time-invariant systems. Dynamic systems, Laplace transforms, z-transforms, sampling theory, system functions, poles and zeros, frequency domain, Fourier Transforms, feedback systems, convolution.

### EE 352, Microcomputer Interfacing, 4 cr

*Prerequisites:* EE 308, 308L  
Design of hardware and software for microcomputer interfacing. Bus signals and timing. Interrupt and direct memory access handling. Students will design, build, program, and test a simple interface card for a common microcomputer bus.

**EE 382, Introduction to Design, 3 cr**

*Prerequisites: EE 308, 308L, 321, 321L, 333, 341, and have declared electrical engineering as a major*  
*Normally offered spring semester*

A course in design methodology as applied to a particular problem in electrical engineering. For a given project, students will integrate their formal course work with the use of computer-aided tools to design, construct, evaluate, and document a prototype system.

**EE 408, Cooperative Education**

On-the-job training to supplement the academic program. Students alternate periods (usually six months long) of full-time semiprofessional employment in Electrical Engineering with periods of full-time academic study. A written report of the student's activities will be required at the end of the training.

**EE 434, Electromagnetic Wave Transmission and Radiation, 3 cr, 3 cl hrs**

*Prerequisite: EE 333*  
*Normally offered spring semester*

Reflection and refraction of plane waves at planar interfaces. The propagation characteristics of metallic and dielectric waveguides with particular emphasis on fiber optics. Radiation from linear current elements and planar apertures and arrays of these elements. Analysis of simple communication links.

**EE 435L, RF and Microwave Laboratory, 1 cr, 3 lab hrs**

*Corequisite: EE 434*

Experiments in radio frequency and microwave techniques and measurements.

**EE 443, Intermediate Control Theory, 3 cr, 3 cl hrs**

*Prerequisite: EE 341*

Modeling of dynamical systems via differential equations, transfer functions, and state-space methods. Performance, characterization, and behavior of linear feedback-systems. Design of various types of control schemes to meet performance specifications.

**EE 443L, Intermediate Control Theory Lab, 1 cr, 3 cl hrs**

*Corequisite: EE 443 or MENG 405 or permission of instructor*

Use of computer based data acquisition and control (DAC) hardware and software. Model validation and verification of physical systems. Implementation of real-time control schemes utilizing actuators and sensors.

**EE 446, Introduction to Communications Theory, 3 cr, 3 cl hrs**

*Prerequisites: EE 341; MATH 382*

Principles of communication theory. Modulation techniques, random signals and noise, analysis of communication systems in presence of noise, digital communication, matched filters, channel capacity, multiple access.

**EE 451, 451L, Digital Signal Processing, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: EE 308, 341*

Principles of digital signal processing. Infinite and finite impulse response filters, discrete and fast Fourier transforms, multirate processing, spectral estimation, quantization effects, system design. Implementation of real-time DSP algorithms on state-of-the-art hardware. Principles discussed in class will be demonstrated with real applications. Labs include design and implementation of infinite and finite impulse response filters, communication systems, sound processing, and other applications.

**EE 481, 481L, Senior Design Project I, 3 cr**

*Prerequisites: EE 382, and have declared electrical engineering as a major*  
*Normally offered fall semester*

Student design teams begin an academic year long capstone design project under the supervision of a faculty advisor. Each team may undertake a different project and will build a team, determine design requirements, perform detailed planning, identify project needs and establish goals leading toward the successful completion of the project. Periodic design reviews and reports, applications of engineering skills, project management and formal presentations are major components of the program. Successful completion of the project requires the application of electronics, applied physics, numerical computation, signal processing and other electrical engineering techniques to real-world engineering problems.

**EE 482, 482L, Senior Design Project II, 3 cr**

*Prerequisites: EE 481, and have declared electrical engineering as a major*  
*Normally offered spring semester*

A continuation of the capstone design projects begun in EE 481. EE 482 must be taken in the semester immediately following EE 481, 481L to maintain project continuity. The student teams bring their design projects to successful conclusion. Status reports, a final presentation to faculty and reviewers and the submission of a senior thesis are included in the program.

**EE 491, Special Topics, hrs and crs to be arranged****EE 500, Directed Research, cr to be arranged**

*Prerequisite: Graduate standing*

Offered both Spring and Fall semester. Credits cannot be applied towards the 30 credit hours required for graduation. Research under the guidance of a EE faculty member.

**EE 521, Measurement and Instrumentation, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: EE 308, 322, 341 or equivalent or consent of instructor*

Survey of various sensors and transducers for measuring physical quantities; measurement errors; analog and digital interfaces; sampling; quantization; actuators; and sensing devices in closed-loop control. Digital interfacing to the measurement devices for both experimentation and microprocessor control will be performed using a computer equipped with data acquisition hardware and software.

**EE 531, Advanced Digital Design: 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite: EE 231 or equivalent or consent of instructor*

Advanced topics in digital design. Synchronous and asynchronous state machines. Timing issues in high-speed digital design. Design of a complex system using the VHDL programming language in a CAD environment.

**EE 533, Optical/RF Engineering, 3 cr, 3 cl hrs**

*Prerequisites: EE 324, 434 or equivalent or consent of instructor*

Explore various topics in data links and telemetry including RF links, antennas, satellite communications, and optical fiber links. Projects will include design and fabrication of basic RF antenna and a case study of a satellite communications system.

**EE 537, Photonics, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: Graduate standing; EE 434; or consent of instructor*

Topics include the generation, propagation, manipulation and detection of light from low to high energy. Uses and applications of optical systems: simple optics, binary and Fourier optics, electro-optics, wavefront analysis, modal decomposition, inversion techniques for wavefront reconstruction and correction and optical signal processing. Other advanced topics in optics.

**EE 544, Modern Control Theory, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: EE 443; MATH 454; or equivalent or consent of instructor*

Treatment of modern approach to control system design primarily via state-space analysis techniques for both continuous and discrete time systems. Topics include the realization of MIMO models for real-systems, linear feedback control, the design of observers, optimal control, and concepts in stability. The latter part of the course will address recent advanced topics of current relevance. Associated hardware and software-based lab/project(s) will include the use of PC based data acquisition systems.

**EE 545, Digital Communication I, 3 cr, 3 cl hrs**

*Prerequisite: EE 446 or equivalent or consent of instructor*

Digital communication systems; response time requirements and control of user errors. Spread spectrum modulation and the fundamental limitations dictated by information theory. Various types of modulation and multiplexing including BPSK, QAM, QPSK, OQPSK. Statistical analysis of various modulation schemes.

**EE 546, Digital Communication II, 3 cr, 3 cl hrs**

*Prerequisite: EE545 or consent of instructor*

Spread-spectrum modulation, frequency hopping techniques, error control coding, multiple access techniques including TDMA (time division multiple access) and CDMA (code division multiple access). Various advanced case studies. Analysis of imperfections; noise and distortion line failures, data errors, delays and blocking, treatment of errors.

**EE 548, Manipulator-based Robotics: 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite: EE 443 or equivalent or consent of instructor*

Fundamentals of the multi-disciplinary field of robotics. Emphasis is placed on understanding how to model and control robotic manipulators while providing an appreciation of the importance of sensing to robotic applications. Topics include: forward, inverse, and motion kinematics; dynamic modeling; position, velocity, and force control.

**EE 551, Discrete-Time Signal Processing, Filtering, and Estimation, 3 cr, 3 cl hrs**

*Prerequisites: EE 451; MATH 254, 382; or consent of instructor*

The fast-Fourier transform and its computer implementation; spectral estimation; analytic signals; multi-dimensional signal processing; digital filters. Signal detection and estimation, Kalman Filters, linear predictive coding, and adaptive filters. Project(s) include the design and implement a Kalman filter for GPS data processing and LPC for speech recognition.

**EE 552, Image Processing and Data Compression Techniques, 3 cr, 3 cl hrs**

*Prerequisites: EE 451; MATH 254, 382; or consent of instructor*

The basics of two-dimensional digital signal processing, image representation and human vision including color models, image transformation and video compression techniques (including JPEG and MPEG). Study of relevant current applications including HDTV.

**EE 554, Embedded Control Systems, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: EE 308, 443 or equivalent or consent of instructor*

Micro-controller or microcomputer based embedded control systems. A comparative survey of currently available embedded computers/controllers including SBC's, PICs, basic-stamps, and single-chip computer solutions. Real time operating systems, including real-time LINUX, and hard real-time process requirements. Projects will include the implementation of an embedded real-time control solution.

**EE 562, Microwave Engineering & Radar, 3 cr, 3 cl hrs**

*Prerequisite: EE 434 or equivalent or consent of instructor*

Transmission media: waveguides, microstrip and glass fiber. Ferrite devices and cavity resonators. Equivalent circuits using scattering and transmission matrices. Active components in microwave circuits.

**EE 569, Wireless Communications, 3 cr, 3 cl hrs**

*Prerequisite: EE 446 or equivalent courses or consent of instructor*

Signaling: exchange, subscriber loops, and local loops, transmission media, and multiplexing. Switching: network switching, space-division and panel switching, and various digital-switching methods. Cellular telephony, data networks and communication protocols.

**EE 570, Advanced Topics in Electrical Engineering, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite: EE 333 or equivalent or consent of instructor*

Emerging technologies and specializations in Electrical Engineering addressed from the perspective of embedded systems and advanced design.

**EE 581, Directed Study, cr to be arranged**

*Prerequisite: Permission of graduate advisor*

**EE 590, Independent Study, cr to be arranged**

*Prerequisite: Permission of graduate advisor*

Independent research supervised by a faculty member. It is expected that this work will culminate in a paper to be published, and an oral presentation is required.

**EE 591, Thesis (Master's Program), cr to be arranged****EE 592, Graduate Seminar, 1 cr, 1 cl hr**

*Prerequisite: Graduate standing*

Offered both Spring and Fall semester. Credits cannot be applied towards the 30 credit hours required for graduation.

**Faculty Research Interests**

Andrews—Optoelectronics, experimental adaptive optics, imaging systems.  
 Arechiga – Speech Processing, Thunderstorms  
 R. Bond—Design for Test/Manufacturability, Teaching Effectiveness  
 Calloni—Gravitational Wave Interferometry  
 El-Osery – Wireless Communications, Control Systems, Soft Computing  
 Erives—Hyperspectral Imaging  
 Jorgensen – Space Physics  
 Krehbiel—Lightning, Thunderstorms, Radar  
 Mansfield—Radar Systems  
 Meason—Nuclear, Electromagnetic and Space Radiation Effects and Directed Energy  
 Parameswariah – Stellar Interferometry  
 Reicher—Physics and Simulation of Thin Films  
 Restaino—Adaptive Optics, Novel Optical Systems  
 Rison—Atmospheric Electricity, Instrumentation, Lightning Protection  
 Teare—Experimental Adaptive Optics, Semiconductor Devices, and Directed Energy  
 Thomas—Lightning, Thunderstorms and Instrumentation  
 Wedeward—Adaptive Control, Robotic Systems, Electric Power Systems  
 Wick—Experimental Adaptive and Active Optics  
 Xiao – Photonic/Fiber Sensors

# Engineering Management

*Professors Sueyoshi*

*Associate Professors Anselmo (Chair of the Department)  
Stuteville*

*Visiting Assistant Professor Ulibarri*

*Adjunct Faculty: Mazumdar, Ostergren, Peterson*

## **Degree offered: Master of Engineering Management**

The New Mexico Tech Master of Engineering Management (MEM) graduate program is designed to provide working engineers and applied scientists with a terminal degree in Engineering Management. The curriculum is designed to be innovative and deliverable both on campus and in other areas of New Mexico live via interactive webcasts and everywhere else via Internet streaming. Qualified students at any location may enroll and receive the program through the Internet and/or mailed copies of lectures and course materials. New Mexico Tech developed the Engineering Management program since most engineers eventually have the opportunity to become managers, and many undergraduate engineering and applied science programs do very little to prepare their graduates for that career event.

## **Graduate Program**

### **Master of Engineering Management (MEM)**

#### **Admission to the Program**

Entrance into the MEM program in the New Mexico Tech Management Department requires competence in engineering, science and mathematics comparable to a calculus-based bachelor of science degree in an engineering or applied science discipline. Preference for limited program slots will be given to individuals with at least 2 years work experience in either engineering or applied science. A committee of New Mexico Tech Management and Engineering faculty will evaluate program applicants, and the Management Department chair will review and finalize committee recommendations. Each student is responsible for forming a graduate committee during the first semester of full-time study or before the end of the second semester of part-time coursework.

For complete information on applying to the MEM Program, see page 48.

#### **Graduate Advisory Committee**

Participants will form a three-member committee that will be composed of at least one New Mexico Tech faculty member and two other qualified individuals. Examples of qualified individuals include faculty members at New

Mexico Tech, faculty members at other higher-education institutions, workplace supervisors, and/or professional peers. In the case where there is only one committee member from the New Mexico Tech faculty, that individual will serve as committee chair. If there are more than one New Mexico Tech faculty members on the student's project committee, the student will select a chair.

The primary roles of the committee will be to assist the student in selection of an elective sequence and to advise and approve the required final project.

#### **Program Requirements**

A total of 30 credit hours, including the following courses, is required for the MEM degree:

- Core (21): EMGT 501 (3), 502 (3), 503 (3), 505 (3), 506 (3), 508 (3); MATH 585 (3)
- Electives (6): Example sequences are EMGT 511 (3) and 512 (3) or EMGT 521 (3) and 522 (3)
- EMGT 590 (3)

The purpose of the core is to provide foundations in quantitative and qualitative methods that will assist the practicing (or aspiring-to-practice) engineer in a changing technological and economic environment. The core is designed for engineers and is grounded in the notion that program participants possess the analytical skills associated with a calculus-based undergraduate bachelor of science in engineering.

The minimum of six (6) hours of electives will assist program participants to gain expertise in an area of interest and relevance to their careers. These two courses should be taken as a sequence, and participants may select their sequence after consulting with their faculty advisor(s). The elective sequence may be any approved graduate elective sequence from graduate coursework offered at New Mexico Tech. Students considering elective sequences from other graduate institutions may do in consultation with their New Mexico Tech graduate committee.

The terminal MEM requirement is a final project, culminating in a formal document and presentation to the faculty that is analogous to the Independent Study option currently available to graduate students at New Mexico Tech. Participants will benefit from designing, supervising, and executing a project that will ideally be a workplace application. This experience will aid them throughout their careers as they are faced with the need to resolve critical strategic questions and implement recommended solutions.



## Engineering Management Courses

*In addition to the listed prerequisites, only students admitted to the MEM program may enroll in the following classes. Engineering Management courses may not be used to fulfill the requirements of any other undergraduate or graduate degree offered by New Mexico Tech without prior approval by the chair of the other department.*

### **EMGT 501, Management Science for Engineering Management, 3 cr, 3 cl hrs**

This course will expose participants to up-to-date Management Science applications in engineering and technology organizations. Techniques include linear programming, inventory models, and material requirements planning.

### **EMGT 502, Financial Management, 3 cr, 3 cl hrs**

This course begins with study of the interaction between financial and accounting systems and continues with a discussion of cash flow analysis. This foundation is followed by discussion of the latest in corporate financial management and capital budgeting techniques.

### **EMGT 503, Information Systems in Technology Organizations, 3 cr, 3cl hrs**

Databases and the interaction between database information systems and organizational decision processes. Data mining and other topics relevant to data- and technology-intensive organizations. Discussion of the optimal information system design and implementation.

### **EMGT 505, Marketing Technology, 3 cr, 3 cl hrs**

Design, development, marketing, and sustaining of new products and technologies both inside and outside the engineering and technology organization. Market research, sampling and other data collection issues.

### **EMGT 506, Managing Technology Resources, 3 cr, 3 cl hrs**

The study of human and other resources within technology and engineering organizations. Negotiation, leadership, resource allocation and other critical management topics will be discussed in this seminar. Research on organizational behavior issues unique to an engineering/technical environment will be studied.

### **EMGT 507, Organizational Entrepreneurship (Capstone), 3 cr, 3 cl hrs**

*Prerequisites: At least four courses from EMGT 501-507*

This seminar is concerned with integration of the concepts and techniques covered in the Engineering Management core. This course, which will be built around case analyses and presentations, is designed to help program participants develop a broader view of the business world and incorporate that view into their assessments of simulated and real-world engineering business problem situations.

### **EMGT 508, Legal and Ethical Issues in Technology Organizations, 3 cr, 3 cl hrs**

*Prerequisites: At least four courses from EMGT 501-506*

This seminar addresses relevant legal and ethical issues associated with managing technology organizations. The course includes basic legal theories of intellectual property rights considered from the perspectives of both employer and employee. Discussions will include established case and statutory law as well as emergent legal theories related to technology.

### **EMGT 511, Financial Modeling, 3 cr, 3 cl hrs**

*Prerequisites: EMGT 502 and three other courses from EMGT 501-507 or consent of instructor*

Portfolio optimization and other applications of Management Science techniques in a financial context. Analysis of domestic and international risky assets, including commodities, financial assets, and debt instruments. Coverage of the latest techniques in financial risk management, including hedging and other risk sharing techniques.

### **EMGT 512, Complex Financial Systems, 3 cr, 3 cl hrs**

*Prerequisite: EMGT 511 or consent of instructor*

Modern financial systems are complex, interconnected, and sensitive to a variety of information from a variety of sources. This course is devoted to development and testing of valid simulation models of complex financial systems and the analysis of model outputs.

### **EMGT 521, Advanced Management Science Applications, 3 cr, 3 cl hrs**

*Prerequisites: EMGT 501 and three other courses from EMGT 501-507 or consent of instructor*

Use of management science techniques such as Data Envelopment Analysis (DEA) to optimally solve resource allocation problems. Management Science techniques applied to public policy issues.

**EMGT 522, Engineering Management Seminar, 3 cr, 3 cl hrs***Prerequisite: EMGT 507*

Study of latest research data concerning engineering management issues. Issues such as measuring performance, project management, and human resource management in technology organizations where tasks and outcomes may be ill defined.

**EMGT 571, 572, Topics in Engineering Management, 2–3 cr**

Study of a special topic in Engineering Management not otherwise treated.

**EMGT 581, Directed Study, cr to be arranged**

Study a current topic in Engineering Management with a member of the faculty. Most directed study topics will be based on and grow out of Engineering Management program coursework.

**EMGT 590, Final Project, cr to be arranged; at least 3 cr required***Prerequisites: EMGT 508**Corequisite: At least one elective-sequence course*

Each program participant will be required to complete a project to complete the MS degree. This project, which will be supervised by at least two New Mexico Tech faculty members, is open-ended with regard to context and scope. Workplace applications are preferred, but any effort that is formally designed, carried out, and analyzed will be considered. Each project will be accompanied by a formal report that will be presented to a diverse audience in a formal setting.

**MATH 585, Statistics for Technology Managers, 3 cr, 3 cl hrs**

Probability and random variables; simple and multiple linear regression using least squares and other methods; experimental design; other topics including nonlinear regression; applications to decision making.

**Faculty Research Interests**

Anselmo—Decision Analysis and Risk Management,  
Computational Finance, Electronic Commerce

Mazumdar—Database Systems, Massive Storage Systems,  
Computational Logic

Ostergren—Program Management, Product Development,  
Total Quality Management

Peterson—Management, Economics, Accounting

Stuteville—Telecommunication Law and Regulation,  
Ethical Issues in Information Assurance and Security

Sueyoshi—Management Science, Data Envelopment  
Analysis, Risk and Policy Analysis

Ulibarri—Financial Economics, Cultural Economics,  
Natural Resource and Environmental Economics

# Environmental Engineering

*Professor Cal (Chair of Department)**Associate Professors Huang, Richardson**Adjunct Faculty Brady, Hendrickx*

*Degrees Offered: B.S. in Environmental Engineering;  
M.S. in Environmental Engineering*

**Department Mission Statement**

The primary objective of this program is to produce well-balanced environmental engineers capable of entering the environmental engineering profession or continuing their studies at the graduate level. Graduates will be well-prepared to solve current environmental engineering problems, and they will have the ability to adapt to problems of the future.

The achievements of environmental engineers are well-known to the general public, because environmental engineers are charged with producing clean water, disposing of waste responsibly, and maintaining air quality. Projects that environmental engineers work on include: design of water and wastewater treatment facilities, landfill design, design of air pollution control devices, and environmental law and permitting.

The undergraduate program offers a balanced approach to environmental engineering education. Students take a common core of engineering science and environmental engineering courses, including courses in environmental law, water and wastewater treatment, soil mechanics, soil and hazardous waste, hydrology and air pollution control. The environmental engineering courses teach students the fundamentals of engineering design, as well as potential applications. Students are taught how to use computer software to expedite the design process, and they are also taught how to balance engineering designs with economic constraints. During their senior year, undergraduate students work with a professor on a design thesis.

**Program Educational Objectives**

1. To develop graduates that function successfully in areas of environmental engineering, such as air pollution, water and wastewater treatment, and solid and hazardous waste engineering.
2. To prepare graduates for advanced education in environmental engineering and related fields, and for professional licensure.

## Undergraduate Program

### Bachelor of Science in Environmental Engineering

Minimum Hours Required—132

In addition to the General Education Core Curriculum (page 100), the following courses are required:

- MATH 231 (4), 283 (3), 335 (3)
- BIOL 111 (3), 111L (1), 343 (3)
- EARTH 440 (4)
- ES 110 (2), 111 (3), 201 (3), 216 (3), 302 (3), 316 (3), 347 (3), 350 (3)
- ENVE 101 (1), 201 (3), 301 (3), 302 (2), 303 (3), 304 (3), 406 (3), 411 (4), 413 (4), 480 (3) or 490 (3)
- ME 420 (3)
- Technical Electives (3): Approved technical electives include ENVE 421, 491; CE 201, 301, 302, 401, 413, 420, 422, 423; EARTH 441, 442, 443; CHE 351, 352, 443; CHEM 333, 422; EE 211; ES 305, 332; MATE 430, 460, 470; ME 220, 409, 410, 422, 427; MENG 304, 305, 421; or other electives approved by the department chair.

Students pursuing a B.S. in Environmental Engineering must take all engineering courses for a letter grade. Environmental engineering majors must maintain a minimum GPA of 2.0 in required courses in order to graduate.

All engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

### Sample Curriculum for the Bachelor of Science Degree in Environmental Engineering

#### Semester 1

- 1 ENVE 101 (environmental engineering seminar)
- 3 ENGL 111 (college English)
- 4 BIOL 111 & 111L (general)
- 4 CHEM 121 & 121L (general)
- 4 MATH 131 (calculus)
- 2 ES 110 (intro to engineering)
- 18 Total credits

#### Semester 2

- 3 ENGL 112 (college English)
- 3 ES 111 (computer programming for engineers)
- 4 MATH 132 (calculus)
- 4 CHEM 122 & 122L (general)
- 5 PHYS 121 & 121L (general)
- 19 Total credit hours

#### Semester 3

- 4 MATH 231 (calculus)
- 5 PHYS 122 & 122L (general)
- 3 ENVE 201 (intro to environmental engineering)
- 3 ES 201 (statics)
- 15 Total credits

#### Semester 4

- 3 ENVE 301 (applied principles)
- 3 MATH 335 (ordinary differential equations)
- 3 ES 216 (fluid mechanics)
- 3 BIOL 343 (microbiology)
- 3 Social Science
- 15 Total credits

#### Semester 5

- 3 ENVE 303 (water treatment process design)
- 3 ES 302 (materials)
- 3 ES 350 (heat and mass transfer)
- 3 MATH 283 (statistics)
- 3 ME 420 (soil mechanics)
- 15 Total credits

#### Semester 6

- 2 ENVE 302 (environmental law)
- 3 ENVE 304 (wastewater treatment process design)
- 3 ES 316 (engineering economics)
- 3 ES 347 (engineering thermodynamics)
- 3 ENGL 341 (technical writing)
- 3 Humanities
- 17 Total credits

#### Semester 7

- 4 ENVE 411 (solid and hazardous waste)
- 4 ENVE 413 (air pollution engineering)
- 4 EARTH 440 (hydrologic theory and field methods)
- 6 Social Science
- 18 Total credits

#### Semester 8

- 3 ENVE 406 (unit operations)
- 3 ENVE 480 or 490 (senior design or senior thesis)
- 3 Approved Technical Elective
- 3 Humanities
- 3 Humanities/Social Science
- 15 Total credits

## Minor in Environmental Engineering

*Minimum credit hours required – 18*

The following courses are required:

- ENVE 201 (3), ENVE 301 (3)
- 12 additional hours of approved courses, including any ENVE courses, ME 420, or EARTH 440

## Graduate Programs

### Master of Science in Environmental Engineering

The Environmental Engineering graduate program at New Mexico Tech provides a unique educational and research experience in the engineering and science of the natural environment and environmental protection. The plan of study and research is suited to each individual, drawing upon the strengths of the student, taking advantage of program capabilities, and complementing research activities within and outside New Mexico. A thesis or independent study project is required to complete the degree. General requirements common to all Master of Science degree curricula also apply.

