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Statement of Affirmative Action

It is the policy of the Missouri University of Science and Technology to provide full and equal employment opportunities to all persons without regard to race, color, religion, sex, sexual orientation, national origin, age, disability, and veteran status; to prohibit discrimination in recruitment, employment or conditions of employment, including salary and benefits related thereto; to promote employment opportunity and to take affirmative action in this regard.

Title VI of the Civil Rights Act of 1964

“No person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance.”

Title IX of the Education Amendments of 1972

“No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance.”

Section 504 of the Rehabilitation Act of 1973

“No otherwise qualified handicapped individual in the United States...shall, solely by reason of the handicap, be excluded from the participation in, be denied the benefits of, or be subject to discrimination under any program or activity receiving Federal financial assistance.”

Section 303 of the Age Discrimination Act of 1975

“No person in the United States shall, on the basis of age, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance.”

The Americans with Disabilities Act of 1990

General Rule – No covered entity shall discriminate against a qualified individual with a disability because of the disability of such individual in regard to job application procedures, the hiring, advancement, or discharge of employees, employee compensation, job training, and other terms, conditions, and privileges of employment.

Missouri S&T conducts its programs and activities involving admission and treatment of students, employment, teaching, research, and public service in a non-discriminatory manner as prescribed by Federal law and regulation.

Inquiries concerning the above may be addressed to:

Chancellor, Missouri University of Science and Technology
Rolla, Missouri 65409-9957

Director, Office for Civil Rights Department of Education
Washington, D.C. 20201

Information on the World Wide Web

For the most current information regarding course descriptions go to: http://registrar.mst.edu

Students are also advised to consult the web sites of individual department offices.

Accreditation

The University has been accredited by the Higher Learning Commission of the North Central Association of Colleges and Schools, http://www.ncahigherlearningcommission.org, 30 North LaSalle Street, Suite 2400, Chicago, Illinois, 60602-2504. (312) 263-0456 Further information on specialized accreditation by department is available in the Missouri S&T Fact Book or at: http://ira.mst.edu/accreditation.html.

Registrar’s Office Contact Information

103 Parker Hall; 300 W. 13th Street; Rolla, MO 65409
(573)341-4181, registrar@mst.edu, or visit http://registrar.mst.edu

Educational Goals of Missouri S&T

As Missouri’s technological research university, Missouri University of Science and Technology’s mission is to educate tomorrow’s leaders. In a world growing increasingly dependent on science and technology, tomorrow’s graduates must be prepared to be leaders in more than just their chosen professions. They must also be leaders in business, in government, in education, and in all aspects of society. Missouri S&T is dedicated to providing leadership opportunities for its students. The opportunity to receive an excellent technological education is only part of the educational experience received by students at Missouri S&T. Missouri S&T offers a full range of engineering and science degrees, coupled with business and liberal arts degrees and programs that are vital to the kind of comprehensive education that turns bright young men and women into leaders.

Missouri S&T is nationally recognized for its excellent undergraduate engineering programs, and is distinguished for producing cutting-edge research and key technologies vital to the economic success of Missouri and the nation. Missouri S&T has a distinguished faculty dedicated wholeheartedly to the teaching, research, and creative activities necessary for scholarly learning experiences and advancements to the frontiers of knowledge. Missouri S&T has excellent physical facilities, which support the best possible education in the liberal arts, engineering, science, applied science, and selected interrelated fields.

Missouri S&T’s programs in science, engineering, and business, its technology transfer programs, its leadership opportunities, and its learning environment are all integral parts of the total educational package available to students who attend the Missouri University of Science and Technology.
Mission Statement

Missouri University of Science and Technology integrates education and research to create and convey knowledge to solve problems for our state and the technological world.

(Approved January 2008 Board of Curators meeting.)

Vision

Missouri University of Science and Technology will be recognized as one of the top five technological research universities in the nation.

On Jan. 1, 2008, UMR became Missouri University of Science and Technology, or Missouri S&T. Our new name will not only help us gain broader national recognition, but will also give us an identity that fits our mission - to be the state’s technological research university.

Administrators

University of Missouri Board of Curators

David R. Bradley, 1-1-2015 (Chair)
Wayne Goode, 1-1-2015 (Vice-Chair)
Donald L. Cupps, 1-1-2017
Don M. Downing, 1-1-2015
Warren K. Erdman, 1-1-2013
Pamela Q. Henrickson, 1-1-2017
Amy Johnson (Student Representative to the Board)

Missouri University of Science and Technology Administrators

Cheryl B. Schrader, Chancellor
Warren K. Wray, Provost and Executive Vice Chancellor, Academic Affairs
Joan M. Nesbitt, Vice Chancellor, University Advancement
Stephen Malott, Vice Chancellor, Administrative Services
Shenethia Manuel, Associate Vice Chancellor, Human Resource Services
Debra Robinson, Vice Chancellor, Student Affairs
Venkat Allada, Vice Provost, Graduate Studies
Harvest L. Collier, Vice Provost, Undergraduate Studies
K. Krishnamurthy, Vice Provost, Research
Philip D. Whitefield, Interim Vice Provost, Academic Affairs
Laura Stoll, Vice Provost & Dean, Enrollment Management
Henry A. Wiebe, Vice Provost, Global Learning
John Bax, Interim Chief Information Officer