Admission to the Master of Science in Environmental Engineering program requires competence in mathematics, chemistry, biology, physics, and engineering science comparable to the Bachelor of Science in Environmental Engineering. The department chair, or an advisory committee, will evaluate the scholastic record of every entering student to determine whether any deficiencies exist in their educational background. For example, students entering the program without an engineering degree may be required to take additional course work in such areas as fluid mechanics, heat and mass transfer, and differential equations before being granted a M.S. in Environmental Engineering. It is up to the student and his or her graduate committee to determine the specific plan of study for the student after the first semester of graduate work. Transfer credit for courses taken at another institution will be evaluated on an individual basis.

### Thesis Option

A total of 30 credit hours are required for a M.S. in Environmental Engineering, which must include a minimum of 18 credit hours of Environmental Engineering coursework, and 6 credit hours of ENVE 591 (thesis). All students must take a minimum of 12 credit hours of 500-level Environmental Engineering courses.

### Independent Study Option

A student may petition the department with the approval of the Department Chair to pursue a Master of Science degree with an independent study option. Candidates for the non-thesis Master of Science option must complete a minimum of 30 credit hours, of which 3 credit hours must be independent

study (ENVE 590). All students must take a minimum of 12 credit hours of 500-level Environmental Engineering courses, and an additional 6 credits of 400- or 500-level Environmental Engineering courses (18 credits total). The student's course of study must be approved by the student's advisory committee, and it must fulfill the other requirements of the M.S. in Environmental Engineering degree program with the exception of 6 credit hours of thesis (ENVE 591).

### Five Year Bachelor's/Master's Degree Program

A five-year B.S. /M.S. Environmental Engineering degree can be achieved by fulfilling the separate requirements of both the undergraduate degree and graduate degree. A combined minimum of 161 credit hours is required for the dual degree with at least 12 credit hours of 500-level ENVE courses and 6 credit hours of Thesis (ENVE 591). Students in the five-year program are also required to take ENVE 581 (summer). A B.S. degree in Environmental Engineering will be granted after the five-year student has completed the 135 credit-hour undergraduate requirement. For the M.S. degree, the 6 credit hours of required graduate electives must be non-ENVE courses of 300-level and above. Students with a minimum GPA of 3.0 are eligible to apply for the admission to the graduate program after the first semester of their junior year. Once admitted to the graduate program, the five-year student will spend his/her senior year as a dual registered student and all rules for graduate student status apply. A sample curriculum for the five-year B.S. /M.S. Environmental Engineering degree is listed below.

#### *Summer*

3 ENVE 581

#### *Semester 7*

4 ENVE 411

4 ENVE 413

4 EARTH 440

3 Social Science

15 Total credit hours

#### *Semester 8\**

3 ENVE 406

3 ENVE 490

3 ENVE 510

3 Humanities/Social Science

12 Total credit hours

*\*B.S. degree is granted*

*Summer*

3 ENVE 591

*Semester 9*

3 ENVE 501

3 ENVE 503

3 ENVE 512

3 ENVE 591

12 Total credit hours

*Semester 10*

3 ENVE 520

3 Elective

3 Elective

3 ENVE 591 (optional)

12 Total credit hours

*Summer*

3 ENVE 591 (optional)

**Environmental Engineering Courses:****ENVE 101, Environmental Engineering Seminar, 1 cr, 1 cl hr**

Seminars by faculty, and guest speakers from industry, consulting, and government provide a brief overview of environmental engineering topics, including air pollution, water quality, and solid and hazardous waste.

**ENVE 201, Introduction to Environmental Science and Engineering,****3 cr, 3 cl hr**

*Prerequisites: CHEM 122 & 122L; BIOL 111 & 111L; MATH 132*

The fundamentals of physics, chemistry, biology, and geology applied to problem solving in science and engineering. A study of environmental phenomena and strategies to control pollution of water, air, and land. Definition of basics for water quality engineering, water treatment, wastewater treatment, solid and hazardous waste management, radioactive waste management, and air pollution. Environmental impact statements and environmental ethics.

**ENVE 301, Applied Principles of Environmental Engineering, 3 cr, 3 cl hrs**

*Prerequisites: ENVE 201*

Application of chemical and biological principles to the study of the natural environment and engineered systems related to pollution of air, water, and soil. Topics include: atmospheric chemistry, biokinetics, carbonate cycle, corrosion, complexation (coordination chemistry), redox reactions, and precipitation. Principles will be tied to specific environmental engineering applications.

**ENVE 302, Environmental Law and Regulations, 2 cr, 2 cl hrs**

*Prerequisite: ENVE 201*

An overview of the major federal and state environmental statutes and regulations. Statutory/regulatory scheme and its application to current environmental problems. Specific regulations pertaining to air, water, toxic substances and pesticides, and solid and hazardous wastes, as well as related regulatory programs. Historical and philosophical basis of environmental regulation.

**ENVE 303, Water Treatment Process Design, 3 cr, 3 cl hrs**

*Prerequisites: ENVE 201 or consent of instructor*

Physical-chemical processes encountered in the design, analysis, and operation of municipal and industrial water treatment systems. Concepts of mass balance and chemical reactor theory applied to water quality improvements. Specific topics include flocculation/coagulation, softening, sedimentation, filtration, stabilization, disinfection, ion exchange, carbon adsorption, and gas transfer. A team design project will be required as partial fulfillment of course requirements.

**ENVE 304, Wastewater Treatment Process Design, 3 cr, 3 cl hrs**

*Prerequisites: BIOL 343; ES 216, 350; or consent of instructor*

Physical-chemical-biological processes encountered in the design, analysis, and operation of municipal and industrial wastewater treatment systems. Microbial kinetics of carbon and nutrient removal. Aerobic and anaerobic biological processes occurring in suspended growth and fixed-film reactors. Processing, management, and disposal of biosolid residuals. Specific topics include collection, pretreatment, sedimentation, trickling filters, activated sludge aerobic and anaerobic digestion. A team design project will be required as partial fulfillment of course requirements.

**ENVE 406, Environmental Engineering Unit Operations, 3 cr, 2 cl, 3 lab hrs**

*Corerequisites: ENVE 303 or 304 or consent of instructor*

Laboratory and field studies of unit operations and processes in environmental engineering. A student-designed feature will be integrated into all of the studies. Potential topics include reactor mixing and hydraulics, coagulation, flocculation, sedimentation, filtration, carbon adsorption, chemical oxidation, air stripping, etc. Emphasis on planning of studies, preparation of work plans, data collection and analysis, report writing, and technical presentation.

**ENVE 411, Solid and Hazardous Waste Engineering, 4 cr, 4 cl hrs**

*Prerequisites: ES 350 or consent of instructor*

A study of solid waste management functions: generation, transport, storage, treatment and recovery, and disposal. Emphasis on design of treatment and recovery unit operations and processes for both municipal and industrial wastes. Site selection criteria and engineering considerations for land disposal alternatives. Special consideration of hazardous waste management: treatment, storage, disposal. Uncontrolled hazardous waste sites: risk assessment and remediation design. Projects on waste management will be developed by teams as partial fulfillment of course requirements.

**ENVE 413, Fundamentals of Air Pollution Engineering, 4 cr, 3 cl, 3 lab hrs**

*Prerequisites: ES 216 and 350; or consent of instructor*

Sources, behavior, and fate of gaseous and particulate air pollutants. Principles of air quality related to visibility, atmospheric chemistry and global climate issues. Principles of meteorology and atmospheric diffusion in relation to modeling pollutant transport and dispersion. Design of air pollution control equipment for removal of gases and particles. In the laboratory section, students learn methods for incorporating emissions estimates and atmospheric dispersion modeling into an air permit application.

**ENVE 421, Green Engineering, 3 cr, 3 cl hrs**

*Prerequisite: junior standing*

Evaluating the full range of environmental effects associated with products and services from raw materials acquisition and manufacturing to use and disposal. Industrial processes, potential waste minimization procedures, relevant regulations as well as life-cycle analysis.

**ENVE 480, Environmental Engineering Senior Design, 3 cr**

*Prerequisite: Senior standing and consent of instructor*

Design of equipment, unit processes, and systems in environmental engineering through application of scientific, technological, and economic principles. Emphasis is placed upon problem formulation and the conceptual, analytical, and decision aspects of open-ended design situations. Course integrates knowledge and skills gained in previous and concurrent courses. Students work as a team in a local, regional or national design competition. A team project report is required. Instructors may also require interim reports, an individual final report, and a final presentation.

**ENVE 490, Senior Design Thesis, 3 cr**

*Prerequisite: Senior standing or consent of instructor*

Design of equipment, unit processes, and systems in environmental engineering through application of scientific, technological, and economic principles. Emphasis is placed upon problem formulation and the conceptual, analytical, and decision aspects of open-ended design situations. Course integrates knowledge and skills gained in previous and concurrent courses.

**ENVE 491, Special Topics in Environmental Engineering, 3 cr, 3 cl hrs**

*Prerequisite: Senior standing or consent of instructor*

**ENVE 501, Physicochemical and Biological Processes, 3 cr, 3 cl hrs**

Fundamentals of physical, chemical, and microbial processes in natural and engineered remedial systems. Phase interactions, chemical transformations, transport phenomena, and separation processes in the natural and engineered systems. Characteristics of microorganisms, microbial ecology, biokinetics, and nutrient requirements. The role of microorganisms in treatment processes and the monitoring and enhancement of *in-situ* activity.

**ENVE 503, Environmental Risk Assessment, 3 cr, 3 cl hrs**

Multi-disciplinary approaches required to develop credible risk analysis within the U.S. regulatory and social framework. Philosophical contexts, regulatory framework, and economic implications. Components of risk and performance assessments, including source term, contaminant transport, exposure, and consequences. Computer models and case studies.

**ENVE 510, Advanced Water Chemistry, 3 cr, 3 cl hrs**

Advanced study of physical and organic chemistry as applicable to natural water bodies and water and wastewater treatment. Chemical cycles, equilibrium chemistry, chemical thermodynamics, reaction kinetics, precipitation and dissolution, oxidation and reduction, colloidal and surface chemistry, complexation phenomena, electroneutrality, mass balances, and transport and fate of chemical species. Relevance of these topics to water quality control are discussed.

**ENVE 511, Water Quality Management and Control, 3 cr, 3 cl hrs**

*Prerequisite: MATH 335 or consent of instructor*

Fundamentals of water quality, including water bodies and their natural setting, water uses and waste input, and water quality cause-effect relationships. Water quality parameters, criteria, and standards; principles of water quality systems analysis, both in the formulation and application of water quality models; engineering controls and socio-economic concepts of water quality management and control, including cost/benefit analysis and management modeling.

**ENVE 512, Industrial Water and Wastewater Treatment, 3 cr, 3 cl hrs**

*Prerequisites: ENVE 303, 304, 501; or consent of instructor*

Advanced study of treatment unit operations and processes within industry-specific water and wastewater situations. Process design, specifications, and costing of physical, chemical, or biological technology to meet a particular treatment objective. Subject matter is developed through references to current practice, critique of completed designs, design exercises, and field trips.

**ENVE 513, Air Resources Engineering, 4 cr, 3 cl, 3 lab hrs**

*Prerequisites: ES 216 and 350; or consent of instructor*

Sources, behavior, and fate of gaseous and particulate air pollutants. Principles of meteorology and atmospheric diffusion in relation to modeling pollutant transport and dispersion. Design of air pollution control equipment for removal of gases and particles from air streams. Unit operations examined include cyclones, electrostatic precipitators, fabric filters, wet scrubbers, incinerators, biofiltration, adsorbers, and absorbers. In the laboratory section, students will develop an air permit, and complete projects using dispersion modeling and air pollution engineering software. Graduate students complete an additional project and a classroom presentation. Graduate work is graded separately. Lectures are shared with ENVE 413.

**ENVE 520, Hazardous Waste Site Remediation, 3 cr, 3 cl hrs**

*Prerequisites: ENVE 411, 501; or consent of instructor*

Design and specification of various physical, chemical, thermal, and biological technologies commonly used in the cleanup of hazardous waste sites. Special emphasis on innovative and emerging technologies for site remediation. Proper sampling and monitoring procedures. Emergency technology in hazardous waste management.

**ENVE 521, Green Engineering, 3 cr, 3 cl hrs**

Evaluating the full range of environmental effects associated with products and services from raw materials acquisition and manufacturing to use and disposal. Industrial processes, potential waste minimization procedures, relevant regulations as well as life-cycle analysis. ENVE 421 and 521 share lectures, but 521 is graded separately and additional graduate-level work is required.

**ENVE 522, Geotechnical Waste Containment Design, 3 cr, 3 cl hrs**

*Prerequisite: ME 420 or consent of instructor*

Design procedures consisting of waste disposal methods, various containment systems, and associated remediation techniques. Waste characterization and soil-waste interactions, contaminant transport in low permeability soils, geosynthetics and soil materials use in waste containment, remedial issues of solidification and stabilization and barrier design, and landfill- and surface impoundment-related design, including liners, leachate and gas collection and removal, final covers, static and seismic slope stability, and settlement analysis. Geotechnical problem definition, application of field and laboratory test data, use of computer models for analysis and design.

**ENVE 523, Open Channel Hydraulics, 3 cr, 3 cl hrs**

*Prerequisite: ES 216 or consent of instructor*

Analysis and characteristics of flow in natural and artificial open channel systems using energy, continuity, and momentum equations as applied to steady-state uniform, gradually varied, and rapidly varied flow profiles with emphasis on design of hydraulic structures. The students will use their knowledge of fluid mechanics, calculus, numerical analysis, and computer science to solve practical open channel flow problems. A variety of hydraulic conveyance and structures are covered, including rigid and flexible boundary channels, culverts, sluice gates, fumes, weirs, spillways, stilling basins, and bridges. Graduate work is graded separately. Lectures are shared with CE 423.

**ENVE 530, Advanced Air Pollution Engineering, 3 cr, 3 cl hrs**

*Prerequisite: ENVE 413 or consent of instructor*

Application of basic pollution control techniques to a variety of source categories, including industrial and mobile sources. State-of-the-art and developing technologies such as catalytic combustion, advanced oxidation, and bioremediation. Classroom presentations and a semester-long design project.

**ENVE 535, Transport and Fate of Air Pollutants, 3 cr, 3 cl hrs**

*Prerequisites: ES 216; MATH 335; or consent of instructor*

Development and application of theories and techniques to predict the movement and dilution of air pollutants after emission from a pollutant source. Basics of meteorology in relation to descriptions of atmospheric motion and stability. Examination of the different types of atmospheric dispersion models (Gaussian, Eulerian, and Lagrangian). Aerosol formation mechanisms and formation of gaseous pollutants in the troposphere.

**ENVE 551, Graduate Seminar, 1 cr each semester**

Seminar presentations by faculty, graduate students, and guest speakers on their interests and current research topics. Graded on S/U basis.

**ENVE 571, Special Topics in Environmental Engineering, 2–4 cr, 2–4 cl hrs**

*Prerequisite: Consent of instructor*

*Offered on sufficient demand*

Special topics in environmental engineering.

**ENVE 581, Directed Study, credit to be arranged**

Independent design project conducted by the student under the direction of the student's advisor. A written final report and oral presentation are required.

**ENVE 590, Independent Study, cr to be arranged**

Independent research organized and conducted by the student under the direction of the student's advisor. A written final report is required

**ENVE 591, Thesis (Master's Program), credit to be arranged****Faculty Research Interests**

Brady—Aquatic chemistry, global change, groundwater remediation

Cal—Air quality engineering, chemical fate and transport, transportation engineering, water resources engineering

Hendrickx—Vadose zone hydrology, water and salt balance of natural and irrigated systems, evapotranspiration, remote sensing, soil physics, electromagnetic induction

Huang—Hazardous waste management, water treatment, wastewater reuse

Richardson—Biological wastewater treatment, groundwater contamination, site remediation



# Materials and Metallurgical Engineering

*Professors: Burleigh, Fuierer, Hirschfeld, Majumdar (Chair of the Department), McCoy*

*Associate Professor: Kalugin*

*Joint Appointment Professors: Leclerc (ChE), Tartis (ChE), Teare (EE)*

*Adjunct Faculty: Curro, Doughty, Hockensmith, Jacobson, Lowe, Ravi, Romig, M. Smith, Vogel*

*Emeritus Professor: Bond*

**Degrees Offered: B.S. in Materials Engineering, Materials Engineering with Metallurgical Engineering option; M.S. and Ph.D. in Materials Engineering**

**Web site:** <http://infohost.nmt.edu/~mtls/>

## Department Mission Statement

- To educate our students so that they are prepared to obtain and succeed in the best positions in industry, government laboratories, and graduate schools.
- To advance the frontiers of materials science and engineering.
- To serve the public of New Mexico through outreach and expanded education.

## Program Educational Objective

Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. The Materials Engineering and the Materials Engineering with Metallurgical Engineering Option programs will prepare graduates who:

- establish themselves in a range of careers in industry or government or pursue post baccalaureate education in engineering, science, business, law, medicine, or related fields;
- demonstrate advancement in their chosen profession;
- engage in appropriate professional societies and in continuing education activities

## Undergraduate Program (ABET accredited)

The design and application of materials rest upon the relationship of structure, properties, and processing at all length scales from sub-atomic to nano- to micro- and ultimately, macro-materials. At the atomic level, structure and property interactions are characterized using techniques such as x-ray scattering, spectroscopy, atomistic computer modeling, atomic force and electron microscopy. At the micron length scale structures are evaluated using, for example, both optical and electron microscopy and

characterized using techniques such as micro-hardness then are related to macroscopic properties, e.g., strength, toughness, and thermal conductivity. An understanding of how processing methods affect the performance of the material is also considered. For example, the performance of an as-cast metal component is very different from the same component that was forged even though both are made of the same material.

These ideas are developed and expanded upon throughout the undergraduate curriculum. The introductory materials engineering courses familiarize students with the general ideas and terminology. Three instrumentation-intensive courses on methods and analysis specifically address the observational basis of the materials and metallurgical engineering discipline. Four classes target the theories used to understand the relations between processing and microstructure as well as those between microstructure and macroscopic properties in the areas of metals, ceramics, polymers, and composites. Upper-level elective materials courses chosen from a rotating selection investigate more specialized topics such as electronic- and nano-materials. The senior design sequence emphasizes the synthesis of skills and ideas as well as providing experience in teamwork and practical design.

Research experience for the students is available and encouraged through part-time employment in the broad range of Materials research projects that are on-going in the department and also in the Energetic Materials Research and Testing Center, New Mexico Bureau of Geology and Mineral Resources, and Petroleum Recovery Research Center. Departmental collaborations with scientists and engineers at Los Alamos and Sandia National Laboratories provide another avenue for student involvement in research projects. Many of our undergraduate students pursue graduate degrees either at New Mexico Tech or elsewhere while others seek employment directly.

The Materials and Metallurgical Engineering Department operates and maintains a broad range of instrumentation for characterization and testing. A full list of instrumentation resources is available on the department's web site. Of particular note is the broad range of microscopy capabilities available for research and instruction, including light microscopes, scanning electron microscopes and a scanning probe (atomic force) microscope.

## Bachelor of Science in Materials Engineering

*Minimum credit hours required—131*

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

- MATH 231 (4), 335 (3)

- ES 110 (2), 111 (3), 201 (3), 302 (3), 332 (3) or EE211 (3)
- MATE 101L (1), 202 & 202L (4), 235 & 235L (4), 301 (3), 310 (3), 311 (3), 314 (3), 350 (3), 351 (3), 410 (3), 445 (3), 481 (3), 482 (3)
- METE 327 (3)
- Advanced basic science (3): CHEM 311, 331, 333 or MATE 452 are recommended.

•Technical electives (12): Approved upper level MATE and METE courses. Up to 3 credit hours can be completed outside the department with the consent of the department.

•Electives to complete 131 credit hours

Credit for trigonometry or college algebra is not allowed for engineering students.

All engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

### Sample Curriculum for the Bachelor of Science in Materials Engineering

#### Semester 1

- 1 MATE 101L (Intro. Materials Lab)
- 3 ENGL 111 (College English 1)
- 4 MATH 131 (Calculus 1)
- 4 CHEM 121 & 121L (General Chemistry 1)
- 3 Social Science
- 2 ES 110 (intro. to Engineering)
- 17 Total credit hours

#### Semester 2

- 3 ENGL 112 (College English 2)
- 4 MATH 132 (Calculus 2)
- 4 CHEM 122 & 122L (General Chemistry 2)
- 3 ES 111 (Computer Programming)
- 3 Social Science
- 17 Total credit hours

#### Semester 3

- 4 MATE 202 & 202L (General Materials 1)
- 4 MATH 231 (Calculus 3)
- 5 PHYS 121 & 121L (General Physics 1)
- 3 Humanities
- 16 Total credit hours

#### Semester 4

- 3 MATH 335 (Applied Analysis)
- 5 PHYS 122 & 122L (General Physics 2)
- 4 MATE 235 & 235L (General Materials 2)
- 3 ES 201 (Statics)
- 3 Social Science
- 18 Total credit hours

#### Semester 5

- 3 METE 327 (Metals)
- 3 Humanities/Social Science
- 3 ES 302 (Mechanics of Materials)
- 3 MATE 350 (Materials Thermodynamics)
- 3 MATE 310 (Processing and Microstructure)
- 15 Total credit hours

#### Semester 6

- 3 ENGL 341 (Technical Writing)
- 3 ES 332 or EE 211 (Electrical Engineering)
- 3 MATE 301 (Ceramics)
- 3 MATE 351 (Polymers)
- 3 MATE 314 (Transport Processes)
- 3 MATE 311 (Thermal and Mechanical Properties)
- 18 Total credit hours

#### Semester 7

- 3 Technical Elective\*
- 3 Technical Elective\*
- 3 MATE 445 (Composites)
- 3 MATE 481 (Senior Design 1)
- 3 MATE 410 (Microstructural Characterization)
- 15 Total credit hours

#### Semester 8

- 3 Technical Elective\*
- 3 Technical Elective\*
- 3 Advanced Basic Science Elective\*
- 3 MATE 482 (Senior Design 2)
- 3 Humanities
- 15 Total credit hours

\* Electives must be approved by the student's advisor.

### Bachelor of Science Degree in Materials Engineering with Metallurgical Engineering Option

Minimum credit hours required—131

In addition to the General Education Core Curriculum (page 100), the following courses are required:

- MATH 231 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 302 (3), 332 (3) or EE 211 (3)
- MATE 101L (1), 202 & 202L (4), 235 & 235L (4), 310 (3), 311 (3), 314 (3), 350 (3), 410 (3), 435 (3), 481 (3), 482 (3)
- METE 327 (3)
- Two of the following: MATE 301 (3), MATE 351 (3), MATE 445(3)
- Advanced basic science (3): MATE 452 is recommended.
- Technical electives (12): Approved upper level MATE and METE courses. Up to 3 credit hours can be completed outside the department.
- Electives to complete 131 credit hours

Credit for trigonometry or college algebra is not allowed for engineering students.

All engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

### Sample Curriculum for the Bachelor of Science in Materials Engineering with Metallurgical Engineering Option

#### Semester 1

1 MATE 101L (Intro. Materials Lab)  
 3 ENGL 111 (College English 1)  
 4 MATH 131 (Calculus 1)  
 4 CHEM 121 & 121L (General Chemistry 1)  
 3 Social Science  
2 ES 110 (Intro. to Engineering)  
 17 Total credit hours

#### Semester 2

3 ENGL 112 (College English 2)  
 4 MATH 132 (Calculus 2)  
 4 CHEM 122 & 122L (General Chemistry 2)  
 3 ES 111 (Computer Programming)  
3 Social Science  
 17 Total credit hours

#### Semester 3

4 MATE 202 & 202L (General Materials 1)  
 4 MATH 231 (Calculus 3)  
 5 PHYS 121 & 121L (General Physics 1)  
3 Humanities  
 16 Total credit hours

#### Semester 4

3 MATH 335 (Applied Analysis)  
 5 PHYS 122 & 122L (General Physics 2)  
 4 MATE 235 & 235L (General Materials 2)  
 3 ES 201 (Statics)  
3 Social Science  
 18 Total credit hours

#### Semester 5

3 METE 327 (Metals)  
 3 Humanities/Social Science  
 3 ES 302 (Mechanics of Materials)  
 3 MATE 350 (Materials Thermodynamics)  
3 MATE 310 (Processing and Microstructure)  
 15 Total credit hours

#### Semester 6

3 MATE 311 (Thermal and Mechanical Properties)  
 3 MATE 314 (Transport Processes)  
 3 METE 326 (Process Metallurgy)  
 3 ES 332 or EE 211 (Electrical Engineering)  
 3 ENGL 341 (Technical Writing)  
3 Humanities  
 18 Total credit hours

#### Semester 7

3 Technical Elective\*  
 3 Technical Elective\*  
 3 MATE 431 (Manufacturing Processes)  
 3 MATE 481 (Senior Design 1)  
3 MATE 410 (Microstructural Characterization)  
 15 Total credit hours

#### Semester 8

3 Technical Elective\*  
 3 Technical Elective\*  
 3 Advanced Basic Science Elective\*  
 3 METE 482 (Senior Design 2)  
3 MATE 435 (Mechanical Behavior)  
 15 Total credit hours

\* Electives must be approved by the student's advisor.

### Minor in Materials Engineering

*Minimum credit hours required—17*

The following courses are required:

- MATE 202 and MATE 235 (6+).
- Approved Technical Electives (to yield total of 17).

### Minor in Polymer Science

*Minimum credit hours required—19*

The following courses are required:

- CHEM 334 (3), 446 (3)
- MATE 202 & 202L (4) or 235 & 235L (4)
- MATE 351 (3)
- Approved Technical Electives (6)

### Graduate Programs

#### Master of Science in Materials Engineering

The student's course of study must be approved by the student's advisory committee and must fulfill the general requirements for the master's degree and must include MATE/METE 591 (thesis). No more than three credit hours of directed study can be used to satisfy the course work requirements.

Students must take MATE 592 each semester offered if the student is in residence. Distance-education students will be required to document conference participation in lieu of this requirement.

Only one credit of MATE 592 may be used to fulfill degree requirements.

## **Master of Science in Materials Engineering, Independent Study Option**

A student may petition the department with the approval of the faculty to pursue a Master of Science degree with an independent option must complete a minimum of 30 credit hours of which 3 credit hours must be independent study and a minimum of 18 credit hours must be 400-500 level Materials or Metallurgical Engineering courses. The student's course of study must be approved by the student's advisor committee and must fulfill the other requirements of the MS degree with the exception of the 6 credit hours of thesis.

## **Five Year Bachelor/Master Degree Program**

The combined degrees of a MS in materials Engineering (either Thesis or Independent Study Option) along with a BS in Materials Engineering or affiliated field may be achieved in five years. For students in MATE or METE BS programs, a minimum of 158 credit hours are required to complete the combined (BS+MS) degree. For students in affiliated BS programs, there are commensurate requirements. To be considered for this program, students typically apply at the end of their sophomore year. Admission is contingent upon their having a 3.0 GPA and the acceptance of their proposed course of study. Students with upper division standing may apply, but admittance into the program will be conditional. Students in the 5-year program must apply for graduate standing, normally in their 6th semester. Graduate admission will be contingent upon adherence to the approved program of study and a 3.0 minimum overall cumulative GPA. Graduate status will be granted upon fulfillment of the requirements for the BS degree.

## **Doctor of Philosophy in Materials Engineering**

The prospective doctoral candidate should develop a good background in materials sciences, chemistry, physics, and mathematics, in addition to achieving a high level of competence in a specialized area of materials. Programs are arranged by the prospective student and the student's advisory committee. Additional information can be found under the Graduate Program (page 47).

In addition to the course requirements specified for the M.S. degree, students seeking the Ph.D. degree in materials are required to take a minimum of 24 credit hours of approved course work, of which at least 12 credit hours must be in 500-level courses; no more than three of these hours should be directed study. Students must take MATE 592 each semester offered if the student is in residence.

Distance-education students will be required to document conference participation in lieu of this requirement. Only one credit of MATE 592 may be used to fulfill degree requirements.

Dissertation research must also be completed. In order to pursue dissertation research, the student must pass a candidacy examination and a qualifying examination. An oral defense of the completed written dissertation is also required.

Suitable topics for doctoral candidates can be selected from a broad range of materials issues (relating to ceramics, composites, metals, or polymers) that are of current interest to the department's faculty.

## **Special Programs**

Students pursuing an advanced degree in materials may elect to emphasize and develop a background in the general area of materials with research centered around an area of structure-property-processing performance of metals, ceramics, polymers, and composites. This could involve modern microstructural characterization techniques (X-rays and electron microscopy); mechanical and physical property measurements; explosive forming, hardening, and consolidation; performance under conditions of fatigue, high temperatures, and aggressive environments.

Interdisciplinary programs in the areas of materials are encouraged. Joint dissertation supervision is provided by the appropriate departments or divisions. Research facilities not available on the campus may be available through cooperative agreements with the Air Force Weapons Laboratory at Kirtland Air Force Base and Sandia National Laboratories in Albuquerque, and Los Alamos National Laboratory.

## **Materials Engineering Courses:**

### **MATE 101L, Introductory Materials Engineering Laboratory, 1 cr, 3 lab hrs**

Hands-on laboratory experience with some fundamental concepts in materials engineering: classification of solids, gelation processes, particulate dispersions, nucleation and growth of crystals, phase diagrams, magnetic domains, (explosive) welding, and composite design. Course provides a glossary of terms and concepts used in the field of materials science and engineering.

### **MATE 102L, Introductory Materials Engineering**

**Laboratory, 2 cr, 3 lab hrs**

See description for MATE101L with additional emphasis on exploration of career opportunities in Materials Science and Engineering.

**MATE 103L, Introduction to Electron Microscopy, 1 cr, 3 lab hrs**

Students will obtain a basic understanding of various techniques of electron microscopy including Scanning Electron Microscopy (SEM), Transmission Electron Microscopy, Auger Electron Spectroscopy (AES), Secondary Ion Mass Spectroscopy (SIMS), and Atomic Force Microscopy (AFM). Demonstrations of various applications of these techniques will be given.

**MATE 104L, Introduction to Electron Microscopy, 2 cr, 3 lab hrs**

See description for MATE 103L with additional emphasis on Electron Microscopy across multiple disciplines.

**MATE 202, Materials Engineering I, 3 cr, 3 cl hrs**

*Corequisite:* CHEM 122

Application of the student's background in physical sciences, mathematics, and computer science to the solution of elementary problems in the materials sciences. Introduction to metallurgical techniques and the science of materials. Elementary design problems involving the optimum use of materials.

**MATE 202L Materials Engineering I Laboratory, 1 cr, 3 lab hrs**

*Corequisite:* MATE 202

Laboratory experiments addressing elementary design problems involving optimal use of materials. Designed to reinforce principles discussed in Mate 202.

**MATE 235 Materials Engineering II, 3 cr, 3 cl hrs**

*Prerequisites:* CHEM 122 and 122L

*Corequisite:* Phys 122 & 122L

Survey of technologically important materials including ceramics, glasses, semiconductors, polymers and composites. The objective is to understand the chemical composition, structure, processing and property relationships in material systems. The student will obtain a basic understanding of the principles of electronic transport, dielectric, thermal, optical and mechanical properties of engineered solids. Undergraduate students majoring in Materials Engineering must take Mate 235L concurrently.

**MATE 235L Materials Engineering II Laboratory, 1 cr, 3 lab hrs**

*Prerequisites:* CHEM 122 and 122L

*Corequisites:* MATE 235

Laboratory experiments introducing the fabrication of technical materials and the measurement of their properties. Designed to reinforce principles discussed in Mate 235.

**MATE 301, Introduction to Ceramic Engineering, 3 cr, 3 cl hrs**

*Prerequisites:* MATE 202 or 235; or consent of instructor

Ceramic processing and beneficiation techniques, from raw materials to finished products. Chemistry and structure of ceramic raw materials. Microstructures of traditional (porcelain and glass) and advanced (modern structural and electrical) ceramics. Properties of ceramics, and their dependence on processing and microstructure.

**MATE 310 Processing and Microstructure Methods and Analysis 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites:* MATE 202, MATE 235; or consent of instructor

Emphasis on the relationship between processing and microstructure. Processing techniques used to form metals, ceramics, polymers, and composites will be studied such as extrusion, pressing, forging, rolling, casting, and joining. Elementary analysis techniques such as optical and electron microscopy will be used to illustrate the effect of processing on microstructure.

**MATE 311 Thermal and Mechanical Methods and Analysis 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites:* MATE 202, MATE 235, ES 302; or consent of instructor

Emphasis on the use of thermal and mechanical techniques to both influence and measure the properties of metals, polymers, ceramics, and composites. Thermal techniques such as DSC, DTA, TGA, TMA, and dilatometry will be described. Thermal processing and temperature measurement techniques will also be covered. Mechanical techniques such as viscometry, rheometry, strength/toughness testing, hardness testing, and fatigue will be covered. These thermal and mechanical techniques will be used to elucidate the relationship between properties and microstructure, relaxation mechanisms, lifetime predictions, phase transformations, chemical reactions, and synthesis.

**MATE 314, Transport Processes, 3 cr, 3 cl hrs**

*Prerequisites:* MATH 131, MATH 132; PHYS 121

Introduction to the concepts of fluid dynamics and mass and heat transfer.

**MATE 350, Materials Thermodynamics, 3 cr, 3 cl hrs**

*Prerequisite:* MATH 231, CHEM 121, PHYS 121. (ES 347 is recommended.)

The mathematical structure of thermodynamics is developed and elucidated from a transport-process-based perspective. Basic quantities such as heat and temperature are carefully defined. The conserved nature of the First-Law and the non-conserved nature of the Second Law are emphasized. The consequences of the ensuing stability-conditions are explored in the area of phase equilibrium in multicomponent mixtures. (Same as ChE 349)

**MATE 351, Introduction to Polymeric Materials, 3 cr, 3 cl hrs**

*Prerequisites:* MATE 202 or MATE 235, MATH 231 or MATH 335

Basic concepts of polymer science; polymerization reactions and mechanisms, as well as kinetics involved; polymer solutions, molecular-weight determinations, analysis and testing of polymers; structural properties of polymers; properties of commercial polymers; processing of polymers.

**MATE 402, Physical Ceramics, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 301

Review of ceramic microstructures. Atomistic, microstructural, and thermodynamic origins of ceramic properties, with emphasis on the effects of atomic and structural defects and interpretation of phase diagrams.

**MATE 410 Microstructural Characterization Methods and Analysis 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* PHYS122, MATE 202, MATE 235 or consent of instructor

Crystalline and non-crystalline materials are characterized using various types of scattering, diffraction, absorption and microscopy techniques. Methodologies such as x-ray diffraction, electron diffraction and microscopy are introduced for analyzing crystallographic and other structural properties of metals, ceramics, polymers and composites.

**MATE 430, Design and Analysis of Experiments, 3 cr, 3 cl hrs**

*Prerequisite:* Senior standing

Methods of statistics and modeling important to many problems in materials science and engineering including Six Sigma. Examples are chosen from a number of actual experiences. Safety considerations and experiment design including analysis of risk, how risks may be integrated, and how formal procedures should be established. The use of information sources, such as materials safety data sheets (MSDS). (Same as ChE 463)

**MATE 431, Fundamentals in Manufacturing Processes of Materials I, 3 cr, 3 cl hrs**

*Prerequisites:* MATE 202; ES 302; and senior standing or consent of instructor

Introduction to materials design; flow theories and work of deformation; microstructure-property relationships for different materials; fracture; casting and heat-flow/mass-transfer issues; bulk deformation processing with applications to rolling and extrusion; powder metallurgy and sintering of metal and ceramic powders.

**MATE 434, Phase Equilibria, 3 cr, 3 cl hrs**

*Prerequisites:* MATE 350/ChE 349 and CHEM 331

The theoretical and practical aspects of phase equilibria of multicomponent systems will be examined in detail. The thermodynamics of these systems will be studied along with the experimental methods of determining phase equilibrium. Particular emphasis will be placed on interpretation of binary and ternary systems for metals and ceramics.

**MATE 435, Mechanical Behavior of Materials, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 202 or consent of instructor

Elasticity and plasticity; flow criteria. Strengthening mechanisms. Deformation processes. Mechanical testing of materials: tensile, hardness, fatigue, fracture, formability.

**MATE 441, 441L, X-Ray Diffraction, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* PHYS 122, MATE 202 or MATE 235

Properties and generation of X-rays, X-ray diffraction phenomena. Single-crystal and powder techniques for study of structure of metals and alloys, imperfections, stress, and strain.

**MATE 442, Solid State Diffusion, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 314 or ES 314

Development of the diffusion equations in solids and their solutions by analytical and numerical methods. Diffusion theory and mechanisms. Diffusion phenomena in semiconductors, metals, alloys, ionic crystals, and oxides. Thermodynamic, point-defect and defect reactions, and impurity effects. High-diffusivity paths; Electromigration (EM) in metallic films and EM measurement. Review of experimental techniques.

**MATE 443, Magnetic Materials, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 235 or consent of instructor

The origin of magnetism, theory of magnetism, comparison of diamagnetic, paramagnetic, ferromagnetic, and ferromagnetic solids. Magnetic measurements, magnetic characterization techniques, domain theory and hysteresis. Structure-processing-property relationships in magnetic materials. Applications of "hard" and "soft" magnetic materials.

**MATE 445, Introduction to Composite Materials, 3 cr, 3 cl hrs**

*Prerequisites:* ES 302 or consent of instructor

Reinforcement materials, glass, Kevlar, polyethylene, carbon, boron, silicon carbide, alumina, metallic fibers. Interface between the matrix and fiber. Polymer matrix, metal matrix, and ceramic matrix composites. Mechanism of fiber strengthening. Micromechanics and macromechanics of composite materials, their strength and fracture behavior.

**MATE 446, Computer Simulation in Materials Science, 3 cr, 3 cl hrs**

*Prerequisite:* MATH 231

Computer simulation techniques are introduced and applied to systems of interest to Materials Science. Monte Carlo and Molecular Dynamics methods are used to explore properties at the atomic level.

**MATE 447, Optical Materials, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 235 or consent of instructor

Review of optical phenomena: reflection, transmission, absorption, color, polarization, refraction and birefringence, and their origin in materials. Structure-processing-property relationships in optical materials including crystals, glasses, and thin films. Applications including mirrors, filters, lenses, lasers, electro-optics, detectors and fiber optics.

**MATE 452, Physics of Metals and Ceramics, 3 cr, 3 cl hrs**

*Prerequisite:* Senior standing or consent of instructor

Discussion of physical properties of metals, semiconductors, and dielectrics from the viewpoint of solid-state theories. Electron dynamics, electronic transport, electromagnetic wave interactions with solids, wave mechanics, quantum mechanics, free electron theory, band theory of solids. Application of semiconductor and quantum physics to modern electronic and opto-electronic devices.

**MATE 452L, Electronic Materials Laboratory, 1 cr, 3 lab hrs**

*Prerequisites:* MATE 235, 235L, or consent of instructor

Use of electronic measurement equipment to characterize the behavior of common circuit components: resistors, capacitors, inductors, temperature- and voltage-dependent resistors, diodes. Interpretation of electronic properties of materials.

**MATE 460, Failure Analysis, 3 cr, 3 cl hrs**

*Prerequisite:* ES 302

Failure analysis is the science of unraveling why a product failed unexpectedly. The results of the failure analysis may be used to design a better product, or as evidence in litigation. This course will cover the proper methodology for investigating a failure, the common failure modes of structures and machines, fractography, the procedure for writing a failure analysis report, and the legal implications.

**MATE 466, Interfacial Phenomena, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 350 or equivalent or consent of instructor

Thermodynamics of interfaces (liquid/liquid, liquid/vapor, liquid/solid, solid/solid, solid/vapor) interfacial equilibria; interfacial free energy (surface tension measurements in liquids; specific surface free energy in solid systems); structure of solid surfaces and interfaces; properties of interfaces; case studies in ethical decision making. Shares lectures with MATE 566, but is graded separately and additional work is required at the graduate level.

**MATE 467, Materials Seminar, 2 cr, 2 cl hrs**

*Prerequisite:* Senior standing

Students, faculty, and distinguished visitors discuss subjects of current and/or long-range interest in various fields of materials.

**MATE 470, Corrosion Phenomena, 3 cr, 3 cl hrs**

*Prerequisite:* CHEM 122, MATE 202 or MATE 235

Theory of aqueous corrosion (thermodynamics and kinetics); forms of corrosion; corrosion testing and evaluation; designing to minimize corrosion; methods of corrosion prevention; corrosion of specific systems; case studies.

**MATE 472, Advanced Transport Phenomena, 3 cr, 3 cl hrs**

*Prerequisite:* ES 216 and 350 or MATE 314 or consent of instructor

Advanced topics in momentum, heat, and mass transfer. Newtonian and non-Newtonian fluid behavior and laminar flow problems, elementary turbulent flow concepts, energy balance applications in incompressible fluid flow, flow and vacuum production. Fourier's law and thermal conductivity of materials, steady state and time dependent heat conduction, application in solidification, elementary convective heat transfer. Diffusivity of materials, diffusion in gases, liquids and solids and through porous media, time dependent diffusion, and interphase mass transfer.

**MATE 474, Polymer Processing and Characterization, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* MATE 351 or consent of instructor

A practical and "hands-on" course covering the essentials of polymer processing and polymer materials characterization. A survey of polymer processing techniques with emphasis on the fundamentals of extrusion. Lab topics include: extruder operation, compounding, scanning calorimetry, rheometry, and mechanical testing. Field trips to manufacturing facilities. (Same course as ChE 474)

**MATE 479, Transmission Electron Microscopy, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* MATE 441, MATE 410, or consent of instructor

Electron optics, design and operation of TEM; specimen preparation; electron diffraction and interpretation of diffraction patterns; imaging, dynamical theory; image interpretation for perfect crystals, crystal defects, interfaces and precipitates. Use of a TEM.

**MATE 480, Advanced Dislocation Theory, 3 cr, 3 cl hrs**

*Prerequisite:* METE 327 or consent of instructor

Dislocations in isotropic continua; effects of dislocations on crystal structure; point defects and physical properties; point defects and mechanical properties; dislocation-point-defect interactions and groups of dislocations; dislocation interactions.

Shares lectures with MATE 580, but is graded separately and additional work is required at the graduate level.

**MATE 481, 481L, Engineering Design I, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* Senior Standing, MATE 301, MATE 351, METE 327, MATE 310, MATE 311

Student design teams begin a year-long capstone design project. The teams will identify project needs, establish goals, determine design requirements, produce alternate solutions, and perform detailed planning. Project initiation, periodic design reports and design reviews. Students, faculty, and distinguished visitors discuss subjects of current and/or long-range interest in various fields of materials. Undergraduate students majoring in Materials Engineering are required to take MATE 481 and MATE 481L concurrently. (Same as METE 481)

**MATE 482, 482L, Engineering Design II, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* MATE 481, MATE 481L

Continuation of the design projects initiated in MATE 481. The student design teams bring the projects to a successful conclusion. Economic analysis and detailed cost evaluation, use of engineering statistics in data analysis and design of experiments, preparation and presentation of final project report. Undergraduate students majoring in Materials Engineering are required to take MATE 482 and MATE 482L concurrently. (Same as METE 482)

**MATE 483, 483L, Scanning Electron Microscopy, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* PHYS 122 or consent of instructor

Fundamental theory and experimental techniques in scanning electron microscopy. Electron optics, electron beam interactions with solids, signal detection and processing. Chemical X-ray microanalysis. Undergraduate students majoring in Materials Engineering are required to take MATE 483 and MATE 483L concurrently.

**MATE 491, Directed Study/Senior Thesis, 3 cr**

*Prerequisite:* Senior standing or consent of instructor

**MATE 500, Directed Research, cr to be arranged**

*Prerequisite:* Graduate standing

This course may not be used to fulfill graduate degree requirements.

**MATE 501, Foundations of Materials, 3cr**

*Prerequisite:* Graduate standing

This course is designed for the Materials graduate students with undergraduate degrees from other disciplines. Fundamental elements of metals, ceramics, polymers and composites will be covered.

**MATE 502, Physical Ceramics, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 301

Review of ceramic microstructures. Atomistic, microstructural, and thermodynamic origins of ceramic properties, with emphasis on the effects of atomic and structural defects and interpretation of phase diagrams. Shares lectures with MATE 402, but is graded separately, and additional work is required at the graduate level.

**MATE 503, Crystal Chemistry and Crystal Physics, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate standing or consent of instructor

Classification of elements and ions. Bonding and rules for building of structures in solids. Systematic review of the basic crystal structures of inorganic solids and their relationship with observed macroscopic properties. Introduction to crystal physics, relating measurable quantities to crystal symmetry.



**MATE 504, Non-linear Dielectric Ceramics, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 235 and graduate standing; or consent of instructor

Review of polarization mechanisms and relaxation phenomena in non-linear dielectrics. New capacitor formulations (high permittivity) and “relaxor” ferroelectrics. Ferroelectric phase transitions and phenomenology. Piezoelectricity, pyroelectricity, and applications.

**MATE 505, Electronic Materials, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 235 and graduate standing; or consent of instructor

Review of electronic, atomic, and defect structures which govern electrical behavior of ceramics and metals. Bulk and printed (thick film) electronic sensors and components. Superionic conductors used in solid electrolyte batteries, and developments in new high-temperature superconducting ceramics. Polarization mechanisms and relaxation phenomena in dielectrics, with discussion of low-permittivity and microwave dielectrics.

**MATE 509, Statistical Mechanics of Simple Materials, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate Standing or consent of instructor

Materials that can be “fooled” into looking like ideal gases are used to introduce the concepts and methods of statistical mechanics. Topics covered include: gas adsorption, blackbody radiation, superfluidity and superconductivity, blackhole formation, electrical conductivity, the Curie temperature, and the calculation of  $\pi$ .

**MATE 510, Mechanical Properties of Ordered Intermetallic Alloys, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate standing or consent of instructor

Development of understanding of the mechanical behavior of ordered alloys and of the process of alloy development. Crystal structures, ordering phenomena, lattice defects in ordered alloys, tensile and compressive behavior, anomalous yielding, enhanced work hardening, fracture, creep and fatigue, environmental effects, alloy development strategies.

**MATE 512, Electronic Thin Films: Science and Technology, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate standing or consent of instructor

Discussion of thin-film deposition techniques (evaporation, sputtering, molecular beam epitaxy, liquid-phase epitaxy, and chemical vapor deposition), and their applications and limitations. Thin-film growth mechanism. Stress and interdiffusion in thin films. Electrical and optical properties of thin films, heterostructures, quantum wells, and superlattices.

**MATE 514, Liquid State Theory, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 509, Graduate Standing or consent of instructor

An introduction to the study of many-particle systems and to the techniques of computer simulation. The statistical mechanics of simple liquids and their mixtures, with particular emphasis on the atomic origin of the structure factor and the relationships between atomic-level structure and macroscopic, thermodynamic properties.

**MATE 516, Biomimetic Materials, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate standing or consent of instructor

An overview of the field of biomimetics: the achievement of unusual materials properties or processes by mimicry of various aspects of biological systems. Mimicry of natural structural design; biomimetic materials processing; “artificial photosynthesis”; biomolecular electronics; and biomimetic catalysis. Interdisciplinary studies.

**MATE 530, Design and Analysis of Experiments, 3 cr, 3 cl hrs**

Methods of statistics and modeling important to many problems in materials science and engineering including Six Sigma. Examples are chosen from a number of actual experiences. Safety considerations and experiment design including analysis of risk, how risks may be integrated, and how formal procedures should be established. The use of information sources, such as materials safety data sheets (MSDS). Shares lectures with MATE 430, but is graded separately, and additional work is required at the graduate level.

**MATE 531, Fundamentals in Manufacturing Processes of Materials I, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 202 or equivalent; ES 302 or equivalent

Introduction to materials design; flow theories and work of deformation, microstructure-property relationships for different materials; fracture; casting and heat-flow/mass-transfer issues; bulk deformation processing with applications to rolling and extrusion; powder metallurgy and sintering of metal and ceramic powders. Shares lectures with MATE 431, but is graded separately, and additional work to include learning manufacturing software, as well as a detailed research paper, is required at the graduate level.

**MATE 534, Introduction to Solidification and Phase Transformations, 3 cr, 3 cl hrs**

*Prerequisites:* MATE 350; METE 327

*Corequisite:* MATE 442

Thermodynamic considerations and phase diagrams (review); influence of interfaces on equilibrium; influence of interfaces and of strain energy on microstructure and kinetics; solidification of single-component and multicomponent systems; ingots, castings, and weldings; sol-gel processing; diffusional transformations in solids: precipitation, eutectoid transformations, massive transformations, and ordering; diffusionless transformations in solids: martensitic transformations. Shares lectures with MATE 434 (formerly 444), but is graded separately, and additional work is required at the graduate level.

**MATE 541, Advanced Physical Metallurgy, 3 cr, 3 cl hrs**

*Prerequisites:* METE 327; or consent of the instructor

Application of thermodynamic principles to formation and stability of alloy systems. Recrystallization. Precipitation hardening. Physical metallurgy of steels, aluminum, rapidly solidified alloys, and quasi-crystals.

**MATE 543, Advanced Mechanical Metallurgy, 3 cr, 3 cl hrs**

*Prerequisites:* MATE 435

Theory of elasticity/plasticity; dislocation theory; strengthening mechanisms; tensile testing; fracture and related failure phenomena; principal features of fatigue and creep; metalworking; related strain state- strain rate phenomena, including shock deformation and high energy rate forming.

**MATE 544, Strengthening Mechanisms, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 435 or consent of instructor

Application of dislocation theory to precipitation, dispersion and solution hardening; yielding; strain aging; Hall-Petch phenomena and strengthening by grain refinement; strengthening by dislocation substructures; work hardening; strength of martensite; fiber- reinforced composites; production of strong microstructures.

**MATE 545, Micromechanics of Fracture, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 435 or equivalent or consent of instructor

Analysis of criteria for crack initiation and propagation leading to structural failure; study of fracture mechanics starting with Griffith theory for ideally brittle materials through plane strain and ultimately elastic- plastic toughness phenomena. Effects of geometry, rate, environment, and microstructure will be considered as related to micromechanisms of fracture (cleavage, ductile fracture, fatigue, stress corrosion cracking).