Missouri S&T Board of Trustees

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Keith Bailey, (retired) Williams Companies, Tulsa, OK
James Bertelsmeyer, (retired) Heritage Propane Partners L.P., Tulsa, OK
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Helene Pierce, GAF Materials Corporation, Wayne, NJ
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Joseph Rupp, Olin Corporation, Clayton, MO
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Cynthia Tang, (retired) Insight Industries, Inc., Platteville, WI
Richard Vitek, (retired) Fotodyne, Inc., Hartland, WI
Cheryl Walker, Obasi Enterprises, LLC, St. Louis, MO
Kathryn Walker, OPENAIR Ventures, Olathe, KS
Theodore Weise, (retired) Federal Express Corporation, Memphis, TN
Joan Woodard, (retired) Sandia National Laboratories, Albuquerque, NM
Steve Wunning, Caterpillar, Inc., Peoria, IL

Missouri S&T Named Professorships

Baojun Bai, Lester Birbeck Endowed Chair
Marias Crow, Fred W. Finley Distinguished Professorship of Electrical and Computer Engineering
Nuran Erçal, Richard K. Vitek/FCR Endowed Chair in Biochemistry
Ralph E. Flori, Jr., Gulf Oil Foundation Professorship
Samuel Frimpong, Robert H. Quenon Missouri Endowed Chair in Mining Engineering
Stewart Gillies, Union Pacific Foundation/Rocky Mountain Energy Co. Professorship
Steven L. Grant, Roy A. Wilkens Missouri Telecommunications Distinguished Professorship
Shubhender Kapila, MO Soybean Res. Professorship
Kamal Khayat, Vernon & Maralee Jones Endowed Professorship
Lampo Leong, Maxwell Weiner Professorship in Humanities
Ming Leu, Keith & Pat Bailey Missouri Professorship in Mechanical Engineering & Aerospace Engineering
Frank Liu, Michael and Joyce Bytner Product Innovation and Creativity Professorship
Daniel B. Oerther, John & Susan Mathes Endowed Chair
Kent Peaslee, F. Kenneth Iverson Chair of Steelmaking Technologies
Von L. Richards, Robert V. Wolf Assoc. Professor of Metals Casting in Metallurgical Engineering
David J. Rogers, Karl F. Hasselman Missouri Chair in Geological and Petroleum Engineering
Jagannathan Sarangapani, Rutledge-Emerson Professor in Electrical Engineering
Joseph D. Smith, Laufer Endowed Chair in Energy
Jay Switzer, Castleman/FCR Missouri Professorship of Discovery in Chemistry
Donald Wunsch, Mary K. Finley Missouri Professorship in Computer Engineering
Reza Zoughi, Schlumberger Distinguished Professor in Electrical & Computer Engineering

Curators’ Professors

Harlan U. Anderson of Ceramic Engineering (Emeritus)
Bassem F. Armaly of Mechanical Engineering (Emeritus)
S.N. Balakrishnan of Mechanical & Aerospace Engineering
Richard K. Brow of Ceramic Engineering
K. Chandrashekhara of Mechanical & Aerospace Engineering
Franklin Yih Cheng of Civil Engineering (Emeritus)
Alfred L. Crosbie of Mechanical Engineering
Delbert E. Day of Ceramic Engineering (Emeritus)
Lokesh Dharani of Mechanical Engineering
James Drewniak of Electrical Engineering
Walter Eversman of Mechanical & Aerospace Engineering
Greg Hilmas of Ceramic Engineering
Nicholas Leventis of Chemistry (Emeritus)
Don H. Madison of Physics
Rajiv S. Mishra of Materials Science and Engineering
Michael Schulz of Physics
James O. Stoffer of Chemistry (Emeritus)
David A. Summers of Mining Engineering (Emeritus)

Curators’ Teaching Professorship

James J. Bogan of Arts, Languages and Philosophy (Emeritus)
James S. Drallmeier of Mechanical Engineering
Larry Gragg of History & Political Science
Frances Dee Hamerle Montgomery of Psychology
Leonard F. Koederitz of Geological & Petroleum Engineering (Emeritus)
Roger A. LaBoube of Civil Engineering (Emeritus)
Yinfa Ma of Chemistry
Kent D. Peaslee Materials Science & Engineering
O. Allan Pringle of Physics
David C. Van Aken of Materials Science and Engineering

Missouri University of Science and Technology

Missouri University of Science and Technology

On Jan. 1, 2008, University of Missouri-Rolla became Missouri University of Science and Technology, or Missouri S&T. Our new name will not only help us gain broader national recognition, but will also give us an identity that fits our mission as the state’s technological research university.