**MATE 548, Advanced Composite Materials, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 445 or consent of instructor

Reinforcements, their fabrication and properties. Matrix materials and their characteristics. Interfaces in various types of composites. Micromechanics of composites; macromechanics of composites. Failure processes in composites. Designing with composites. Specific important composite systems, their fabrication, properties, and applications.

**MATE 549, Nano-Materials, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate standing or consent of instructor

Physical basics of nanosystems, physics and chemistry of nanostructure synthesis and fabrication, semiconductor nanostructures, magnetic nanostructures and spintronics, molecular nanostructures, electron transport in nanosystems, optical effects in nanosystems, nanomachines, nanoscale biological assemblies, nanocomposite materials.

**MATE 554, Scattering Techniques, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 351 or consent of instructor

Application of scattering techniques to the characterization of polymeric materials, ranging from polymer solutions to melts or composites. Molecular motion of polymers in solutions and melts, Flory-Huggin theory, phase separation. Fundamentals and applications of scattering techniques to polymeric materials. Dynamic light scattering, laser light scattering neutron scattering, X- ray scattering.

**MATE 560, Failure Analysis, 3 cr, 3 cl hrs**

*Prerequisite:* ES 302 or consent of instructor

Failure analysis is the science of unraveling why a product failed unexpectedly. The results of the failure analysis may be used to design a better product, or as evidence in litigation. This course will cover the proper methodology for investigating a failure, the common failure modes of structures and machines, fractography, the procedure for writing a failure analysis report, and the legal implications. Shares lecture with MATE 460, but is graded separately, and additional graduate-level work is required.

**MATE 563, Radiation Effects in Materials, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate standing or consent of instructor

Fundamentals of radiation damage (energetic particles and energy dissipation, atomic displacements and cascades, evolution of damage); material-dependent radiation-damage phenomena (at atomic, microstructural, and macrostructural levels); applications (swift-ion irradiation effects, ion-beam modification of materials, nanostructure design via irradiation, nuclear fuels and waste forms, radiation detectors and dosimeters, solar and galactic cosmic particles).

**MATE 564, Nano-Optics, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate standing or consent of instructor

Review of Nano-Optics—an emerging field, rapidly developing as a part of nanoscience and nanotechnology requiring tools and techniques for fabrication, manipulation and characterization at nanoscale. The class covers theoretical foundations on propagation and focusing of optical fields; methods of nanoscale optical microscopy: near-field optical probes and nanoscale distance control; features of optical interaction in nanoscale environments. Modern applications of nano-optics including quantum emitters, photonic crystals and resonators, surface plasmons structures and devices, will be discussed in the frames of this class.

**MATE 565, Catalyst Characterization Techniques, 3 cr, 3 cl hrs**

*Prerequisite:* ChE 349/MATE 350 and/or CHEM 331/332 or consent of instructor

The course provides an overview of techniques used to characterize catalytic materials including data analysis and linking physical and chemical properties to catalytic activity at the laboratory and process level. Topics include x-ray methods, neutron scattering methods, physical adsorption, chemical adsorption, temperature programmed techniques, photoelectron spectroscopy, vibrational spectroscopy, and electron microscopy. A research project is required.

**MATE 566, Interfacial Phenomena, 3 cr, 3 cl hrs**

Thermodynamics of interfaces (liquid/liquid, liquid/vapor, liquid/solid, solid/solid, solid/vapor); interfacial equilibria; interfacial free energy (surface tension measurements in liquids; specific surface free energy in solid systems); structure of solid surfaces and interfaces; properties of interfaces.

**MATE 567, Dynamic Deformation of Solids, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate standing

Elastic waves. Plastic waves. Shock waves (Rankine-Hugoniot equations and more advanced treatments incorporating materials strength). Wave interactions and attenuation (including spalling). Spherical and cylindrical waves. Impact; Gurney equation. Principles of detonation.

**MATE 568, Material Behavior at High Strain Rates, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 567

Mechanical properties of materials as a function of strain rate. Dislocation dynamics at high velocities. Structural changes introduced by shock waves: phase transformations, point defects, line defects, interfacial defects. Dislocation models for shock front. Materials aspects of adiabatic shear localization, spalling, dynamic deformation. Shock modification of ceramics.

**MATE 563, Radiation Effects in Materials, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate standing or consent of instructor

Fundamentals of radiation damage (energetic particles and energy dissipation, atomic displacements and cascades, evolution of damage); material-dependent radiation-damage phenomena (at atomic, microstructural, and macrostructural levels); applications (swift-ion irradiation effects, ion-beam modification of materials, nanostructure design via irradiation, nuclear fuels and waste forms, radiation detectors and dosimeters, solar and galactic cosmic particles).

**MATE 569, Fuel Cell Technology, 3 cr, 3 cl hrs**

*Prerequisite:* Consent of instructor

The principles of fuel cell technology, including classification of fuel cells and operating mechanisms. Analysis of underlying thermodynamics and physical factors which govern fuel cell performance and efficiency. Cell components and integrative cell design.

**MATE 570, Corrosion Phenomena, 3 cr, 3 cl hrs**

*Prerequisite:* CHEM 122 and Graduate Standing

Theory of aqueous corrosion (thermodynamics and kinetics); forms of corrosion; corrosion testing and evaluation; designing to minimize corrosion; methods of corrosion prevention; corrosion in specific systems; case studies. Shares lecture with MATE 470, but is graded separately and additional graduate-level work is required.

**MATE 575, Introduction to Nano Materials, 3 cr, 3 cl hrs**

*Prerequisite:* Graduate standing or consent of instructor

An introduction to physical basics of nanosystems, physics and chemistry of nanostructure synthesis and fabrication. Other topics include: semiconductor nanostructures, magnetic nanostructures and spintronics, molecular nanostructures, electron transport in nanosystems, optical effects in nanosystems, nanomachines, nanoscale biological assemblies, nanocomposite materials.

**MATE 576, Drug Delivery Techniques, 3 cr, 3 cl hrs**

*Prerequisite:* Senior or graduate standing or consent of instructor

Focus is on current developments in drug delivery techniques, with only a brief discussion of common clinical techniques. The first portion of the class focuses on various delivery mechanisms and the tools needed to validate successful targeted drug delivery (both in vitro, in vivo and diagnostic tools). The second part of the course focuses on current developments in drug delivery based on published research articles. Students will read, digest, and critically analyze scientific work from leading research laboratories. Students will also gain valuable communication tools, as each student will present an article of interest to the class. Finally, the third part of the course focuses on important materials characterization methods such as biological sample prep, SEM, TEM, DSC, Flow Cytometry, Fluorescence Microscopy, ELISA Assays. . Shares lecture with ChE 476 but is graded separately and additional graduate-level work is required.

**MATE 579, Advanced Electron Microscopy, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* MATE 479 or MATE 483; graduate standing

Advanced topics in transmission electron microscopy. In-situ studies of deformation and fracture processes, environmental effects, and radiation damage. High-resolution electron microscopy, weak-beam techniques, scanning transmission electron microscopy, electron microdiffraction. Analytical electron microscopy; electron energy loss spectroscopy and energy-dispersive analysis of X-rays; instrumentation, techniques, quantitation, applications.

**MATE 580, Advanced Dislocation Theory, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 435 or consent of instructor

Dislocations in isotropic continua; effects of dislocations on crystal structure; point defects and physical properties; point defects and mechanical properties; dislocation-point-defect interactions and groups of dislocations; dislocation interactions.

Shares lectures with MATE 480, but is graded separately, and additional work is required at the graduate level.

**MATE 581, Directed Study, cr to be arranged**

Study under the guidance of a member of the department. In general, subject matter will supplement that available in the other graduate course offerings in metallurgy or materials engineering.

**MATE 590, Independent Study, cr to be arranged**

The student must clearly demonstrate the ability to organize and pursue research. A written final report and public oral presentation is required.

**MATE 591, Thesis (master's program), cr to be arranged****MATE 592, Materials Engineering Graduate Seminar, 1 cr, 1 cl hrs**

*Must be taken S/U*

*Prerequisite:* Graduate standing or consent of instructor

Seminar presentations by students, faculty and outside speakers. Discussion of topics of technical interest, and of global, societal, and ethical issues related to materials engineering.

**MATE 595, Dissertation (doctoral degree program), cr to be arranged**

*Prerequisite:* CHEM 595

**MATE 599, Special Topics, cr to be arranged**

Lectures in new or advanced areas of materials.

## Metallurgical Engineering Courses:

**METE 326, Introduction to Process Metallurgy, 3 cr, 3 cl hrs**

*Prerequisite:* CHEM 121

*Corequisite:* MATH 132

Introduction to stoichiometric computations. Calculations of energy and material balance. Elementary process analysis and reactor design. Single-phase and multi-phase systems. (Same as ChE 326)

**METE 327 Introduction to Physical Metallurgy, 3 cr, 3 cl hrs**

*Prerequisite:* MATE 202

Mechanisms of deformation and fracture in metals. Binary phase diagrams. Phase transformations, age hardening, heat treatment of steels, TTT diagrams, CT diagrams, martensitic transformation, shape-memory effects. Common ferrous and non-ferrous alloys.

**METE 434, Introduction to Dislocation Theory, 3 cr, 3 cl hrs**

*Prerequisite:* METE 327 or consent of instructor

An introduction to elasticity and the theory of plastic flow in materials. Geometrical and crystallographic features of dislocations, elastic equations of dislocations in crystals. Partial dislocations and stacking faults. Dislocation interactions and multiplication.

**METE 481, 481L, Engineering Design I, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* Senior Standing, MATE 310, MATE 311, METE 327

Student design teams begin a year-long capstone design project. The teams will identify project needs, establish goals, determine design requirements, produce alternate solutions, and perform detailed planning. Project initiation, periodic design reports and design reviews. Students, faculty, and distinguished visitors discuss subjects of current and/or long-range interest in various fields of materials.

Undergraduate students majoring in Materials Engineering are required to take METE 481 and METE 481L concurrently. (Same as MATE 481)

**METE 482, 482L, Engineering Design II, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* METE 481, METE 481L

Continuation of the design projects initiated in METE 481. The student design teams bring the projects to a successful conclusion. Economic analysis and detailed cost evaluation, use of engineering statistics in data analysis, preparation and presentation of final project report. Undergraduate students majoring in Materials Engineering are required to take METE 482 and METE 482L concurrently. (Same as MATE 482)

**METE 491, Directed Study/Senior Thesis, 3 cr**

*Prerequisite:* Senior standing or consent of instructor

**Faculty Research Interests**

- Burleigh—Corrosion Mechanisms, Alloy Design, Coatings for Corrosion Prevention
- Fuierer—Electronic Ceramics, Chemical Routes to Ceramic Materials and Thin Films, Atomic Force Microscopy
- Hirschfeld—Properties and Processing of Structural Ceramics, Glass Ceramics, and Advanced Composites; Porous Ceramics; Ceramic Coatings for Corrosion Resistance, Thermal Spray
- Kalugin — Optoelectronics and nonlinear optics, nanostructures and nanotechnology, TeraHz lasers and photodetectors, solid state physics of nanostructures, semiconductor materials and devices
- Majumdar — Structure-Property Relations in Materials, Processing of Metals and Composites, SMAs, Fatigue, Creep, Fracture
- McCoy—Statistical Theory, Atomistic Simulation, Rheology, Glass Transition, Thin Films
- G. Bond—Electron Microscopy, Hydrogen Effects, Metal Hydrides, Radiation Damage, Biomimetic Materials and Processing, Carbon Dioxide Sequestration, Controlled Crystallization
- Leclerc—Catalysis, Reactor Design, Alternative Fuels
- Riley—Electrochemical Engineering, Transport Phenomena, Colloidal-Based Nanocomposites
- Tartis—Biomedical Engineering, Biomaterials, Targeted Drug Delivery, Ultrasound Mediated Drug Release
- Teare—Experimental Adaptive Optics, Directed Energy
- Curro—Polymer Theory and Simulation
- Doughty—Chemical Routes to Ceramic Materials, Chemical Sensors, Catalysis, Mechanisms of Chemical Reactions
- Hockensmith—Chemistry of Energetic Materials, Phytoremediation, Chemical Synthesis and Characterization
- Jacobson — Alloys, Beryllian metallurgy and fracture testing
- Ravi—Processing of Composites, Coatings
- Romig—Electron Optics, Phase Transformations, Solid-State Diffusion
- M. Smith—Thermal Spraying
- Vogel—X-ray/Synchrotron/Neutron Diffraction, Texture Analysis, Crystal Structure Refinement, Thermo-mechanical Treatment of Materials, Phase Transformations

# Mechanical Engineering

*Professor: Gerity*

*Associate Professors: Bakhtiyarov, Ford, Ghosh, A.K. Miller, Ostergren (Chair of the Department), Yimaz, Zagrai*

*Assistant Professor: Lim*

*Adjunct Faculty: Abernathy, Borden, Cooper, DeChant, Dinwiddie, Field, Higgins, Kennedy, Marcy, Meason, Rivera, Romero, Ruff, Stofleth, Walsh*

*Emeritus Faculty: A. Miller*

**Degrees Offered: B.S. in Mechanical Engineering; M.S. in Mechanical Engineering**

The Department of Mechanical Engineering at New Mexico Tech administers the following programs:

- Bachelor of Science in Mechanical Engineering
- Master of Science in Mechanical Engineering
  - Specialization in Explosives Engineering
  - Specialization in Fluid and Thermal Sciences
  - Specialization in Mechatronics Systems Engineering
  - Specialization in Solid Mechanics

## Program Educational Objectives

The Department of Mechanical Engineering at New Mexico Tech will produce Bachelor of Science graduates who are independent thinkers, taking ownership in identifying problems and determining effective solution strategies in a timely manner. Following working experience after graduation, they will:

1. Be employed successfully in government laboratories, graduate schools, industry, or other areas of the profession
2. Have an understanding of the importance of life-long learning such that they seek personal and professional growth.
3. Have achieved a noteworthy level of workplace responsibility.

## Undergraduate Programs

### Bachelor of Science in Mechanical Engineering

Mechanical engineering is considered to be one of the cornerstone engineering disciplines and is perhaps the broadest of all engineering disciplines. Mechanical engineers are found in every sector of our technology-based economy. Mechanical engineers find careers in (to name just a few): electric power generation and distribution; petroleum exploration, production and refining; automotive, truck and bus manufacturing; light and heavy rail transportation and manufacturing; agricultural equipment manufacturing; commercial and industrial construction industries; aeronautical design and manufacturing; national defense

industries; semiconductor manufacturing; biomedical technology; petrochemical process industries; basic materials extraction and refining industries.

The undergraduate mechanical engineering program is very broad in its scope, yet it contains sufficient depth to ensure competency in the discipline. Mechanical engineering students must take a heavy load of science and mathematics as prerequisites for their engineering science courses.

Mechanical engineers in industry must be able to interact with many engineering disciplines, so they are required to take courses in other engineering disciplines. Also, because mechanical engineers design and manufacture components and systems, they are required to take courses that emphasize the engineering design/definition process. The mechanical engineering graduate engineer should be well equipped to undertake a professional engineering career in any technology that he or she chooses.

The mechanical engineering program at New Mexico Tech offers the students hands-on laboratory experience in fluid and thermal sciences, mechanics of materials, vibrations, mechatronics, dynamic systems and controls, instrumentation, and measurement. Junior and senior mechanical engineering students work on design projects for two years that range from the Baja SAE® vehicles to aerospace aircraft design.

*Minimum credit hours required—136*

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

- ES 111 (3), 201 (3), 216 (3)\*, 302 (3), 303 (3), 316 (3), 332 (3), 347 (3), 350 (3)
- MENG 110 (2), MENG 302L (1), 304 (3), 305 (3) 351L (1), 352L (1), 381 (2), 382 (2), 405 (2), 405L (1), 421 (3), 431 (3), 441 (3), 451 (3), 481 (3), 482 (3), 483 (2) & 483L (1)
- MATE 202 & 202L (4)
- MATH131 (4), MATH 132 (4), MATH 231 (4), MATH 335 (3) , MATH 337 (3)
- Technical Electives: Three hours from upper-division courses chosen by the student with the faculty advisor's approval.  
\* or MENG 216(3)

Credit for MATH 103, pre-calculus, and MATH 104, trigonometry, is not allowed for mechanical engineering students.

Courses used for the degree, including the General Education Core Curriculum, may not be taken on an S/U basis except for two courses in Humanities and/or Social Science.

All engineering majors must take the Fundamentals in Engineering (FE) exam as a requirement for graduation. Passing this exam is a major step in the process of attaining professional registration. It is **strongly** recommended that the exam be taken in semester 7, before the graduation semester (semester 8).

It is strongly recommended that all Mechanical Engineering students follow the sample curriculum.

### Sample Curriculum for the Bachelor of Science in Mechanical Engineering

#### Semester 1

- 3 ENGL 111 (college English)
- 4 MATH 131 (calculus)
- 4 CHEM 121 & 121L (general)
- 2 MENG110 (intro.)
- 3 Social Science
- 16 Total credit hours

#### Semester 2

- 3 ENGL 112 (college English)
- 4 MATH 132 (calculus)
- 5 PHYS 121 & 121L (general)
- 3 ES 111 (computer engr.)
- 3 Humanities
- 18 Total credit hours

#### Semester 3

- 3 Social Science
- 4 MATH 231 (calculus)
- 4 CHEM 122 & 122L (general)
- 3 ES 201 (statics)
- 4 MATE 202 & 202L (intro to materials)
- 18 Total credit hours

#### Semester 4

- 3 MATH 335 (ordinary differential equations)
- 5 PHYS 122 & 122L (general)
- 3 MATH 337 (engineering math)
- 3 MENG 216/ES 216 (fluid mechanics)
- 3 ES 302 (mechanics of materials)
- 1 MENG 302L (mechanics of materials lab)
- 18 Total credit hours

#### Semester 5

- 3 MENG 305 (engineering analysis)
- 3 ES 303 (dynamics)
- 3 MENG 304 (advanced strength of materials)
- 3 ES 347 (thermodynamics)
- 2 MENG 381 (junior design)
- 3 ENGL 341 (technical writing)
- 17 Total credit hours

#### Semester 6

- 3 ES 332 (electrical circuits)
- 3 MENG 421 (finite element analysis & design)
- 1 MENG 351L (fluids lab)
- 1 MENG 352L (instrumentation and measurements lab)
- 2 MENG 382 (junior design)
- 3 ES316 (engineering economics)
- 3 ES 350 (heat & mass transfer)
- 16 Total credit hours

#### Semester 7 (Take FE exam)

- 2 MENG 405 (dynamic systems & controls)
- 1 MENG 405L (dynamics systems & controls lab)
- 3 MENG 451 (machine design)
- 3 MENG 481 (senior design)
- 3 MENG 441 (dynamics & vibration)
- 3 Humanities
- 3 Social Science
- 18 Total credit hours

#### Semester 8

- 3 MENG 431 (fluid/thermal systems)
- 3 MENG 483 & 483L (mechatronics)
- 3 MENG 482 (senior design)
- 3 Technical Elective
- 3 Humanities/Social Science
- 15 Total credit hours

### Minor in Mechanical Engineering

*Minimum credit hours required – 18*

The following courses are required:

At least eighteen (18) credit hours of ES or MENG courses and/or labs beyond those required for major. These courses and labs are subject to the approval of the Mechanical Engineering Minor Advisor.

### Minor in Aerospace Engineering

*Minimum credit hours required – 18*

The following courses are required:

AE 311, Aerodynamics I, 3 cr, 3 cl hrs  
 AE 412, Aerospace Systems, 3 cr, 3 cl hrs  
 AE Elective, 3 cr, 3 cl hrs

#### One course from:

- AE 313, Orbital Mechanics, 3 cr, 3 cl hrs
- AE 414, Aerospace Structures, 3 cr, 3 cl hrs

#### Two courses from:

- AE 313, Orbital Mechanics, 3 cr, 3 cl hrs
- AE 318, Experimental Methods in Aerodynamics, 2 cr, 2 cl hrs
- AE 318L, Experimental Methods in Aerodynamics Lab, 1 cr, 3 lab hrs
- AE 414, Aerospace Structures, 3 cr, 3 cl hrs

- AE 415, Aerodynamics II, 3 cr, 3 cl hrs
- AE 416, Aircraft Flight Dynamics and Controls, 3 cr, 3 cl hrs
- AE 417, Aerospace Propulsion, 3 cr, 3 cl hrs
- AE 418, Structural Dynamics in Aerospace Engineering, 3 cr, 3 cl hrs

### Minor in Explosives Engineering

*Minimum credit hours required – 18*

The following courses are required:

EXPL 311/MENG 545, Introduction to Explosives

Engineering, 3 cr, 3 cl hrs

EXPL 412/MENG 549, Wave Propagation, 3 cr, 3 cl hrs

EXPL Elective, 3 cr, 3 cl hrs (subject to the approval of the Explosives Engineering Minor Advisor)

#### One course from:

- EXPL 314, Theory and Application of Pyrotechnic, 3 cr, 3 cl hrs
- EXPL 413/MENG 589, Impact Dynamics, 3 cr, 3 cl hrs

#### Two courses from:

- EXPL 314, Theory and Application of Pyrotechnic, 3 cr, 3 cl hrs
- EXPL 316, Energetic Material Chemistry, 3 cr, 3 cl hrs
- EXPL 317, Energetic Material Safety, 3 cr, 3 cl hrs
- EXPL 320, Explosives Technology and Applications, 3 cr, 3 cl hrs
- EXPL 413/MENG 589, Impact Dynamics, 3 cr, 3 cl hrs
- EXPL 414/ChE 475, Explosives Surety, 3 cr, 3 cl hrs
- EXPL 415/MENG553, Computer Modeling of Detonations, 3 cr, 3 cl hrs
- EXPL 418, Shock Physics and Structural Response to Blast, 3 cr, 3 cl hrs
- EXPL 419, Experimental and Diagnostic Techniques, 3 cr, 3 cl hrs

### Minor in Biomedical Engineering

*Minimum credit hours required – 19*

The following courses are required:

BIOL 111, 111L, General Biology, 4 cr, 3 cl hrs, 2 lab hrs

BIOL 331, Cell Biology, 3 cr, 3 cl hrs

BIOL 351, Physiology I, 3 cr, 3 cl hrs

BIOL 352, Physiology II, 3 cr, 3 cl hrs

#### Two courses from:

- MATE 351, Introduction to Polymeric Materials, 3 cr, 3 cl hrs
- MENG 460, Introduction to Biomedical Engineering, 3 cr, 3 cl hrs
- MENG 465, Biorheology, 3 cr, 2 cl hrs, 3 lab hrs
- MATE 516, Biomimetic Materials, 3 cr, 3 cl hrs

- CHE 473, Polymer Materials Engineering, 3 cr, 3 cl hrs
- MENG 576, Biomedical Mechatronics, 3 cr, 3 cl hrs
- MENG 489, Special Topics in Biomedical Engineering, 3 cr, 3 cl hrs

### Senior Design Project:

Students, who are interested in a minor in Biomedical Engineering, will do their Junior/Senior Design Project in the Biomedical Engineering field. This is an opportunity for them to implement their learning in the mechanical engineering and life sciences fields to tackle a particular problem in the biomedical engineering field.

## Graduate Program

### Department Requirements for the Master of Science in Mechanical Engineering

The Mechanical Engineering Department administers the Master of Science in Mechanical Engineering degree for those students wanting to pursue an advanced degree in mechanical engineering. The degree may be earned with and without a thesis. There are currently four areas of specialization for this degree:

- Specialization in Explosives Engineering
- Specialization in Fluid and Thermal Sciences
- Specialization in Mechatronics Systems Engineering
- Specialization in Solid Mechanics

Students must take MENG 585 each semester offered if the student is in residence. Distance-education students are required to take two semester of MENG 585. Only one credit of MENG 585 may be used to fulfill degree requirements.

### Specialization in Explosives Engineering

The Master of Science in Mechanical Engineering with Specialization in Explosives Engineering is available to students with an engineering degree in any field. However, students must demonstrate a competence in mathematics and the basic undergraduate mechanics offered in a typical mechanical engineering curriculum, such as differential equations, mechanics of materials, and engineering dynamics. The degree may be earned with or without a thesis.

### Requirements

A minimum of 30 credit hours is required for the Master of Science in Mechanical Engineering with Specialization in Explosives Engineering.

- Core Classes— at least 12 credit hours from the



following: MENG 545, Introduction to Explosives Engineering; MENG 546, Detonation Theory; MENG 549, Wave Propagation; MENG 550, Advanced Explosives Engineering; MENG 575, Advanced Engineering Mathematics.

- Elective Courses — at least 6 credit hours from the following: MENG 504, Advanced Mechanics of Materials; MENG 517, Advanced Finite Element Method; MENG 547; Theory and Application of Pyrotechnics; MENG 552, Explosives Technology and Applications; MENG 553, Computer Modeling of Detonation; MENG 555, Shock Physics and Structural Response to Blast; MENG 586, Advanced Topics in Engineering Science: The recommended courses for MENG 586 are: Energetic Materials Safety; Shock Physics and Structural Response to Blast; Experimental and Diagnostic Techniques; Energetic Materials Chemistry; Instrumentation and Analysis of Dynamics Testing; Stochastic Processes; MENG 589, Impact Dynamics.
- Courses Outside of the Department — at least 6 credit hours of approved upper-division or graduate course work from another department. The advisory committee may determine that a student's previous academic experience has provided breadth and may recommend modification of this requirement.
- MENG 591, Thesis (6 credit hours) or MENG 590, Independent Study (3 credit hours)— A student must prepare and submit a thesis to his/her advisory committee for approval in accordance with the general requirements of the graduate school, or complete an independent study with accompanying report.

### Specialization in Fluid and Thermal Sciences

The Master of Science in Mechanical Engineering with Specialization in Fluid and Thermal Sciences may be earned with or without thesis. The student must have a B.S. degree in an engineering or science discipline as a prerequisite for this program. The synergy of this program suggests the accommodation of a wide variety of students (from computer science, mechanical engineering, petroleum engineering, chemical engineering, etc.) to this specialization; hence, the study program may be designed to accommodate each student's academic background.

### Requirements

A minimum of 30 credit hours is required for the Master of Science in Mechanical Engineering with Specialization in Fluid and Thermal Sciences.

- Core Classes — at least 12 credit hours from the following: MENG 575, Advanced Engineering Mathematics; MENG 577, Advanced Fluid Mechanics; MENG 578, Advanced

Thermodynamics; MENG 579, Advanced Heat Transfer.

- Elective Courses — at least 6 credit hours from the following: MENG 541, Vibrations in Elastic Continuum; MENG 556, Compressible Fluid Flow; MENG 557, Two-Phase Flow; MENG 558, Non-Newtonian Fluid Mechanics; MENG 559, Theory and Design of Internal Combustion Engines; MENG 560, Principles of Combustion; MENG 580, Computational Fluid Dynamics and Reactive Flow; MENG 504, Advanced Mechanics of Materials; MENG 515, Theory of Elasticity; MENG 517, Advanced Finite Element Analysis; MENG 589, Impact Dynamics.
- Courses Outside of the Department — at least 6 credit hours of approved upper-division or graduate course work from another department. The advisory committee may determine that a student's previous academic experience has provided breadth and may recommend modification of this requirement.
- MENG 591, Thesis (6 credit hours) or MENG 590, Independent Study (3 credit hours)— A student must prepare and submit a thesis to his/her advisory committee for approval in accordance with the general requirements of the graduate school, or complete an independent study with accompanying report.

### Specialization in Mechatronics Systems Engineering

The Master of Science in Mechanical Engineering with Specialization in Mechatronics Systems Engineering may be earned with or without thesis. The student must have a B.S. degree in an engineering or science discipline as a prerequisite for this program. The synergy of this program suggests the accommodation of a wide variety of students (from computer science, mechanical engineering, electrical engineering, etc.) to this specialization; hence, the study program may be designed to accommodate each student's academic background.

### Requirements

A minimum of 30 credit hours is required for the Master of Science in Mechanical Engineering with Specialization in Mechatronics Systems Engineering.

- Core Classes — at least 12 credit hours from the following: MENG 544/EE 544, Modern Control Theory; MENG 548/EE 548, Manipulator Based Robotics; MENG 551, Optimal Control Systems; MENG 554/EE 554, Embedded Control Systems; MENG 567/CS 567, Smart Engineering Systems; MENG 568/CS 568, Smart Engineering Systems II; MENG 570, Advanced

Mechatronics; MENG 572, Sensor Technology; MENG 575, Advanced Engineering Mathematics.

Elective Courses — at least 6 credit hours from the following:

EE 308 & 308L, Microcontrollers; MENG 504, Advanced Mechanics of Materials; MENG 517/ME 517, Advanced Finite Elements; MATE 530, Design and Analysis of Experiments; EMGT 506, Managing Technology Resources; MATH 589, Applied Multivariate Analysis; MATH 532, Perturbation Methods; EMGT 571, Engineering Statistics; MATH 583/584, Topics in Probability and Statistics; MATH 430, Mathematical Modeling; MATH 530, Modeling Case Studies; MENG 582, Nondestructive Evaluation and Structural Health Monitoring.

Courses Outside of the Department — at least 6 credit hours of approved upper-division or graduate course work from another department. The advisory committee may determine that a student's previous academic experience has provided breadth and may recommend modification of this requirement.

MENG 591, Thesis (6 credit hours) or MENG 590, Independent Study (3 credit hours)— A student must prepare and submit a thesis to his/her advisory committee for approval in accordance with the general requirements of the graduate school, or complete an independent study with accompanying report.

### Specialization in Solid Mechanics

The Master of Science in Mechanical Engineering with Specialization in Solid Mechanics may be earned with or without thesis. The student must have a B.S. degree in an engineering or science discipline as a prerequisite for this program. The synergy of this program suggests the accommodation of a wide variety of students (from computer science, mechanical engineering, civil engineering, industrial engineering, etc.) to this specialization; hence, the study program may be designed to accommodate each student's academic background.

### Requirements

A minimum of 30 credit hours is required for the Master of Science in Mechanical Engineering with Specialization in Structural Mechanics.

Core Classes—at least 12 credit hours from the following:

MENG 515, Theory of Elasticity; MENG 516, Plates and Shells; MENG 517/ME 517, Advanced Finite Element Method; MENG 541, Vibration in a Elastic Continuum; MENG 521, Elastic Stability; MENG 504, Advanced Mechanics of Materials; MENG 520, Fracture Mechanics.

Elective Courses — at least 6 credit hours from the following:

MENG 583, Engineering Mechanics of Composite Structures; MATE 516, Biomimetic Materials; MATE 548,

Advanced Composite Materials; MENG 549, Wave Propagation; MATE 568, Material Behavior at High Strain Rates; MENG 519, Adaptive Structures; MENG 522, Mechanics of Inelastic Continuum; MATE 530, Design and Analysis of Experiments; MATE 531, Fundamentals in Manufacturing Processes of Materials; MATE 560, Failure Analysis; MENG 523, Engineering Mechanics of Cellular Structure; MENG 524, Continuum Mechanics.

Courses Outside of the Department — at least 6 credit hours of approved upper-division or graduate course work from another department. The advisory committee may determine that a student's previous academic experience has provided breadth and may recommend modification of this requirement.

MENG 591, Thesis (6 credit hours) or MENG 590, Independent Study (3 credit hours)— A student must prepare and submit a thesis to his/her advisory committee for approval in accordance with the general requirements of the graduate school, or complete an independent study with accompanying report.

## Aerospace Engineering Courses

**AE 311, Aerodynamics I, 3 cr, 3 cl hrs**

*Prerequisites: MENG 216/ES 216*

Fundamental concepts of aerodynamics, equations of compressible flows, irrotational flows and potential flow theory, singularity solutions, circulation and vorticity, Kutta-Joukowski theorem, thin airfoil theory, finite wing theory, slender body theory, subsonic compressible flow and Prandtl-Glauert rule, supersonic thin airfoil theory, introduction to performance, basic concepts of airfoil design

**AE 313, Orbital Mechanics, 3 cr, 3 cl hrs**

*Prerequisites: PHYS 122 or 132, MATH 332 or MENG 305*

This is a first upper-division course covering the Newtonian mechanics of orbits. Applications include ballistic missiles, satellites, and lunar and interplanetary orbits.

**AE 318, Experimental Methods in Aerodynamics, 2 cr, 2 cl hrs**

*Prerequisite: ES 216/MENG 216*

Experimental approach to problem solving and validation of theoretical/computational methods. Uncertainties in measurement. Review of fundamental equations of fluid dynamics, properties of gases and liquids, similarity laws. Wind tunnels, water channels, simulation of phenomena in processing equipment. Pressure sensors, including optically-reactive surface paint. Measurement of skin friction by direct force sensors, Preston and Stanton-tubes, diffusion analogies, liquid crystals. Flow visualization with laser light sheet; Schlieren, shadowgraph and interferometric methods. Future trends; flow control, impact of microelectronic sensors and actuators.

**AE 318L, Experimental Methods in Aerodynamics Lab, 1 cr, 3 lab hrs**

*Corequisite: AE318*

Laboratory demonstrations and exercises using available instrumentation in Mechanical Engineering Department.

**AE 412, Aerospace Systems, 3 cr, 3 cl hrs**

*Prerequisites: ES 111; MATH 335; MENG 305*

*Corequisites: MENG 405, 451; EE 341 for EE majors or consent of instructor*

The course explores formulation, development and implementation of a comprehensive approach to the design, analysis, and life-cycle cost management of highly complex, often adaptive systems. An appreciation for the strength of integrated, multidisciplinary skills, within a structured framework for concept development is a desired outcome of the course. A number of case studies are examined as leading examples for completion of a final class project in systems conceptualization and development management.

**AE 414, Aerospace Structures, 3 cr, 3 cl hrs**

*Prerequisites: MENG 304, MENG 305*

Behavior, analysis and design of discrete and continuous plates and shells, membrane and bending behavior, numerical methods of solution, Composite structures, Macro-mechanics to Structural design and development. Development of analytical procedures for determining material properties. Effective experimental methods and prediction of structural behavior.

**AE 415, Aerodynamics II, 3 cr, 3 cl hrs**

*Prerequisites: AE 411*

The course is covering advanced aerodynamic theories and their application. Includes airfoil shape, drag, velocity, lift, thrust, stability and control. Also included are advanced principles of performance including airplane capabilities and limitations, performance design criteria, load factors, weight and balance, comparative analysis of aircraft and aircraft certification.

**AE 416, Aircraft Flight Dynamics and Controls, 3 cr, 3 cl hrs**

*Prerequisites: ES 332, MATH 254 or equivalent, MATH 335, MENG405, AE 411, AE 412*

The application of aerodynamic surfaces to determine the trajectory and the attitude of flight vehicles involves knowledge of the forces and moments applied to the vehicle from the surrounding media in subsonic, transonic and supersonic flow regimes. Methods of either specifying, or estimating the performance parameters of a flight vehicle, operating in a particular velocity range are introduced, including the critical factors in determining the size, shape and placement of control surfaces, and the forces or torques required to reliably and accurately position such surfaces in desired states. Time-domain methods are taught for simulating flight vehicles and synthesizing robust, stable control schemes.

**AE 417, Aerospace Propulsion, 3 cr, 3 cl hrs**

*Prerequisites: ES 216/MENG 216, ES 347*

Aerospace propulsion can be classified into four categories: propeller, jet, ramjet and rocket propulsion. Among them gas turbine engines and jet propulsion are the essentials for modern aircraft. In this course, the fundamentals of different propulsion systems will be first introduced. Then the course focus will be on gas turbine engines. The material can be divided into four parts: (1) review of thermodynamics and compressible flow; (2) one-dimensional gas dynamics analysis of gas engine performance; (3) analysis and performance of air breathing propulsion system; and (4) the analysis and design of gas turbine engine components, e.g. inlets, nozzles, turbomachinery (compressors, turbines, turbofan, turbopropeller) and combustors. Further, the fundamentals of ramjet and rocket propulsion will be also discussed in this course.

**AE 418, Structural Dynamics in Aerospace Engineering, 3 cr, 3 cl hrs**

*Prerequisites: MATH 231, ES 302, ES 303, AE 414.*

This course explores structural dynamic topics covering a broad range of aerospace applications. Vibration of single and multi-degree-of-freedom systems is reviewed in the context of modeling the aerospace structural systems. Essential structural elements – bars, beams, and plates are addresses in the dynamics of continuous systems section. Structural response to transient, shock, and random loads is discussed and practical aspects of dynamic testing are presented.

**AE 420, Compressible Fluid Flow, 3 cr, 3 cl hrs**

*Prerequisites: ES 216, ES 347, ES 350, MATH 335*

Explanation of the physical phenomena encountered in compressible flow by providing practical applications and examples. Provide the knowledge and understanding of the basic fundamentals of compressible flow and gas dynamics.

**AE 489, Special Topics in Aerospace Engineering, 3 cr, 3 cl hrs****AE 491, Directed Study, cr to be arranged****Explosives Engineering Courses:****EXPL 189 - Beginning Explosives Engineering, 2 cr, 2 cl hrs**

*Prerequisites: none*

This course will introduce the student to the subjects of pyrotechnics and explosives and encompasses subjects including basic combustion chemistry, the physical chemistry of energetic materials, and some test instrumentation. This course also will include a design project.

**EXPL 189 - Beginning Explosives Engineering Lab, 3 lab hrs**

*Prerequisites: none*

This course is based primarily in the laboratory, however, two days will be spent at the Energetic Materials Research and Testing Center working with high explosives

**EXPL 311, Introduction to Explosives Engineering, 3 cr, 3 cl hrs**

*Prerequisites: CHEM 122 and 122L; PHYS 122 and 122L; ES 111 or CS111; ES347 or ES350; or consent of instructor*

Introduction to the broad field of explosives science and technology. Basic organic chemistry, decomposition reactions, properties of explosives, thermodynamics of explosives, shock wave theory, detonation theory, initiators, Gurney equations, blast effects and demolition.

**EXPL 314 Theory and Application of Pyrotechnic, 3 cr, 3 cl hrs**

*Prerequisite: EXPL 311*

Fundamentals of basic concepts of pyrotechnic. Thermo-mechanical/chemical aspects of pyrotechnics, formulation and mixing of pyrotechnic mixtures, application of pyrotechnic including illumination, tracers, incendiaries, delays, etc.

**EXPL 316 Energetic Material Chemistry, 3 cr, 3 cl hrs**

*Prerequisite: EXPL 311*

An introduction to the chemical aspect of energetic materials. Based on basic/advanced chemical and thermo-chemical concepts and dynamics, understand the characteristic and typical properties of energetic materials.

**EXPL 317 Energetic Material Safety, 3 cr, 3 cl hrs**

*Prerequisite: EXPL 311*

Development of the concept of detonation process or Detonation-Deflagration Transition (DDT) mechanics. Analysis of the thermo-dynamic behavior of explosives, hydro hot-spot theory, shock initiation, explosives cook-off, explosive sensitization.

**EXPL 320 Explosives Technology and Applications, 3 cr, 3 cl hrs**

*Prerequisite: EXPL 311*

Focus on the application of explosives mechanics. Fundamentals of explosive welding/cutting, shaped charges, explosive-driven flux-compression generators, spallations, explosives initiation methods, explosives applied testing methods, etc.

**EXPL 412, Wave Propagation, 3 cr, 3 cl hrs**

*Prerequisites: EXPL 311 and MATH 335; or consent of instructor*

An in-depth study of the propagation of waves in various media. The derivation and application of the Rankine-Hugoniot jump equations. The concept of the rarefaction wave and various wave interactions. Derivation and application of the Mie-Grüneisen equation of state. The differential form of the conservation equations, as well as some numerical solutions for simple cases. (Same as ME 549)

**EXPL 413 Impact Dynamics, 3 cr, 3 cl hrs**

*Prerequisites: EXPL 412*

A specialized but very important branch of engineering mechanics deals with the collision of multiple bodies throughout a broad range of relative velocities. The physical phenomenon during impact and subsequent response of each of the bodies is dependent on the mechanical material properties of each, the impact velocities, and the relative size and orientation of each of the bodies. Impact response is most easily categorized based on the impact velocity (relative approach velocity of two bodies), ranging from elastic response with little change in temperature at low velocities, through plastic deformation and/or fracture at higher velocities, to physical state changes of bodies or a portion of a body at hyper-velocity impacts (> 1 km/sec).

**EXPL 414 Explosives Surety, 3 cr, 3 cl hrs**

*Prerequisite: Upper class standing or consent of instructor*

An introduction to explosives and other energetic materials. The basic chemical compositions, properties and environmental effects of commercial, military, and improvised explosives and some pyrotechnics will be compared. The basic physics of shock waves and detonation. Explosive effects, blast detection, tagging and environmental issues. Case studies or recent bombings will be used to describe a variety of terrorist approaches. Safety in handling of explosive materials and classifications for transportation and storage. (Same as ChE 475.)

**EXPL 415 Computer Modeling of Detonations, 3 cr, 3 cl hrs**

*Prerequisite: EXPL 412; or EXPL 311 and MENG 421: or consent of instructor.*

Introduction to the numerical/hydrocode modeling of detonation behaviors. Focus on the area of detonation initiation, behavior of heterogeneous explosives, explosive/propellant performances, experiment interpretations, and numerical expressions of explosives relate theories.

**EXPL 418 Shock Physics and Structural Response to Blast, 3 cr, 3 cl hrs**

*Prerequisite: EXPL 412 or consent of instructor*

An in-depth study of structural behaviors on blast and vibration. Structure damage prediction/estimation, blasting shockwave mitigation methods/concepts, shockwave propagation/properties on structures, structure failure criteria.

**EXPL 419 Experimental and Diagnostic Techniques, 3 cr, 3 cl hrs**

*Prerequisite: EXPL 412*

An introduction to the explosive testing data acquisition systems. Basic concepts of the measurement of detonation product properties and characteristics of detonation process. Analysis of material properties under high pressure shock compression, and data interpretations

**EXPL 419L Explosives Testing and Diagnostic Techniques Laboratory, 1cr., 3 cl. hrs**

*Prerequisite: MENG 545 or EXPL 311 and EXPL 412 or consent of instructor.*

*Co-requisite: EXPL 419*

An introduction to the explosive testing data acquisition systems. Basic concepts of explosives initiation and the measurement/characterization of detonation effects. Experimental analysis of energetic materials and explosives devices utilizing various state-of-art testing equipment. Ultra-high speed camera, VISAR, shock measurement systems, etc. Analysis of material properties under high-pressure shock compression, and data interpretations.

**EXPL 489, Special Topics in Explosives Engineering, 3cr., 3 cl. Hrs****EXPL 491 Directed Study, cr to be arranged****Mechanical Engineering Courses:****MENG 110, 110L Introduction to Mechanical Engineering, 2 cr, 1 cl hr, 3 lab hrs**

*Corequisites: MATH 103 or higher; MENG 110 and 110 L are co-requisites of each other*

A broad overview of mechanical engineering, including an introduction to mechatronics, explosives, thermal and fluid sciences, solid and structural mechanics. Practical hands-on experience using the Mechanical Engineering department's computer-based applications software and lab equipment.

**MENG 216, Engineering Fluid Mechanics, 3 cr, 3 cl hrs**

*Prerequisite: ES 201*

*Corequisite: MATH 231*

Fundamentals of fluid mechanics including fluid statics, velocity of continuous media, continuity, and momentum balance. Introduction of laminar and turbulent flows, similitude, dimensionless analysis, Bernoulli's equation, friction factor, introduction to pump and compressor selection.

**MENG 302L, Mechanics of Materials Laboratory, 1 cr, 3 lab hrs**

*Corequisite: ES 302*

Experiments in mechanics of materials, testing methods, and measurement techniques.

**MENG 304, Advanced Strength of Materials, 3 cr, 3 cl hrs**

*Prerequisites: ES 302 passed with C or better*

Unsymmetrical loading of beams, shear flow and shear center in thin-walled beams, curved beams, thin plates, thick walled cylinders, stress concentrations, thermal stresses, impact loads, and vibration loads. Applying energy methods to various solid mechanics and beam problems.

**MENG 305, Engineering Analysis, 3 cr, 3 cl hrs**

*Prerequisites: ES 216/MENG 216, ES 302; MATH 335; or consent of instructor*

Solution of linear systems of equations using Gaussian elimination and matrix methods. Scalar and vector fields; gradient; divergence; curl; line, surface and volume integrals; Green's theorem and Stokes' theorem. Solutions to partial differential equations from heat transfer, mechanical vibrations, and fluid mechanics using separation of variables, series and Laplace transforms. (Same as ES 305)

**MENG 351L, Fluid and Thermal Sciences Laboratory, 1 cr, 3 lab hrs**

*Prerequisites: ES 216/MENG 216, ES 347, ENGL 341*

*Corequisites: ES 350*

Experimental analysis of fluid flow, heat transfer and thermodynamic systems. CFD tools are used for visualization, validation and comparisons with experimental data. A final project in the field of fluid and thermal sciences is required for each laboratory group. Laboratory reports are presented in oral and written formats.

**MENG 352L, Instrumentation and Measurement Laboratory, 1 cr, 3 lab hrs**

*Prerequisites: ES111, MATH 132*

An introduction to a variety of programming and simulation environments, such as Matlab, Simulink, and LabView. Conduct experiments using instrumentation in conjunction with data acquisition software and hardware, to develop programs simulating systems and reducing data. The underlined direction of this course will be to simulate, observe, and record natural phenomena in the world of mechanical engineering.

**MENG 381, Junior Engineering Design Clinic I, 2 cr, 1 cl hr, 3 lab hrs**

*Prerequisites: ES 216/MENG 216, ES 302; MATH 335; PHYS 122 & 122L; junior standing*

An academic-year-long engineering design project. Organized and directed by a faculty member. Weekly intensive workshops in specialized design topics pertinent to actual design project. Junior-level students are under the direct supervision of the faculty members and the senior-level students assigned to the project.

**MENG 382, Junior Engineering Design Clinic II, 2 cr, 1 cl hr, 3 lab hrs**

*Prerequisite: MENG 381; ENGL 341*

A continuation of MENG 381 academic-year-long engineering design project.

**MENG 405, Dynamic Systems and Controls, 2 cr, 2 cl hrs**

*Prerequisites: ES 332; MENG 305; MATH 335 or consent of the instructor*

*Corequisite: MENG 405L or ES 405L*

A practical survey course examining the basic components of instrumentation, measurement, and process control systems common to the field of engineering. Sensing and measurement (temperature, pressure, flow rate, level, stress-strain, concentration, etc.), signal generation and data acquisition, control loops and controllers, and process control theory.

**MENG 405L, Dynamic Systems and Controls Laboratory, 1 cr, 3 lab hrs**

*Prerequisite: ES 111; MATH 335*

Laboratory exercises involving instrumentation and design of basic control systems.

**MENG 421, Finite Element Analysis and Design, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites: MENG 304 passed with grade C or better;*

Introduction to finite element analysis for structural, heat transfer, and fluid-flow systems. Use of computer-aided design (CAD) to address engineering design problems. Laboratory devoted to CAD operations and its use in complex design problems.

**MENG 431, Fluid and Thermal Systems Design I, 3 cr, 3 cl hrs**

*Prerequisites: MENG 305; ES 350; MATH 335*

Advanced dimensional analysis. Design and synthesis of systems based on application of incompressible fluid flow, heat transfer, design optimization theories, and economics. Design problems to include complex pressure conduit and pipe networks, heat exchangers, dynamic and positive displacement pumps, and hydraulic motors.

**MENG 441, Dynamics and Vibrations in Structural Design, 3 cr, 3 cl hrs**

*Prerequisites: MATH 335 and MENG 305.*

*ES 332 recommended*

Definition of various dynamic loads. Design and synthesis of structural systems and machine members subject to impact and periodic load conditions. Seismic and blast loads on structures. Relevant failure criteria for dynamically loaded systems in structural and mechanism design.

**MENG 451, Design of Machine Elements, 3 cr, 3 cl hrs**

*Prerequisites: ES 303; MENG 304, 305, 381, 382; MATE 202 and 202L*

Principles of design and failure analysis of mechanical machine elements such as fasteners, shafts, columns, and gears. Design of mechanical drives such as roller chains, belts, speed reducers, and hydraulic transmissions.

**MENG 460, Introduction to Biomedical Engineering, 3 cr, 3 cl hrs**

*Prerequisite: Sophomore classification or consent of instructor*

An overview of research in biomedical engineering, biomechanics, biocompatibility, tissue engineering, biomedical instrumentation, and moral and ethical issues.

**MENG 465, Biorheology, 3cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: MENG 351L or consent of instructor*

Concepts of rheology. Rheology of body fluids. Different rheological models of fluids and applications in diagnosis and treatment of diseases. Laboratory experiments of plasma and blood rheological characterization (viscosity, elasticity, plasticity, etc.).

**MENG 481, Senior Engineering Design Clinic I, 3 cr, 1 cl hr, 6 lab hrs**

*Prerequisite: MENG 382*

*Corequisite: MENG 451*

An academic-year-long engineering design project. Organized and directed by a faculty member. Senior-level students are under the direct supervision of the faculty member. Weekly intensive workshops in specialized design topics pertinent to actual design projects. Topics include costing of capital equipment, cost of materials and labor, design optimization concepts, as well as specialized topics. Formal reports, fabrication drawings, and cost estimates prepared and submitted to faculty and outside industrial reviewers. Formal presentation to reviewing group.

**MENG 482, Senior Engineering Design Clinic II, 3 cr, 1 cl hr, 6 lab hrs**

*Prerequisite: MENG 481*

A continuation of MENG 481 academic-year-long engineering design project.

**MENG 483, Mechatronics, 2 cr hr, 2 cl hr**

*Prerequisites: MENG 352L, MENG 405/405L, and MENG 441; or consent of instructor*

*Corequisite: MENG 451 or consent of instructor*

This course is an in-depth examination of the field of mechatronics, which is a consolidation of computer science (software), electrical engineering (microprocessor control), and mechanical engineering (machine design). Topics covered include: system analysis/ control theory, robotics, dynamic systems and control, elements of mechatronics systems, modeling and simulation of mechatronic systems and computer aided mechatronics.

**MENG 483L, Mechatronics Lab, 1 cr hr, 3 cl hr**

*Corequisite: MENG 483*

This is a hands-on lab where the student will design and build a simple mechatronics system. The student will learn the principles of instrumentation and sensors as they relate to the robotic control. The student will also learn the programming methods for the microprocessor controller.

**MENG 484L, Design Clinic Lab, 1 cr, 3 lab hrs**

*Prerequisites: ES or MENG-110, ES or MENG-110L*

*Corequisites: MENG-381 or consent of the instructor*

The Design Clinic Lab Course will introduce students to critical skills important in the engineering design and verification process. Weekly sessions will be conducted in specialized topics pertinent to the design process. Topics include Computer Aided Engineering (CAE), Computer Aided Design (CAD) using Solidworks, mechanical drawing layout, mechanical assemblies, clearances and tolerances, analytical modeling, concepts in machining of components, and the joining of components.

**MENG 485, Advanced Design Clinic, 3 cr, 1 cl hrs, 6 lab hrs**

*Prerequisites: MENG 482*

Enables students to enhance their understanding of the engineering design and verification process for mechanical design projects. Weekly seminars in specialized topics pertinent to the design process. Students focus on developing best practices for completing mechanical design projects. These best practices are used to improve the performance of design clinic project teams. Students participate in design project teams, contributing as senior technical members and/or advisers. Students contribute to the formal reports and oral presentations of these teams.

**MENG 489, Special Topics in Biomedical Engineering, 3 cr, 3 cl hrs**

**MENG 491, Directed Study, cr to be arranged**

## Graduate Courses:

*The major content of these courses is directed toward a Master of Science degree in Mechanical Engineering.*

**MENG 504, Advanced Mechanics of Materials, 3 cr, 3 cl hrs**

*Prerequisite: MENG 304 or equivalent or consent of instructor*

Development of advanced mechanics of materials principles and techniques for use in engineering design and problem solving. Topics include material yielding, torsion, unsymmetrical bending of beams, shear stresses in thin-walled structures, curved beams, beams on elastic foundations, axisymmetric thin-walled shells and thick-walled cylinders, column stability, stress concentrations, and material failure behavior under steady and cyclic loading.

**MENG 515, Theory of Elasticity, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of the instructor*

An introduction to tensor analysis, analysis of stress, balance laws, infinitesimal and finite theories of motion, strain and rotation tensors, compatibility equations, constitutive equations, materials symmetry, uniqueness of the solution, solution of two-dimensional elasticity problems. Airy stress function, application of complex variable technique in elasticity, three-dimensional elasticity problems, energy methods, bending theory of plates. (Same as ME 515)

**MENG 516, Plates and Shells, 3 cr, 3 cl hrs**

*Prerequisites: MENG 305, MENG 451 or approval of the instructor.*

Behavior, analysis and design of discrete and continuous plates and shells, membrane and bending behavior, numerical methods of solution.

**MENG 517/ME 517, Advanced Finite Element Method, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of the instructor*

An introduction to the numerical analysis calculus of variation, weak form of a differential equation, weighted residual techniques, solution of one-dimensional problems by the finite element method, bending problems, Lagrange and Hermite interpolation functions, isoparametric elements, numerical integration, two-dimensional problems, solution of Poisson and Laplace equations, triangular and quadrilateral elements, elasticity problems, theorem of minimum potential energy stiffness matrix, examples. (Same as ME 517)

**MENG 519, Adaptive Structures, 3 cr, 3 cl hrs**

*Prerequisites: MENG 305, Pre/Corequisite MENG 589 or approval of the instructor*

Adaptive structures with embedded intelligent sensors and actuators, self-monitoring and self healing characteristics, biological system/ structures.

**MENG 520, Fracture Mechanics, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of the instructor*

An introduction to the theory of elasticity, singular stress fields, Westergaard method, complex variable technique, stress intensity factor, fracture energy, numerical and experimental methods in determination of stress intensity factor, fracture toughness, J-integral Elasto-plastic fracture. (Same as ME 520)

**MENG 521, Elastic Stability, 3 cr, 3 cl hrs**

*Prerequisite: MENG 304 or consent of the instructor*

Classical theory of elastic stability for beams, plates, and shell structures. Geometric non-linear equations for thin-walled structures. Linear, linearized, and non-linear solutions of problems. Approximate analytic methods and numerical methods for problem solving.

**MENG 522, Mechanics of Inelastic Continuum, 3 cr, 3 cl hrs**

*Prerequisites: MENG 515, MENG 524 or approval of the instructor*

Modeling systems that yield inelastic equations, coupled with methods for their solutions and analysis. Development of insight into the fundamental behavior of inelastic systems.

**MENG 523, Engineering Mechanics of Cellular Structures, 3 cr, 3 cl hrs**

*Prerequisites: MENG 305, Pre/Corequisite MENG 589 or approval of the instructor*

Cellular structures with combinations of mechanical, energy-absorption, thermal and acoustic/vibration characteristics and their implementation in diverse applications.

**MENG 524, Continuum Mechanics, 3 cr, 3 cl hrs**

*Prerequisites: MENG 515, Pre/Corequisite MENG 517 or approval of the instructor*

Matrix, indicial and direct notation, tensor calculus, deformation analysis; general principles of stress, curvilinear coordinates.



**MENG 531, Mechanics of Viscous Fluids, 3cr, 3 cl hrs**

*Prerequisite:* MENG 431 or consent of the instructor

Fundamental laws of motion for a viscous fluid. Navier-Stokes equation. Laminar fluid flow, turbulent boundary layer topics. Compressible and incompressible flow problems.

**MENG 541, Vibrations in an Elastic Continuum, 3 cr, 3 cl hrs**

*Prerequisites:* ES 302, 303; MENG 441; or consent of instructor

Analysis of single and multi degree-of-freedom systems for time dependent loads, including periodic and impact loads. Thin-walled structures—beams, plates, and shells. Dynamic stability of thin-walled structures.

**MENG 544, Modern Control Theory, 3 cr, 3 cl hrs**

*Prerequisites:* MENG 405 or consent of instructor

Designing and analyzing modern control systems that can be devised from dealing exclusively in the time domain. Methods of expanding control concepts from simple single-input single-output processes to full multi-input multi-output, continuous and discrete, linear and nonlinear systems will be explored. Students will submit a semester-long research paper.

**MENG 545, Introduction to Explosives Engineering, 3 cr, 3 cl hrs**

*Prerequisites:* ES 216, ES 302 and ES 347; or consent of instructor

Introduction to the broad field of explosives science and technology. Basic organic chemistry, decomposition reactions, properties of explosives, thermodynamics of explosives, shock wave theory, detonation theory, initiators, Gurney equations, blast effects and demolition. Students will submit a semester-long research report.

**MENG 546, Detonation Theory, 3 cr, 3 cl hrs**

*Prerequisites:* MENG 549 or consent of instructor. MENG 556 recommended.

Development of classical detonation model for full order detonation of secondary explosives. Ideal versus non-ideal detonation. Burn-rate models for pyrotechnics. The concept of deflagration to detonation transition. (Same as ME 546)

**MENG 547, Theory and Application of Pyrotechnics, 3 cr, 3 cl hrs**

*Prerequisites:* MENG 545 or consent of instructor

Fundamentals of basic concepts of pyrotechnic. Thermo-mechanical/chemical aspects of pyrotechnics, formulation and mixing of pyrotechnic mixtures, application of pyrotechnic including illumination, tracers, incendiaries, delays, etc.

**MENG 548, Manipulator Based Robotics, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite:* MENG 405 or equivalent or consent of instructor

Fundamentals of the multi-disciplinary field of robotics. Emphasis is placed on understanding how to model and control robotic manipulators while providing an appreciation of the importance of sensing to robotic applications. Topics include: forward, inverse, and motion kinematics; dynamic modeling; position, velocity, and force control. Shares lecture/lab with EE 448, but is graded separately, and additional graduate-level work is required. (Same as EE 548)

**MENG 549, Wave Propagation, 3 cr, 3 cl hrs**

*Prerequisites:* MENG 545 and MATH 335; or consent of instructor

An in-depth study of the propagation of waves in various media. The derivation and application of the Rankine-Hugoniot jump equations. The concept of the rarefaction wave and various wave interactions. Derivation and application of the Mie-Grüneisen equation of state. The differential form of the conservation equations, as well as some numerical solutions for simple cases. (Same as ME 549)

**MENG 550, Advanced Explosives Engineering, 3 cr, 3cl hrs**

*Prerequisites:* MENG 549 or consent of instructor

The detonation of non-ideal explosives, equation of state for porous media, shaped charge effect and explosively formed projectiles. Shock compaction of powders, explosive welding and experimental methods used in the evaluation of explosives and their applications. The dynamic fracture of ductile and brittle materials. (Same as ME 550)

**MENG 551, Optimal Control Systems, 3 cr, 3 cl hrs**

*Prerequisites:* ES 332, MATH 254 or equivalent, MATH 335, MENG 405

Formulation of stochastic dynamic systems models, combined with optimal full-state and reduced-state estimators are introduced. Various cost functionals are defined and used to design real-time control algorithms that produce specific desired system responses. Mathematical measures of control robustness are defined which allow the student to gain an appreciation for predicting and measuring system stability margins under sub-optimal conditions.

**MENG 552, Explosives Technology and Applications, 3 cr, 3 cl hrs**

*Prerequisites: MENG 545 or consent of instructor*

Focus on the application of explosives mechanics. Fundamentals of explosive welding/cutting, shaped charges, explosive-drives flux compression generators, spallations, explosives initiation methods, explosives applied testing methods, etc. Students will submit a semester-long research report.

**MENG 553, Computer Modeling of Detonations, 3 cr, 3 cl hrs**

*Prerequisites: MENG 519 or consent of instructor. MENG 517 is recommended.*

Introduction to hydrodynamic modeling applied to explosives. Numerical methods for modeling shock physics, detonation, and material response. Finite difference, finite element and smoothed particle hydrodynamic methods, equation of state and strength models, and numerical fracture and fragmentation. (Same as ME 553)

**MENG 554, Embedded Control Systems, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisites: EE 308 or EE 443 or MENG 405 or equivalent or consent of instructor*

Micro-controller or microcomputer based embedded control systems. A comparative survey of currently available embedded computers/controllers including SBC's, PIC's, basic-stamps, and single-chip computer solutions. Real time operating systems including real-time LINUX, and hard real-time process requirements. Projects will include the implementation of an embedded real-time control solution. (Same as EE 554)

**MENG 555, Shock Physics and Structural Response to Blast, 3 cr, 3 cl hrs**

*Prerequisites: MENG 549 or consent of instructor*

An in-depth study of structural behavior during blast and vibration. Structure damage prediction/estimation, blasting shockwave mitigation methods/concepts, shockwave propagation/properties on structures, structure failure criteria. Students will submit a semester-long research report.

**MENG 556 Compressible Fluid Flow, 3 cr, 3 cl hrs**

*Prerequisites: ES 216/MENG 216, ES 347, ES 350, MENG 431, MATH 335*

Explanation of the physical phenomena encountered in compressible flow by providing practical applications and examples. Provide the knowledge and understanding of the basic fundamentals of compressible flow and gas dynamics.

**MENG 557, Multiphase Flow, 3 cr, 3 cl hrs**

*Prerequisites: MENG 431 or equivalent or consent of the instructor*

Selected topics in multiphase flows with emphasis on engineering applications. Topics include basic two-phase flow equations, pressure drop in two-phase flow, gas-liquid, gas-solid and liquid-solid two-phase flows.

**MENG 558, Non-Newtonian Fluid Mechanics, 3 cr, 3 cl hrs**

*Prerequisite: consent of the instructor*

This course offers the specific techniques and understanding necessary for being able to compute and understand issues associated with non-Newtonian fluid dynamics. Issues of rheology and analytic techniques are covered.

**MENG 559, Theory and Design of Internal Combustion Engines, 3 cr, 3 cl hrs**

*Prerequisites: ES 347, ES 350, MENG 304, MENG 421, or consent of the instructor*

Thermodynamic analysis and performance characteristics of spark ignition and compression ignition engines. Effects of thermodynamics, heat transfer and combustion on engine power, efficiency and emissions. Design of internal combustion engines; stress analysis, kinematics and dynamics of the crank mechanism, design of piston, connecting rod and crankshaft.

**MENG 560, Principles of Combustion, 3 cr, 3 cl hrs**

*Prerequisites: ES 347 or consent of the instructor*

Covers the fundamentals of combustion. Topics include chemical reactions, calculation of adiabatic flame temperature, chemical kinetics and flammability limit, characteristics of premixed, diffusion, laminar and turbulent flames.

**MENG 567, Smart Engineering Systems, 3 cr, 3 cl hrs**

*Prerequisites: MATH 254, 382; CSE 344; or equivalent; or consent of instructor*

Artificial neural networks, with emphasis on multiplayer feedback networks, self-organizing networks, and Hopfield-style networks. Learning algorithms. Introduction to fuzzy systems and evolutionary computing. Engineering applications of soft computing.

**MENG 568, Smart Engineering Systems II, 3 cr, 3 cl hrs**

*Prerequisites: MATH 254, 382; CSE 344; or equivalent; or consent of instructor*

Overview of the major paradigms of soft computing: neural networks, fuzzy systems, and evolutionary computing. In-depth coverage of selected topics in each area as relevant to intelligent systems. Recent advances in the field, and case studies of intelligent systems. Coursework includes a large-scale project.

**MENG 570, Advanced Mechatronics, 3 cr, 3 cl hrs**

*Prerequisite: MENG 405 or EE 443 or equivalent or consent of instructor*

The theory, design, manufacture and use of instrumentation and control in the various sciences. The use of electrical and electronic instruments and equipment to measure, monitor and/or record physical phenomena. Measurements of force, mass dimension, strain; displacement, velocity, and acceleration; tensile, impact and comprehensive strength; temperature and thermal properties; time and frequency; thrust and torque; pressure vacuum and flow; electrical quantities; photo-optics and radiation.

**MENG 572, Sensor Technology, 3 cr, 3 cl hrs**

*Prerequisites: ES 332 and MENG 405, or EE 443 or equivalent, or consent of instructor*

The operating principles and properties of sensors/transducers for the measurement of physical quantities in the mechanical domain, as well as the associated interface circuits. Focus is on commercially available sensors, but where appropriate, recent trends toward miniaturization, integration, and higher quality performance will be addressed.

**MENG 574, Electrical Measurements of Non-Electrical Quantities, 3 cr, 3 cl hrs**

*Prerequisites: ES 332 and MENG 405, or EE 443 or equivalent, or consent of instructor*

This course is particularly reliant on advances in scientific knowledge. Establishment of units and scales of measurement, their development, realization, maintenance and dissemination, as well as the performance of traceable measurements. Hence, this course serves a key factor of modern manufacture through automation, which both enhances productivity and ensures consistent quality. The demand for improved and assured quality means ever better instrumentation. Focus on the course will be on measurement science, design principles for instrument systems, electrical measurements of thermal quantities, electrical measurements of mechanical quantities, electrical measurements of optical quantities, and electrical measurements of chemical quantities.

**MENG 575, Advanced Engineering Mathematics, 3 cr, 3 cl hrs**

*Prerequisites: MENG 305 or consent of the instructor*

A comprehensive study of applied mathematics. Vector analysis, tensors and Eigenvalue problems. Analytical solutions to linear ordinary and partial differential equations. Separation of variables, boundary value problems, and Laplace and Fourier transforms. Numerical analysis of non-linear ordinary and partial differential equations with emphasis on engineering applications. Complex Analysis; complex numbers, Cauchy-Riemann equations and conformal mapping.

**MENG 576, Biomedical Mechatronics, 3 cr, 3 cl hrs**

*Prerequisites: MENG 405 or EE 443 or ES 332 or equivalent or consent of instructor*

This course will give students direct experience with computational tools used to create simulations of human movement. Lectures and labs cover animation of movement; kinematic models of joints; forward dynamic simulation; computational models of muscles, tendons, and ligaments; creation of models from medical images; control of dynamic simulations; collision detection and contact models. The course is intended as an introduction to medical device design for graduate engineering students because the class will have a significant design and prototyping emphasis.

**MENG 577, Advanced Fluid Mechanics, 3 cr, 3 cl hrs**

*Prerequisites: MENG 431 or equivalent*

*Corequisite: MENG 575*

Fundamental concepts and analysis of Fluid Mechanics. Derivation of the partial differential equations governing the conservation of mass, momentum and energy. Introduction to potential flows. Exact solutions of the Navier-Stokes equations. Laminar and turbulent boundary layers. Compressible and incompressible flow problems.

**MENG 578, Advanced Thermodynamics, 3 cr, 3 cl hrs**

*Prerequisites: ES 347 or consent of the instructor*

The first and second laws of thermodynamics. Clapeyron relation, availability concepts and analysis, equations of state, non-reacting mixtures and thermodynamics of chemical reactions.

**MENG 579, Advanced Heat Transfer, 3 cr, 3 cl hrs**

*Prerequisites: ES 350 or consent of the instructor*

Covers analytical and numerical techniques in conduction, convection, radiation with emphasis on combined heat transfer.

**MENG 580, Computational Fluid Dynamics and Reactive Flow, 3 cr, 3 cl hrs**

*Prerequisites: MENG 560, MENG 577 or consent of the instructor*

Introduction to Computational Fluid Dynamics and application of CFD tools to thermal and fluid flow problems. Coupling of fluid flow with combustion chemistry. Discussion of combustion modeling, importance of the mixing intensity, heterogeneous and homogeneous chemical reactions, and application of computer analysis to chemically reacting flow problems.

**MENG 581, Directed Study, cr to be arranged**

**MENG 582, Nondestructive Evaluation and Structural Health Monitoring, 3 cr, 3 cl hrs**

*Prerequisites: MENG 304, MENG 305, MATH 335 or consent of instructor.*

This multi-disciplinary course introduces key physical concepts in elasticity, material science, acoustics, optics, and electromagnetics applied to system condition monitoring, material characterization, structural damage detection and failure prevention. A broad spectrum of nondestructive evaluation (NDE) methods and emerging structural health monitoring (SHM) technologies is discussed including the ultrasonic inspection, vibration monitoring, acoustic emission, radiography, eddy currents, electrical and magnetic testing. Examples of practical NDE/SHM applications in scientific research and industrial practice are presented.

**MENG 583, Engineering Mechanics of Composite Structures, 3 cr, 3 cl hrs**

*Prerequisites: MENG 305, Pre/Corequisite MENG 523 or consent of the instructor*

Composite structures, Macro-mechanics to Structural design and development. Development of analytical procedures for determining material properties, effective experimental methods and prediction of structural behavior.

**MENG 585, Graduate Seminar, 1 cr**

**MENG 586, Advanced Topics in Engineering Science, 2 - 3 cr each semester**

*Prerequisites: MENG 549 or consent of the instructor*

**MENG 589, Impact Dynamics, 3 cr, 3 cl hrs**

*Prerequisites: ES 303, ES 305, MENG 305 or equivalent*

A specialized but very important branch of engineering mechanics deals with the collision of multiple bodies throughout a broad range of relative velocities. The physical phenomenon during impact and subsequent response of each of the bodies is dependent on the mechanical material properties of each, the impact velocities, and the relative size and orientation of each of the bodies. Impact response is most easily categorized based on the impact velocity (relative approach velocity of two bodies), ranging from elastic response with little change in temperature at low velocities, through plastic deformation and/or fracture at higher velocities, to physical state changes of bodies or a portion of a body at hyper-velocity impacts (> 1 km/sec).

**MENG 590, Independent Study, cr to be arranged**

**MENG 591, Thesis (master's degree), cr to be arranged**

## Faculty Teaching & Research Interests

Bakhtiyarov—Non-Newtonian Fluid Mechanics, Heat and Mass Transfer, Rheology, Multiphase Flows, Instrumentation, Fluidized Beds, Porous Medium Flows, Nanotechnology, Self-Healing Materials, Tribology, Turbulence

Cooper - Explosives Technology, Explosives Engineering

Dinwiddie - Dynamic Antenna Modeling

Field – Structural dynamics, random vibration, applied probability, computational modeling, model validation, and robust control

Gerity—Robotics, System Integration, Technology Turnkey and Licensing

Ghosh—Macro Behavior of Composites, Biomechanics, Finite Element Analysis, Experimental Mechanics and Instrumentation, Structural Health Monitoring and Restoration, Construction Materials and Project Management

Ibragimov – Applied Mathematics, Fluid Mechanics, Engineering Mathematics

Kennedy - Basic Science and Applications of Explosives, especially in Microdetonics and Initiation of Detonation in Explosives

Kutelia – Mechanics of Materials, Self-Healing Materials, Nanotechnology

Lim-Energetic Materials, Explosives Technology, Linear and Conical Shaped Charges

Marcy—General Aviation, Conceptual Design

Melof—Energetic Materials, Synthesis of Explosives, Explosives Chemistry

Meason – Explosives Technology

Miller, A. – Finite Element Analysis, Explosive Synthesis of Materials, High-temperature Systems

Miller, A.K. – System Dynamics, System Modeling and Simulation, Actuators and Actuator Controls

Ostergren—Mechanics of Materials, Structural Analysis, Machine Design, Propulsion and Power Systems

Rivera – Energetic Materials, Explosives Technology

Ruff – Mechanics of Materials, Instrumentation

Scarborough – Machining and Metalworking Technology

Shuter – Solid Mechanics

Stofleth – Instrumentation and Measurements, Explosives Technology

Yilmaz - Computational Fluid Dynamics, Reactive Flow, Combustion and Chemical Kinetics, Fire Modeling, Internal Combustion Engines, Wetsteking, PAH and Soot Formation in Diesel Engines, Alternative Fuels

Zagrai--Structural Dynamics and Acoustics, Intelligent Systems and Structures, Sensor Networks, Structural Health Monitoring and Nondestructive Evaluation.

# Mineral Engineering

*Professor Chávez, Fakhimi, N. Mojtabai (Chair of the Department)*

*Associate Professor Razavi*

*Adjunct Faculty, Gundiler, Kozushko, Kuhn, McLemore, Wimberly, Walder*

*Emeritus Professor Oravec, Aimone-Martin*

**Degrees Offered: B.S. in Mineral Engineering; B.S. in Mineral Engineering with Emphasis in Explosives Engineering; M.S. in Mineral Engineering**

## Department Mission Statement

- To provide the students with an education in the fundamentals of engineering that will allow immediate entry into industry or research work while providing a good opportunity for continued professional growth.
- To maintain a team of faculty who are committed to providing high quality of teaching and research.
- To prepare the students for the challenges of establishing a successful diversified career in the rapidly changing professional environment.

## Program Educational Objectives

- 1) Continue to inspire, as a primary goal, creativity in thinking and skills in problem solving to assist industry in meeting daily challenges as they advance in their professional career.
- 2) Maintain a strong sense of ethical and professional responsibilities with a sense of social awareness
- 3) Continue to develop excellence in oral and written communication skills
- 4) Demonstrate skills in leadership and ability to work independently as well as in the framework of a team
- 5) Achieve a measurable advancement in professional duties and salaries and be capable of demonstrating continued professional growth within the first seven years after graduating.

Mineral engineering is concerned with the exploration for and development of minerals and earth materials in the most efficient manner while protecting the environment. The undergraduate program is oriented toward developing the student's understanding of, and skill in, engineering design. Proficiency in project management and leadership are encouraged through coursework and projects that emphasize professional-quality written and oral communication skills. The objective of the program is to provide the student with an education in the fundamentals of engineering that will allow immediate entry into industry or research work while providing a good opportunity for continued professional growth. Emphasis is placed on developing a responsible

professional with a sense of social awareness.

The curriculum includes basic engineering principles that provide the foundation for applied engineering design concepts. The program provides a concentrated study in mechanics, mineral evaluation and economics, ground and environmental control, environmental issues, and project management. Engineering design is introduced in courses covering surface and underground mining, ventilation, mineral processing, equipment selection, drilling and blasting, soil and rock mechanics, hydraulic structures, and geomechanics. Instruction in the environmental aspects of minerals development and production include mine permitting and reclamation, extending to the legal issues and concerns in natural resources development.

A large-scale design project is undertaken in the senior year. This project integrates engineering principles and design in one of three areas: economic evaluation and exploration for mineral properties; design and planning of a mining project; or the planning and implementation of geotechnical construction projects, such as landfills, tailings impoundments, earth dams, and structures.

The department has modern well-equipped laboratories for instruction and research in soil and rock mechanics, ventilation, blast vibrations, mineral evaluation, and computer applications. The department also maintains its own experimental underground mining facility to allow students valuable hands-on experience in solving mineral engineering problems. Students are provided the opportunity to work on a wide range of applied research projects within both the department and the Institute. Students are encouraged to obtain summer jobs available in mines across the Southwest, providing excellent industrial experience.

## Undergraduate Program

### Bachelor of Science in Mineral Engineering

Minimum Credit Hours Required—132

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

- MATH 231 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 216 (3), 302 (3), ES 303 or 347
- EARTH 101 & 103L, 200 (4)
- ME 101 (1), 220 (3), 320 (2), 340 (3), 360 (3), 380 (6), 410 (3), 413 (3), 419 (2), 420 (3), 422 (3), 440 (2), 442 (4), 462 (3), 470 (1), 471 (2)
- Technical Elective (3)

All engineering majors are required to take the Fundamentals in Engineering (FE) exam as a requirement for graduation.

## Bachelor of Science in Mineral Engineering with Emphasis in Explosives Engineering

Minimum credit hours required—141

In addition to the General Education Core Curriculum (page 100), the following courses are required:

- MATH 231 (4), 335 (3)
- ES 110 (2), 111 (3), 201 (3), 216 (3), 302 (3), ES 303 or 347 (3)
- EARTH 101 & 103L (4), 200 (4)
- ME 101 (1), 220 (3), 320 (2), 340 (3), 360 (3), 380 (6), 410 (3), 413 (3), 419 (2), 420 (3), ME 422 (3), 440 (2), 442 (4), 462 (3), 470 (1), 471 (2)
- Technical Elective (3),
- Three courses from: ChE 475 (3), ME 434 or ME 535 (3), MENG 441 (3), ME 545 (3), MENG 545 (3)

Students are strongly encouraged to do their senior design project in the area of Explosive Engineering or related projects

### Minor in Mineral Engineering

Minimum credit hours required—19

Chosen from the following courses:

ME 220 (3), ME 320 (2) or ES 216 (3), ME 340 (3), ME 360 (3), ME 380 (6), ME 410 (3), ME 413 (3), ME 419 (2), ME 420 (3), ME 422 (3), ME 435 (3), ME 440 (2), ME 442 (4), ME 462 (3)

### Sample Curriculum for the Bachelor of Science in Mineral Engineering

#### Semester 1

- 1 ME 101 (intro)
- 4 EARTH 101 & 103L (earth processes)
- 4 MATH 131 (calculus)
- 4 CHEM 121 & 121L (general)
- 3 ENGL 111 (college English)
- 2 ES 110 (intro)
- 18 Total credit hours

#### Semester 2

- 3 ES 111 (intro)
- 4 MATH 132 (calculus)
- 4 CHEM 122 & 122L (general)
- 3 ENGL 112 (college English)
- 3 Social Science/Humanities
- 17 Total credit hours

#### Semester 3

- 5 PHYS 121 & 121L or 221 & 221L (general)
- 4 MATH 231 (calculus)
- 4 ES 201 (statics)
- 3 Social Science/Humanities
- 15 Total credit hours

#### Semester 4

- 5 PHYS 122 & 122L or 222 & 222L (general)
- 4 EARTH 203 (Earth's Crust)
- 3 ES 302 (strength of materials)
- 3 ME 220 & 220L (surveying & map preparation)
- 2 ME 320 (economic analysis)
- 17 Total credit hours

#### Semester 5

- 3 ES 216 (fluids)
- 3 ME 360 (exploration and field mapping)
- 3 ME 340 (geostatistics and mineral evaluation)
- 3 ENGL 341 (technical writing)
- 3 ME 420 & lab (soil mechanics)
- 3 Humanities/Social Science
- 18 Total credit hours

#### Semester 6

- 6 ME 380 (mine systems)
- 3 ME 410 & 410L (environmental issues)
- 3 ME 413 (foundation engineering)
- 3 ME 422 & lab (rock mechanics)
- 15 Total credit hours

#### Semester 7

- 1 ME 470 (senior design I)
- 3 ME 442 (applied geomechanics)
- 3 MATH 335 (applied analysis)
- 3 Technical Elective
- 2 ME 440 (mine ventilation)
- 3 Humanities/Social Science
- 15 Total credit hours

#### Semester 8

- 3 ME 462 (mineral deposits)
- 2 ME 442 & 422L (applied geomechanics)
- 2 ME 471 (senior design II)
- 3 ES 347 (thermodynamics) or ES 303 (dynamics)
- 3 Humanities/Social Science
- 3 Humanities/Social Science
- 16 Total credit hours

## Graduate Program

### Master of Science in Mineral Engineering

Admission to the Master of Science in Mineral Engineering program requires competence in mathematics, chemistry, physics, and engineering science comparable to the bachelor of science degree in mineral engineering. Applicants without an engineering degree may apply for the graduate program in Mineral Engineering. However, the student will be required to take ES 201, ES 302, and ME 420. Any other deficiencies may have to be covered as required the advisory committee.

The student's course of study must be approved by the student's advisory committee and fulfill the general requirements for the master's degree.

Of the 30 hours required for the M.S. degree, a minimum of 12 credit hours must be in approved Mineral Engineering courses. All graduate students must complete at least one credit of ME 572 (graduate seminar). Under special consideration, a student may petition the advisory committee with approval of the Department Chair to pursue a Master of Science degree with Independent Study (three hours of ME 590). A formal paper will be submitted with an oral presentation to the advisory committee.

The student may select one area of specialization as outlined below; within each specialization, recommended courses are provided.

#### Specialization in Mineral Exploration

At least 12 credits selected from ME 511, ME 521, ME 522, ME 523, ME 551, ME 562, ME 563. Other courses can be substituted with the approval of the research advisor and committee.

#### Specialization in Geotechnical Engineering

At least 12 credits selected from ME 506, ME 508, ME 512, ME 515 or MENG 515, ME 517 or MENG 517, ME 520, ME 525, ME 531, ME 532, ME 543, ME 535, ME 537, ME 540. Other courses can be substituted with the approval of the research advisor and committee.

#### Specialization in Explosive Engineering

At least 12 credits selected from ME 534, ME 545, ME 546, or MENG 546, ME 548, ME 549 or MENG 549, ME 550 or MENG 550, ME 553 or MENG 553. Other courses can be substituted with the approval of the research committee and the department.

## Mineral Engineering Courses:

**ME 101, Introduction to Mineral Engineering, 1 cr, 1 cl hr**

The fundamentals of geology and mineral resource exploration and development applied to engineering. The role of the mineral engineer in mining, exploration, and geotechnical engineering. Field trips to mining and construction operations as well as guest speakers from industry, government, and research.

**ME 215, Health and Safety, 2 cr, 2 cl hrs**

*Offered on demand*

The roles of health and safety in the construction, operation, and maintenance of extractive mineral facilities. Federal and state health and safety codes. Laboratory and field work.

**ME 220, Surveying and Map Preparation, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites: MATH 103, 104*

Surveying instruments and measurement techniques. Data acquisition by means of advanced surveying methods for map production. Layout design and measurements. Correlations of surface and underground surveys.

**ME 315, Mining Lab, 2 cr, 1 cl hr, 2 lab hrs**

*Prerequisite: Consent of instructor*

*Offered on demand*

An introduction and hands-on experience in underground mine work: health and safety, support placement, mucking, dewatering, mapping and surveying. All classes are held at the department's experimental mine (Waldo mine).

**ME 320, Economic Analysis, 2 cr, 2 cl hrs**

*Corequisite: MATH 131*

Economic principles applied to decision-making problems in mineral engineering. Compound interest, depreciation, present worth and rate of return pertinent to project evaluation.

**ME 340, Geostatistics and Mineral Evaluation, 3 cr, 2 cl hr, 2 lab hrs**

*Prerequisites: ES 111; ME 320*

Introduction to statistics. Obtaining, evaluating, and presenting mineral resource information. Ore reserves estimation using geometric weighting techniques and geostatistical methods. The use of computers is emphasized.



**ME 360, Exploration and Field Mapping, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites:* EARTH 203; ME 220

*Corequisite:* ENGL 341

The acquisition and presentation of field geological data applied to engineering site characterization and mineral exploration. Data presentation. Elements of exploration techniques including field applied mineralogy, geophysics, structural geology, geochemistry, drilling and sampling, and mapping. Laboratory reports and oral presentations.

**ME 380, Mine Systems, 6 cr, 4 cl hrs, 6 lab hrs**

*Prerequisite:* ME 340, ME 320, or ES 316

Surface and underground mining methods and design; drilling and blasting design; materials handling and equipment selection. Concepts of mine plant design. Emphasis on computer applications.

**ME 409, Design of Structures, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* ES 302

*Offered on demand*

Reinforced concrete; concrete design, beams, slabs, retaining walls, columns, and footings. Grouting and shotcreting. Structural steel design: tension members, beams, columns, bolted and welded connections, frames, and trusses. Rock bolting. Rigging. PC applications. Student presentations on selected topics. A design project is required.

**ME 410, Environmental Issues, 3 cr, 3 cl hrs**

*Prerequisites:* ME 380

*Corequisite:* ME 413

Mine waste characteristics; regulations affecting mine operations; site selection, design and stability analysis of tailings impoundments. Water quality issues and control in mining. Mine waste management. Mine permitting requirements and reclamation. Design projects.

**ME 413, Foundation Engineering, 3 cr, 3 cl hrs**

*Prerequisite:* ME 420

Principles of soil mechanics and foundation engineering. Immediate and time dependent settlements, service loads, lateral loads, loading, approximate analysis methods, performance requirements, shallow foundations, lateral earth pressure, design of retaining walls, deep foundations, special footings, slope stability, and computer modeling of foundations. (Same as CE 413).

**ME 419, Legal Aspects of Mineral Engineering, 2 cr, 2 cl hr**

*Prerequisite:* Senior standing or consent of instructor

A comprehensive study of laws pertaining to the exploration, planning, and development for resource extraction including minerals and water. Mineral and water rights issues will be presented and debated. A case study paper will be presented.

**ME 420, Soil Mechanics, 3 cr, 2 cl hrs, 3 lab hrs**

*Corequisites:* ES 302

Phase relationships, soil classification, clay mineralogy, compaction, flow of water in soils, effective stress, Mohr circle, stress-strain relationships and failure criteria, Mohr-Coulomb failure criterion, shear strength, consolidation, and consolidation settlement.

**ME 421, Applied Economic Geology, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* EARTH 203

*Offered on demand*

Lithologic and lithochemical characterization of metalliferous ore deposits through the use of ore and alteration sample suites collected from various classes of deposits. Identification of hand specimen mineralogy; thin section and polished section analyses to establish paragenesis of both ore and gangue mineralization. Theoretical considerations ascertained by use of appropriate phase diagrams. Interpretation of wallrock alteration and characteristics of mineral paragenesis for major ore deposit types. Design and implementation of mineral exploration using field and laboratory observations.

**ME 422, Rock Mechanics, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites:* ME 420

Mechanical properties of intact rock and rock masses, classification of rock masses for engineering purposes, rock failure criteria, in situ stress measurement techniques, rock deformability. Labs consists of sample preparation, point load test, Brazilian test, Uniaxial test, and Triaxial test.

**ME 427, Site Investigation, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* ME 420

*Offered on demand*

Design of engineering site investigation for project planning and construction; acquisition, presentation, and interpretation of geologic field data for engineering design. Design concepts for rock and soft ground tunneling, rock slopes, tailings dams, landslides, ground subsidence, collapsible and swelling soils. Computer-aided data reduction and design.

**ME 434, Drilling and Blasting Engineering, 3 cr, 3 cl hrs**

*Prerequisite:* ES 302

*Offered on demand*

Introductory course in the application of explosives to rock fragmentation; theory of detonation and mechanisms of rock failure, dynamics, and propagation. The effects of rock properties on breakage. Blasting systems and production blasting techniques used in both surface and underground designs; environmental considerations and regulations. Principles of blasthole drilling and drill performance. Drilling and blasting economics.

**ME 435, Mineral Processing, 3 cr, 3 cl hr, 2 lab hrs**

*Prerequisites:* ME 380; ES 216

Theory and practice of concentration of ores and industrial minerals. Crushing, grinding, sizing, gravity separation, flotation, leaching, solid-liquid separations.

**ME 440, Mine Ventilation, 2 cr, 2 cl hrs**

*Prerequisite:* ME 380; ES 216

Control of underground environmental problems; dusts, gases, temperature, and humidity. Analysis of natural and mechanical ventilation systems and equipment. Measurement techniques

**ME 442, Applied Geomechanics, 4 cr, 3 cl hrs, 3 lab hrs**

*Prerequisite:* ME 422

Analysis and design of structures and excavations in geological media on surface and underground. Geologic and geotechnical data collection and analysis. Rock slope stability, modes of failure, and stabilization. Application of rock mass classification systems, stress analysis, structural geology to design of underground excavations and tunneling. Support and reinforcement design. Geological hazards and remedial measures. Design projects.

**ME 462, Mineral Deposits, 3 cr, 2 cl hrs, 2 lab hrs**

*Prerequisite:* EARTH 203

Ore formation processes and ore mineralogy; geologic and geochemical characterization of ore deposits using hand specimen, petrographic, and field mapping techniques. Visits to prospects and operating mines to observe variations in ore deposit characteristics to document geologic and geochemical parameters used to describe ore-forming systems. (Same as EARTH 462)

**ME 470, Senior Design I, 1 cr, 1 cl hr**

*Prerequisites:* Senior standing and consent of instructor

Initiation of senior design project including written and oral project proposal; estimation of project design requirements and costing. Preliminary data acquisition and evaluation. Design topics are selected from mineral exploration, mine or geotechnical engineering.

**ME 471, Senior Design II, 2 cr, 2 cl hrs**

*Prerequisite:* ME 470 passed with a grade of "C" or better.

Continuation of design projects initiated in ME 470; implementation and evaluation of design details including cost analysis. Preparation of final project report with written and oral professional-style presentations.

**ME 491, Directed Study, 1–4 cr as arranged**

Special projects or topics in mining or geological engineering.

**ME 500, Directed Research, cr to be arranged**

This course may not be used to fulfill graduate degree requirements.

Research under the guidance of a faculty member.

**ME 505, Graduate Seminar, 1 cr****ME 506, Soil Mechanics, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites:* Consent of instructor

Phase relationships, soil classification, clay mineralogy, compaction, flow of water in soils, effective stress, Mohr circle, stress-strain relationships and failure criteria, Mohr-Coulomb failure criterion, shear strength, consolidation, and consolidation settlement.

**ME 508, Rock Mechanics, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisites:* consent of instructor

Mechanical properties of intact rock and rock masses, classification of rock masses for engineering purposes, rock failure criteria, in situ stress measurement techniques, rock deformability. Labs consists of sample preparation, point load test, Brazilian test, Uniaxial test, and Triaxial test.

**ME 511, Mineral Economics, 3 cr, 3 cl hrs**

*Prerequisite:* ES 316 recommended, or consent of instructor

Domestic and international mineral statistics, marketing, trade, conservation, and taxation. Energy economics. Labor economics. Economic calculations for feasibility studies on mineral properties. Participants prepare and present professional-style reports on international mineral development.

**ME 512, Advanced Rock Mechanics, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite:* ME 420 or consent of instructor

Three-dimensional continuum mechanics. Basic theoretical solutions of idealized excavations. Numerical methods applied to design and stability analysis of excavations. Selected topics.

**ME 515, Theory of Elasticity, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of the instructor*

An introduction to tensor analysis, analysis of stress, balance laws, infinitesimal and finite theories of motion, strain and rotation tensors, compatibility equations, constitutive equations, materials symmetry, uniqueness of the solution, solution of two-dimensional elasticity problems. Airy stress function, application of complex variable technique in elasticity, three-dimensional elasticity problems, energy methods, bending theory of plates. (Same as MENG 515)

**ME 517, Advanced Finite Element Method, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of the instructor*

An introduction to the numerical analysis calculus of variation, weak form of a differential equation, weighted residual techniques, solution of one-dimensional problems by the finite element method, bending problems, Lgrange and Hermite interpolation functions, isoparametric elements, numerical integration, two-dimensional problems, solution of Poisson and Laplace equations, triangular and quadrilateral elements, elasticity problems, theorem of minimum potential energy stiffness matrix, examples. (Same as MENG 517)

**ME 520, Fracture Mechanics, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of the instructor*

An introduction to the theory of elasticity, singular stress fields, Westergaard method, complex variable technique, stress intensity factor, fracture energy, numerical and experimental methods in determination of stress intensity factor, fracture toughness, J-integral Elasto-plastic fracture. (Same as MENG 520)

**ME 521, Advanced Minerals Exploration, 3 cr, 3 cl hrs**

*Prerequisite: ME 360 or consent of instructor*

Practical application of geologic, geochemical, and geophysical exploration techniques to ore search. Remote sensing technology and integration into grassroots exploration programs. Recent developments in geophysical and geochemical prospecting. Case histories. Field application of mineral exploration techniques.

**ME 522, Advanced Mineral Exploration Field Mapping, 3 cr, 2 cl hrs, 2 lab hrs**

*Prerequisite: ME 360 or consent of instructor*

Detailed mapping of mineral deposits and prospects in collaboration with professional exploration geologists and engineers with application to minerals exploration. Design and implementation of orientation surveys. Field studies will include geochemical and geological laboratory analysis. Written reports and oral presentation of projects will be reviewed by professionals.

**ME 523, Ore Petrography, 3 cr, 3 cl hrs**

*Prerequisite: EARTH 203 or consent of instructor*

Identification and description of opaque and semi-opaque minerals using polished sections complemented by reflected-light petrographic techniques. Sampling techniques for exploration, mining, and environmental remediation purposes. Preparation of polished samples from rock, rock chip, ore concentrate, and tailings sample types. Heavy liquid separation techniques for concentration of heavy minerals and quantitative mineral analyses.

**ME 525, Rock and Soil Plasticity, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of the instructor*

Introduction to the theory of elasticity, Tresca, Von Mises and Mohr-Coulomb failure criteria, flow rule, hardening, softening and perfect plasticity, method of characteristics in solving plasticity problems, kinematics and velocity discontinuity, plastic limit analysis, upper- and lower-bound theorems, examples in soil and rock mechanics.

**ME 531, Advanced Foundation Design and Analysis, 3 cr, 3 cl hrs**

*Prerequisite: ME 420 or consent of instructor*

Advanced foundation design. Design of construction projects including but not limited to highways, airports, landfills, and slopes. Application of geosynthetics in design. Causes and remediation of structural cracking and foundation failures. Legal aspects. Case studies.

**ME 532, Advanced Soil Mechanics, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: ME 420 or consent of instructor*

Advanced laboratory testing of soils and their behavior with special attention to problem soils. Lab testing will include but not be limited to direct shear, compaction, swell consolidation, and analysis. Special projects may be selected.

**ME 534, Advanced Drilling and Blasting Engineering, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of the instructor*

Application of explosives to rock fragmentation; theory of detonation and mechanisms of rock failure, dynamics, and propagation. The effects of rock properties on breakage. Blasting systems and production blasting techniques used in both surface and underground designs, environmental considerations and regulations. Principles of blasthole drilling and drill performance. Drilling and blasting economics.

**ME 535, Stability of Rock Slopes, 3 cr, 2 cl hrs, 3 lab hrs**

*Prerequisite: ME 420 or consent of instructor*

Basic mechanics of slope failure. Field exploration and presentation of geological data. Shear strength of rock and rock discontinuities. Groundwater pressure and flow. Plane, wedge, circular, and toppling failure. Improvement of slope stability by drainage and support. Monitoring of slope displacements.

**ME 537, Design and Construction of Underground Openings, 3 cr, 3 cl hrs**

*Prerequisite: ME 420 or consent of instructor*

Rock mass classification systems. Empirical design and support selections, stand-up times, block stability, and structural analysis. Elasto-plastic strain around openings. Ground reaction and response. Rock bolting and rock-support interaction analysis.

**ME 540, Computer Application in Geotechnical Engineering, 3 cr, 3 cl hrs**

*Prerequisites: Soil Mechanics, Rock Mechanics, and basic computer skills*

Computer programming using MATLAB, image processing and its applications in geotechnical engineering, introduction to finite difference and finite element methods with applications to various problems in geomechanics including steady, consolidation, slope stability, design of foundations, and underground excavations.

**ME 545, Vibration Analysis and Control, 3 cr, 3 cl hrs**

*Prerequisite: ME 434 or consent of instructor*

Characteristics and analysis of vibrations from mining and construction blasting, heavy equipment and transient loads. Prediction of ground motions, air blast, and frequency; response spectra, structural response and damping. Damage analysis and prediction; probabilistic study of cracking. Human response. Vibration monitoring equipment and control.

**ME 546, Detonation Theory, 3 cr, 3 cl hrs**

*Prerequisite: MENG 549 or ME 549; or consent of instructor. MENG 556 is recommended.*

Development of classical detonation model for full-order detonation of secondary explosives. Ideal versus non-ideal detonation. Burn-rate models for pyrotechnics. The concept of deflagration to detonation transition. (Same as MENG 546)

**ME 548, Rock Fracturing and Fragmentation by Explosives, 3 cr, 3 cl hrs**

*Prerequisite: Graduate or senior standing or consent of instructor*

Fundamentals of dynamic rock strength, mechanisms of fracturing and fragmentation of rocks by explosives. Theoretical treatment of rock stress induced by internal explosion, methods for computer calculations of rock damage. Brief overview of devices, accessories, and methods used in industrial applications of fragmentation.

**ME 549, Wave Propagation, 3 cr, 3 cl hrs**

*Prerequisite: MENG 545 or ME 545 and MATH 335; or consent of instructor*

An in-depth study of the propagation of waves in various media. The derivation and application of the Rankine-Hugoniot jump equations. The concept of the rarefaction wave and various wave interactions. Derivation and application of the Mie-Grüneisen equation of state. The differential form of the conservation equations, as well as some numerical solutions for simple cases. (Same as MENG 549)

**ME 550, Advanced Explosives Engineering, 3 cr, 3cl hrs**

*Prerequisites: MENG 549 or ME 549; or consent of instructor.*

The detonation of non-ideal explosives, equation of state for porous media, shaped charge effect and explosively formed projectiles. Shock compaction of powders, explosive welding and experimental methods used in the evaluation of explosives and their applications. The dynamic fracture of ductile and brittle materials. (Same as MENG 550)

**ME 551, Industrial Minerals, 3 cr, 3 cl hrs**

*Prerequisite: Graduate standing or consent of instructor*  
*Offered alternate years*

Study of basic concepts of production and use of industrial minerals in modern society. Emphasis on complex interactions between economics, geology, processing, marketing, and transportation. Selected industrial minerals studies in detail. Several field trips to operations and occurrences. (Same as GEOL 551)

**ME 552, Applied Explosives Engineering, 3 cr, 3 cl hrs**

*Prerequisite: Graduate or senior standing or consent of instructor*

Commercial and other applications of explosives. Basics of thermal decomposition, explosion, shock initiation, and detonation. Laboratory methods of performance evaluation of explosives including shock initiation tests and underwater explosion tests. Techniques of forming and shaping of detonation waves. Some unusual applications of explosives in creating large magnetic fields.

**ME 553, Computer Modeling of Detonations, 3 cr, 3 cl hrs**

*Prerequisite: MENG 549 or ME 549; or consent of instructor. MENG 517/ME 517 is recommended.*

Introduction to hydrodynamic modeling applied to explosives. Numerical methods for modeling shock physics, detonation, and material response. Finite difference, finite element and smoothed particle hydrodynamic methods, equation of state and strength models, and numerical fracture and fragmentation. (Same as MENG 553)

**ME 561, Advanced Topics in Engineering Geology, 3 cr, 3 cl hrs**

*Offered on demand*

Study of special topics in geologic hazards, site characterization, and related fields of interest in engineering geology.

**ME 562, International Mining Field Trip, 3 cr, 3 cl hrs**

Field trip in conjunction with the Student Chapter of the Society of Economic Geologists to a geologic and mining interest in a foreign country, usually Chile. Seminar-style class with a required term paper. Students are responsible for preparation of a field-trip guidebook, to be used by students and professionals participating in the field trip.

**ME 563, Field Studies in Hydrothermal Alteration, 3 cr, 3 cl hrs**

*Prerequisites: EARTH 211, 318 or 319 or equivalent; ME 360 or EARTH 480*

A field and lab-based course emphasizing the geochemistry and mineralogy of hydrothermal ore deposits, with substantial hands-on exercises and field-based descriptive work. Lab exercises utilize thin section and polished section samples from hydrothermal ore deposit suites to demonstrate variations in protolith and alteration mineralogy, and result in the production of professional-style reports, interpreting the geochemical and exploration significance of the alteration assemblages observed. Field trips to mineral deposits emphasize the areal extent of hydrothermal alteration associated with porphyry, epithermal and skarn-style ore deposits.

**ME 564, Economic Geology Field Camp, 1-4 cr to be arranged**

*Prerequisites: EARTH 353, ME 360 or equivalent*

Field-based course emphasizing detailed mapping of mineral deposits and preparation of professional-style reports. Field areas comprise of distinct ore deposit settings, and involve description and recognition of rock types, alteration assemblages, and ore-related minerals. mapping in operating mines, and at prospects. Preparation of professional-style Executive Summary reports required. In autumn to be held in western U.S.; summer course to be held in western U.S. and in eastern U.S. in alternate summers.

**ME 565, Mine Waste Characterization, 3 cr, 3 cl hrs**

*Prerequisite: Consent of instructor*

Environmental aspects of mine waste materials. Geologic, geochemical, and engineering evaluation of tailings, waste rock dumps, and processing chemicals. Sampling and mineralogic analysis of mine wastes. Characterization of physical, chemical, and biological environments surrounding mine sites. Current environmental and mining regulations. Field trips, laboratory studies, and case histories.

**ME 566, Mine Waste Management and Control, 3 cr, 3 cl hrs**

*Prerequisite: ME 565*

Control of wastewater and solid pollutants from mining and processing of minerals. Design of facilities to control and manage waste streams resulting from mine and mill operations. Mine land reclamation and closure design. Design projects and field trips.

**ME 570, Advanced Topics in Explosives Engineering, 3 cr, 3 cl hrs**

*Prerequisite: Consent of instructor*

Study of special topics in the application of explosives in the fields of rock blasting, structure response to vibrations, and ordnance.

**ME 571, Advanced Topics in Mineral Engineering, 2-3 cr****ME 572, Graduate Seminar, 1 cr, 2 cl hrs**

*Prerequisite: Graduate standing*

Presentation and discussion of research ideas, including presentation of published papers.

**ME 581, Directed Study, 1-3 cr****ME 590, Independent Study, cr to be arranged**

Independent research organized and conducted by the student under the direction of the student's advisor. Written final report and oral presentation required.

**ME 591, Thesis (master's program), cr to be arranged**

## Faculty Research Interests

Chávez—Applied Mineral Exploration, Ore Deposits, Natural Resource Utilization

Fakhimi—Geomechanics, Numerical Modeling

Gundiler—Hydrometallurgy and Mineral Processing

Kozushko—Mine Design, Support and Reinforcement Design, Underground Safety

McLemore—Economic Geology

N. Mojtabai—Site Investigation, Rock Fragmentation, Mine Design, Geomechanics

Razavi – Soil Mechanics, Image Processing, X-Ray computer Tomography

Oravec—Rock Mechanics, Surveying

Walder—Geochemistry, Mine Reclamation, Mine Waste Characterization

C. Wimberly—Natural Resources Law

# Petroleum Engineering

*Distinguished Professor Anderson*

*Professors Engler (Dean of Engineering, Chair of the Department) , Lee*

*Associate Professors Chen, Kelly*

*Assistant Professor Nguyen*

*Adjunct Faculty: Balch, Buckley, Grigg, Huang, Martin, Lorenz, Plisga, Ruan, Seright, Warpinski*

***Degrees Offered: B.S. in Petroleum and Natural Gas Engineering, M.S. and Ph.D. in Petroleum Engineering***

Petroleum and natural gas engineering is a broad-based discipline primarily concerned with the development, exploration, and conservation of oil and gas resources. Petroleum and natural gas engineers plan and supervise drilling and well-completion programs, design and select drilling and production equipment, optimize the production of oil and natural gas, estimate reserves, and manage oil and gas properties.

The oil and gas industry is a progressive and highly technical business, which offers opportunities to young engineers, both in the United States and abroad. A petroleum and natural gas engineering graduate may obtain a responsible position with an oil company, establish a consulting business, or become an independent oil producer.

## Program Educational Objectives

The mission of the Petroleum Engineering program is to prepare students for the challenges of such a diversified career by providing students with the necessary skills to achieve success in their future profession. To achieve this mission, the following educational objectives are emphasized:

- Our graduates will use their highly competitive skills in a range of engineering career paths to become leaders in the energy industry.
- Our graduates will seek out continuing education opportunities, striving for technical excellence
- Our graduates will leverage evolving technology through collaborative engagement in both industry workshops and professional societies.

By graduation, a student will be capable of solving a variety of petroleum engineering problems and be able to integrate petroleum engineering concepts to a practical design project.

The Ph.D. and master's programs are open to students with degrees in fields other than petroleum and natural gas engineering. A special course program will be tailored for those students who have not completed a B.S. in petroleum and natural gas engineering to provide an appropriate background. Prospective students are encouraged to visit [www.nmt.edu/~petro](http://www.nmt.edu/~petro) for more details.

## Undergraduate Program

### Bachelor of Science in Petroleum and Natural Gas Engineering

*Minimum credit hours required—134*

*In addition to the General Education Core Curriculum (page 100), the following courses are required:*

- PETR 101 (1), 111 (3) 245 (3), 311 & 311L (4), 345 & 345L (4), 370 (4), 413 & 413L (3), 424 & 424L (4), 425 (3), 441 (3), 445 (3), 450 (2), 471(2), 472 (2)
- ES 201 (3), 216 (3), 302 (3), 303 (3), 316 (3), 332 (3), 347 (3)
- MATH 231 (4), 335 (3)
- EARTH 101 & 103L (4), 460 (3)
- E&ES Elective: EARTH 203, 325, or 440; or other 200-level or higher E&ES course with approval of faculty advisor.
- Technical Electives: Three credit hours of upper-division technical and petroleum and natural gas engineering electives are selected by the student with the faculty advisor's approval to fulfill the requirement of 134 credit hours needed for graduation.

Petroleum and natural gas engineering majors must achieve a minimum GPA of 2.0 in required courses in order to graduate.

All engineering majors are required to take the Fundamentals in Engineering (FE) exam and receive a non-zero score as a requirement for graduation.

### Sample Curriculum for the Bachelor of Science in Petroleum and Natural Gas Engineering

#### *Semester 1*

1	PETR 101 (intro)
4	MATH 131 (calculus)
4	CHEM 121 & 121L (general)
3	ENGL 111 (college English)
4	ERTH 101 & 103L (earth processes)
<hr/>	2 ES 110 (intro)
	18 Total credit hours

#### *Semester 2*

4	MATH 132 (calculus)
3	ES 111 (intro)
5	PHYS 121 & 121L (general)
3	ENGL 112 (college English)
<hr/>	3 Social Science/Humanities
	18 Total credit hours

*Semester 3*

- 4 MATH 231 (calculus)
- 4 CHEM 122 & 122L (general)
- 5 PHYS 122 & 122L (general)
- 3 ES 201 (statics)

16 Total credit hours

*Semester 4*

- 3 PETR 245 (petroleum fluids)
- 3 MATH 335 (ordinary differential equations)
- 3 ES 216 (fluid mechanics)
- 3 ES 302 (mechanics)
- 3 ES 347 (thermodynamics)
- 3 EARTH 206 (earth's crust)

18 Total credit hours

*Semester 5*

- 4 PETR 311 & 311L (drilling)
- 4 PETR 345 & 345L (reservoir engineering I)
- 3 ES 303 (dynamics)
- 3 ENGL 341 (technical writing)
- 3 Social Science/Humanities

17 Total credit hours

*Semester 6*

- 3 PETR 370 (formation evaluation)
- 2 PETR 450 (well testing)
- 3 PETR 413 & 413L (well design)
- 3 PETR 445 (reservoir engineering II)
- 3 EARTH 460 (subsurface)
- 3 Social Science/Humanities

17 Total credit hours

*Semester 7*

- 3 PETR 424 & 424L (production engineering)
- 3 PETR 464 (natural gas)
- 2 PETR 471 (reservoir description)
- 3 ES 316 (economics)
- 3 Social Science/Humanities
- 3 Technical Elective

17 Total credit hours

*Semester 8*

- 2 PETR 425 (well completions)
- 2 PETR 472 (reservoir management)
- 3 ES 332 (electrical)
- 3 Humanities/Social Science
- 3 Humanities/Social Science

13 Total credit hours

**Minor in Petroleum Engineering**

*Minimum credit hours required—20*

The following courses are required:

- PETR 245 (3), 311 & 311L (4), 345 & 345L (4), 424 & 424L (3), 464 (3)
- At least one of the following: PETR 413 & 413L (3), 425 (3), 445 (3)

**Graduate Program**

The Petroleum Engineering program offers two options for a Master of Science Degree—with thesis or independent study—and a Doctor of Philosophy degree. All graduate students are required to register for and attend the Graduate Seminar (PETR 570) each semester it is offered. Exceptions may be made only with approval of the student's advisor and the department chair.

Students without a B.S. in petroleum engineering will be required to undertake a course of study to prepare them as petroleum engineers. Further details of the departmental requirements can be found at [www.nmt.edu/~petro](http://www.nmt.edu/~petro).

**Master of Science in Petroleum Engineering Thesis Option**

The master's program requires a minimum of 24 credit hours of coursework and 6 credit hours of thesis. The courses are designed to advance the student's knowledge in topics of petroleum engineering. The research thesis provides a means to do independent and analytical thinking on a specific subject. The student's course of study must be approved by the student's advisory committee and the department chair and must fulfill the general requirements for the master's degree.

**Independent Study Option**

Candidates for the non-thesis Master of Science option must complete a total of 36 credit hours, of which a minimum of three (3) credit hours must be independent study (PETR 590). At least 18 of the credit hours must be from graduate-level Petroleum Engineering courses, excluding PETR 581 and 590. The student's course of study must be approved by the student's advisory committee and must fulfill the general graduate requirements for the master's degree without thesis. The final outcome of the independent study is to submit a formal paper followed by an oral presentation to the advisory committee.



## Doctor of Philosophy in Petroleum Engineering

In order to be admitted to the Ph.D. program, a student must meet the requirements as set forth by the Graduate Program and have completed an M.S. degree with thesis. A minimum of 60 credit hours past the masters degree is required. New Mexico Tech courses taken to satisfy this requirement must have content different from courses applied to previous degrees. In addition to the department administered preliminary examination, the student is required to successfully complete a candidacy examination and a defense of the dissertation administered by the student's advisory committee. (See [www.nmt.edu/~petro](http://www.nmt.edu/~petro) for more detailed information.)

The 60-credit requirements should be distributed as follows:

1. Minimum 30 credits regular\* courses and Directed Study (581).
    - Minimum 12 credits of regular\* 500-level petroleum engineering courses.
    - Maximum 9 credits of Directed Study (PETR 581); maximum 6 credits from the same professor.
    - Minimum 6 credits from outside of petroleum engineering in either engineering, engineering management, or science disciplines. Students with degrees in disciplines other than Petroleum Engineering may take an additional 6 credits of petroleum engineering courses instead.
  2. Minimum 24 credits and maximum 30 credits of Dissertation (PETR 595).
  3. Registration in Graduate Seminar (PETR 570) is required.
- \* Courses are considered regular only if a course title and scheduled meeting time are specified and the course is open to all qualified students.

## Petroleum Engineering Courses

### PETR 101, Introduction to Petroleum Engineering, 1 cr, 1 cl hr

Introduction to energy supply and demand. Define reservoir, drilling and production aspects of petroleum engineering. Included are professionalism and ethics in the work environment.

### PETR 111, Computer Applications for Petroleum Engineering, 3 cr, 2 cl hrs, 3 lab hrs

*Corequisite: MATH 104*

Development of algorithms in Excel™ to solve petroleum engineering problems: gas z-factor, static and flowing gradients, pump design, well testing functions and others.

### PETR 245, Petroleum Fluids, 3 cr, 3 cl hrs

*Prerequisites: CHEM 122; MATH 132; PETR 111*

Characteristics and properties of reservoir fluids. Representation of fluid property data for computer uses with models and regression.

### PETR 311, Drilling Engineering, 3 cr, 3 cl hrs

*Prerequisite: ES 216*

*Corequisite: ES 302*

Introduction to drilling engineering through the study of rig equipment functions. Engineering analysis of drill string buoyancy, drilling mud circulation and flow hydraulics, drill string components, and well control. Preliminary discussion of pore and fracture pressure gradients. Well plan profile including drill bit selection, drilling fluid selection, drill string component section, and well control.

### PETR 311L, Drilling Mud Laboratory, 1 cr, 3 lab hrs

*Corequisite: PETR 311*

The composition, measurement, and design of the properties of drilling fluids.

### PETR 345, Reservoir Engineering I, 3 cr, 3 cl hrs

*Prerequisites: PETR 245*

Properties of reservoir rocks and homogeneous and multiphase fluid flow in reservoirs. Capillary phenomena, relative permeability, compressibility, and fluid saturation distribution. Material balances. Statistical analysis using regression, probability concepts, and computer applications to reservoir data.

### PETR 345L, Reservoir Engineering Laboratory, 1 cr, 3 lab hrs

*Corequisite: PETR 345*

Laboratory measurement of reservoir fluid/rock properties, PVT, and core analysis. Computer data analyses using statistical techniques including probability concepts, regression, and optimization.

### PETR 370, Formation Evaluation, 3 cr, 2 cl hrs, 3 lab hrs

*Prerequisites: PHYS 122; PETR 345*

Introduction to logging tool principles and operation. Evaluation of reservoir properties and interpretation of open hole well logs. Multiwell correlations with application to volumetric calculations. Lab exercises on reservoir mapping and well log case studies. (Same as EARTH 370)

**PETR 411, Advanced Drilling, 3 cr, 3 cl hrs**

*Prerequisite: PETR 311 or consent of instructor*

Drilling operations technology with an emphasis on field practices and techniques. Advanced topics including drilling fluids rheology and hydraulics. Mechanics of BHA in vertical and directional holes. Directional well trajectory predictions and design. Modeling of drag and torque. Dynamics of drill string, wellbore measurements, deepwater drilling and heat transfer in wells.

**PETR 413, Well Design, 2 cr, 2 cl hrs**

*Prerequisite: PETR 311 or consent of instructor*

Details of the development of pore and fracture pressure gradients. Casing depths using pore and fracture pressure gradients plots. Review of engineering analysis for casing string design. Types of well completions. Selection of casing, cement class and well cementing equipment and methods. Development of detailed well plan for drilling and completion of oil and gas wells.

**PETR 413L, Well Design Lab, 1 cr, 3 lab hrs**

*Corequisite: PETR 413*

The composition, testing, and design of cement slurries and fracturing fluids.

**PETR 424, Production Engineering, 3 cr, 3 cl hrs**

*Prerequisite: PETR 345*

Elements of producing oil and gas wells. Flow of single and multiphase fluids in vertical and horizontal pipes. Choke performance. Nodal analysis systems approach to well production performance optimization. Production decline analysis using exponential, harmonic, and hyperbolic decline curves applied to actual well production data. Introduction to artificial lift techniques.

**PETR 424L, Production Engineering Laboratory, 1 cr, 3 lab hrs**

*Prerequisite: PETR 111, ES 216*

*Corequisite: PETR 424*

Design and determination of pressure losses for various components in a flow loop. Design of artificial lift systems including rod pumps, submersible pumps and gas lift.

**PETR 425, Well Completion, 3 cr, 3 cl hrs**

*Prerequisites: PETR 345*

Well completion methods. Design and selection of tubing; perforating performance; sand, water and gas control. Introduction to stimulation operations, selection of stimulation techniques, design of acid and hydraulic fracture treatments.

**PETR 440, Directional Drilling & Innovative Drilling Methods, 3 cr, 3 cl hrs**

*Prerequisites: PETR 311*

Two and three dimensional directional well path design; horizontal drilling; mathematical model deflection tool analysis; 2D and 3D vector application; down-hole motors and MWD techniques; underbalanced drilling; casing while drilling; coiled-tubing drilling.

**PETR 441, Natural Gas Reservoir Engineering, 3 cr, 3 cl hrs**

*Prerequisite: PETR 345*

Estimation of gas reserves for dry and gas condensate reservoirs. Evaluation of deliverability tests and subsequent development of flow equations. Determination of gas recovery from unconventional reservoirs; e.g., coalbed methane, tight gas sands, shales. Strategies for gas field development. Additional work is required at graduate level.

**PETR 443, Underbalanced Drilling and Completions, 3 cr, 3 cl hrs**

*Prerequisite: PETR 311*

Air and gas, aerated, and stable foam drilling and completions operations. Development of basic calculational theory and application to operational problems. Emphasis on the planning of successful drilling and completions operations. Selection of appropriate field equipment for drilling and completions operations. Solution of drilling and completions field problems.

**PETR 445, Reservoir Engineering II, 3 cr, 3 cl hrs**

*Prerequisite: PETR 345*

Advanced reservoir engineering principles and applications including material balances, decline curve analysis, unsteady flow in porous media, partial penetration, water influx, reservoir heterogeneity, fractional flow, and frontal advance.

**PETR 446, Improved Petroleum Recovery, 3 cr, 3 cl hrs**

*Prerequisite: PETR 445 or consent of instructor*

Water flooding techniques. Water handling. Injection and production well patterns. Productive techniques for economic operations. Introduction to enhanced oil recovery; polymer, surfactant, thermal and miscible flooding.

**PETR 450, Well Testing, 2 cr, 2 cl hrs**

*Prerequisite: PETR 345*

Design well testing program to meet specific guidelines. Apply conventional well test data to estimate the reservoir's capacity to transmit fluids, the reservoir's energy, and the effectiveness of the well completion.

**PETR 460, Numerical Simulation, 3 cr, 3 cl hrs**

*Prerequisite: PETR 445*

Application of finite difference and finite element techniques for solving reservoir engineering problems.

**PETR 471, Reservoir Description, 2 cr, 2 cl hrs**

*Prerequisites: PETR 370, 445; EARTH 460*

*Corequisite: PETR 424*

*Offered fall semester*

Applied characterization of a field project through integration of reservoir, production and geological data. Well performance and production optimization.

**PETR 472, Reservoir Management, 2 cr, 2 cl hrs**

*Prerequisite: PETR 471; ES 316*

*Offered spring semester*

Economic analysis of petroleum-producing properties; evaluation of reservoir management decisions for oil and gas development; establishing the effect of risk and uncertainty on economic evaluation.

**PETR 478, Petroleum Seminar, variable credit, 2 cl hr**

*Prerequisite: Senior standing or consent of instructor*

Current topics in petroleum and natural gas engineering. Techniques of oral presentation of research and development data.

**PETR 491, Special Problems in Petroleum and Natural Gas Engineering, 1-3 cr as arranged**

*Prerequisite: Senior standing or consent of instructor*

Individual studies in petroleum and natural gas engineering problems of special interest.

**PETR 523, Numerical Simulation, 3 cr, 3 cl hrs**

*Prerequisite: PETR 445 or consent of instructor; ability to write a computer program*

The simulation of subsurface fluid reservoirs using numerical models.

**PETR 524, Fluid Flow in Porous Media, 3 cr, 3 cl hrs**

*Prerequisites: PETR 445 or consent of instructor.*

Physical concepts involved in the flow of fluids in porous media; aspects of Darcy's Law; multiphase flow concepts of relative permeability and capillary pressure.

**PETR 532, Advanced Well Stimulation, 3 cr, 3 cl hrs**

*Prerequisite: Consent of instructor*

Theories of hydraulic fracturing, mechanics of fracturing, rheology of fracturing fluids, acid fracturing treatment, models for matrix acidizing, evaluation of stimulation operations.

**PETR 535, Advanced Drilling Mechanics, 3 cr, 3 cl hrs**

*Prerequisite: PETR 311 or consent of instructor*

Principles of materials failure applied to rotary drilling. Principles of drilling optimization involving bit weight, rotary speed, and rheological properties of the drilling fluid. Minimum cost drilling.

**PETR 537, Petroleum-Related Rock Mechanics, 3 cr, 3 cl hrs**

Studies of theories and applications of rock mechanics to petroleum engineering. Topics include laboratory measurements of porosity, permeability, and deformation behavior as a function of stress state, insitu stress measurements, wellbore stability, sand control, and reservoir compaction/subsidence.

**PETR 540, Directional Drilling & Innovative Drilling Methods, 3 cr, 3 cl hrs**

*Prerequisites: PETR 311*

Two and three dimensional directional well path design; horizontal drilling; mathematical model deflection tool analysis; 2D and 3D vector application; down-hole motors and MWD techniques; underbalanced drilling; casing while drilling; coiled-tubing drilling. Shares lectures with PETR 440, but is graded separately and additional work is required at the graduate level

**PETR 541, Natural Gas Reservoir Engineering, 3 cr, 3 cl hrs**

*Prerequisite: PETR 345*

Estimation of gas reserves for dry and gas condensate reservoirs. Evaluation of deliverability tests and subsequent development of flow equations. Determination of gas recovery from unconventional reservoirs; e.g., coalbed methane, tight gas sands, shales. Strategies for gas field development. Additional work is required at graduate level.

**PETR 544, Advanced Reservoir Engineering, 3 cr, 3 cl hrs**

*Prerequisite: PETR 445 or consent of instructor*

Studies of natural water drive reservoirs in finite and infinite aquifers. Transient pressure behavior in heterogeneous reservoirs. Material Balance Equations from advanced viewpoint.

**PETR 545, Advanced Production Design, 3 cr, 3 cl hrs**

*Prerequisite: PETR 425 or consent of instructor*

Oil and gas well production principles. Flowing well performance, two-phase vertical flow, theory and design of artificial lift systems.

**PETR 546, Advanced Formation Evaluation, 3 cr, 3 cl hrs**

*Prerequisite: PETR 370 or consent of instructor*

Study of physical and textural properties of reservoir rocks which provide a link between reservoir engineering and well logging. Advanced exploration and production logging. Estimation of geological environment. Quantitative reservoir evaluation in different lithologies from log data. New logging techniques.

**PETR 547, Naturally Fractured Reservoirs, 3 cr, 3 cl hrs**

Geological characterization and reservoir simulation of naturally fractured reservoirs. Description of natural fractures and fracture systems from surface outcrops, core analysis, log interpretation, and well testing. Fluid-flow simulation of fractured reservoirs using numerical models.

**PETR 548, Reservoir Geomechanics, 3 cr, 3 cl hrs**

*Prerequisites: PETR 445 or consent of instructor*

Fundamentals and issues of coupled fluid-flow/thermal/geomechanics associated with hydrocarbon production. Topics include elasticity, poroelasticity, thermo-poroelasticity, reservoir stress depletion/rebound, productivity of stress-sensitive reservoirs, and waterflood-induced fracturing.

**PETR 554, Advanced Natural Gas Engineering, 3 cr, 3 cl hrs**

*Prerequisite: PETR 464 or consent of instructor*

Gas flow in vertical and inclined pipes, surface facilities, gas processing, overall transportation requirements.

**PETR 552, Fluid/Surface Interactions, 3 cr, 3 cl hrs**

*Prerequisite: Consent of instructor*

The physics and chemistry of interfaces, focusing on the behavior of multfluid systems both in the presence and absence of solids. How basic interactions among microscopic particles can explain macroscopic phenomena. Application-oriented, focusing on interactions important in hydrology, petroleum engineering, and environmental engineering. (Same as HYD 552)

**PETR 555, Advanced Directional Drilling, 3 cr, 3 cl hrs**

*Prerequisite: PETR 311 or consent of instructor*

Two- and three-dimensional directional well path design. Mathematical model deflection tool analysis. Mechanics of BHA — conventional and finite element techniques. Down-hole motors and MWD techniques.

**PETR 558, Advanced Topics in Enhanced Oil Recovery Methods, 3 cr, 3 cl hrs**

*Prerequisite: PETR 446 or consent of instructor*

Advanced topics may include surfactant and alkali flooding mechanisms. Polymer flooding and rheology of non-Newtonian fluids. Gas injection methods including carbon dioxide, hydrocarbons, and nitrogen. Thermal recovery.

**PETR 560, Phase Behavior of Petroleum Fluids, 3 cr, 3 cl hrs**

*Prerequisite: PETR 245 or consent of instructor*

Use of equations of state for predicting PVT behavior of complex petroleum fluids. Emphasis on the descriptions of fluids used in simulating gas injection recovery processes and multiphase flow in pipes. Correlations for phase viscosity and interfacial tension.

**PETR 564, Advanced Well Testing, 3 cr, 3 cl hrs**

*Prerequisite: PETR 370 or consent of instructor*

The partial differential equations for liquid and gas flow in porous media, boundary conditions including skin and well-bore storage effects. Applications of Laplace transformation. Pressure buildup and drawdown tests.

**PETR 570, Graduate Seminar, 1 cr, 2 cl hrs**

*Prerequisite: Senior or graduate standing*

Presentation and discussion of research ideas. Review of recently published papers/new concepts.

**PETR 571, 572, Advanced Topics, 2–3 cr, 2–3 cl hrs**

*Offered on demand*

*Prerequisite: Consent of instructor*

Special topics in petroleum and natural gas engineering.

**PETR 581, Directed Study, 1–3 cr each semester**

*Prerequisite: Consent of instructor*

Research and literature survey as directed by advisor on subjects of interest pertaining to petroleum and natural gas engineering.

**PETR 590, Independent Study, 1–3 cr**

Independent research organized and conducted by the student under the direction of the student's advisor. Written final report and oral presentation required.

**PETR 591, Thesis (master's program), cr to be arranged****PETR 595, Dissertation (doctoral degree program), cr to be arranged**

*Prerequisite: CHEM 595*

## Faculty Research Interests

- Balch—Fuzzy Expert Systems, Data Mining
- Bretz—Transport Phenomena, Phase Behavior, Natural Gas Processing
- Buckley—Petrophysics and Surface Chemistry, Reservoir Wettability
- Chen—Well Testing, Reservoir Mechanics
- Engler—Formation Evaluation, Petrophysics, Unconventional Gas Recovery, Simulation/Modeling
- Grigg—Gas Flooding Processes, Phase Behavior
- Kelly—Reservoir Evaluation and Management
- Lee—Natural Gas Storage, Applied Numerical Methods, Phase Behavior, Membrane Technology
- Lorenz—Petroleum Geology
- Martin—Reservoir Management, EOR
- Nguyen—Drilling Fluids, Multiphase Flow and Artificial Lift
- Plisga—Production Operations
- Ruan—Design of Web-Based Systems
- Seright—Profile Control; Polymer, Water, and Chemical Flooding
- Teufel—Rock Mechanics, Naturally Fractured Reservoir Characterization, In-Situ Stresses, Reservoir Simulation including Stress Distribution, Subsidence Mechanisms
- Warpinski—Hydraulic Fracturing, In-Situ Stresses, Natural Fractures, Geomechanics, Rock Mechanics