About the Campus

Founded in 1870 as one of the first technological schools west of the Mississippi, Missouri University of Science and Technology is one of the nation’s top technological research universities. One of the four campuses in the University of Missouri System, the university was first known as the University of Missouri School of Mines and Metallurgy. It was later named the University of Missouri-Rolla in 196 and Missouri S&T in 2008.

The 284-acre campus is located in Rolla, MO, a town of nearly 20,000 in the heart of the Ozarks. The university offers bachelor of arts and bachelor of science degrees in 30 fields of study, including engineering, science, humanities, business and social sciences. Master of science degrees are offered in 27 disciplines, the doctor of philosophy in 20 and the doctor of engineering in eight.

The Missouri S&T campus is home to 50 research and academic support centers. Externally sponsored program expenditures have increased about 150 percent since FY2001, from $17.23 million to $38.08 million in FY2009. In FY2010, Missouri S&T received a record $52.3 million in new grant and contract awards. Missouri S&T will enhance its research activity and performance to be recognized as a top-five technological research university, distinguishing itself by interdisciplinary collaborations of national significance.

Missouri S&T enrolls more than 7,600 students from 50 states and 50-plus countries. More than 70 percent of students study in engineering, science or computer fields, but Missouri S&T also offers liberal arts, humanities, social science, and business degrees, as well as certification in select education fields. More than 700 different employers, many of the nation’s top companies, recruited S&T graduates in 2010-11. S&T graduates also get great jobs at great salaries—nearly $60,000 on average for those earning undergraduate degrees.

Campus Life

Missouri S&T offers a number of campus living options, including fraternity and sorority houses, traditional residence halls and the new Residential College. The university has more than 200 student organizations, including a dozen student design teams, a competitive NCAA Division II athletic program, student professional societies, a student radio station, and theatre and music programs. Each year, Missouri S&T students help to organize one of the largest St. Pat’s celebrations in the nation.

University of Missouri Structure & History

The four University of Missouri campuses are located in Rolla, Columbia, Kansas City and St. Louis. Governing these campuses is the Board of Curators, whose members are appointed by the Governor of Missouri and confirmed by the Missouri Senate. The president of the university directs and coordinates programs of all four campuses with assistance from staff in finance, business management, academic affairs, research, extension, development, public information, and other university services. The activities of each campus are under the supervision of a chancellor, who directs campus affairs within policies established by the UM Board of Curators and the president.

The University of Missouri has a long and proud history. It was established at Columbia in 1839, only 18 years after Missouri became a state. A land-grant university, UM is recognized as the first state university west of the Mississippi River. The university remained a single campus institution until 1870 when the University of Missouri School of Mines and Metallurgy (Missouri S&T’s former designation) was established at Rolla. Campuses at St. Louis and Kansas City were added in 1963.

On July 1, 1964, the UM Board of Curators took action to rename the University of Missouri School of Mines and Metallurgy to the University of Missouri-Rolla.

Student Consumer Information

Various state and federal laws, specifically the Higher Education Opportunity Act, require Missouri University of Science and Technology to provide information and notice to students on a variety of topics. In addition, Missouri S&T occasionally develops statements or policies on
important matters and distributes them to all students. For a listing of 
onofficial notifications that are currently provided to students visit the web 

It is a student’s responsibility to know and follow current requirements 
and procedures at the departmental and University levels, including those 
described in the University’s Student Academic Regulations, Student 
Handbook, Undergraduate and Graduate Catalogs, Residential Housing 
Terms and Conditions and the Collected Rules and Regulations of the 
University of Missouri.

For More Information

If you have additional questions, contact the Director of Admissions, 
Missouri University of Science and Technology, Rolla, MO 65409-1060, 
or call (800) 522-0938 or visit http://admissions.mst.edu. You also may 
wish to contact one of the following offices for specific information:

• Career Opportunities Center (573) 341-4343
• Counseling & Disability Support Services (573) 341-4211
• Disability Support Services (573) 341-4222
• Distance & Continuing Education (573) 341-6576
• Extended Learning (573) 341-4132
• Intercollegiate Athletics (573) 341-4175
• International Affairs (573) 341-4208
• Registrar (573) 341-4181
• Residential Life & Student Support (573) 341-4218
• Student Diversity Programs (573) 341-4212
• Student Financial Aid (573) 341-4282
• Student Health Services (573) 341-4284
• University Police (573) 341-4300
• Vice Chancellor Student Affairs (573) 341-4292
• Women in Engineering & Science Programs (573) 341-4212

Academic Calendar

(See http://registrar.mst.edu/calendars)
Admissions and Academic Program Procedures

Admission to Graduate Study

Any person who holds a bachelor’s degree, a master’s degree, or any equivalent degree from a college of good standing and who wishes to enroll as a graduate student at Missouri S&T must submit a complete package of application materials to the Director of Admissions. This package includes an application form, an official transcript from all undergraduate and any graduate institutions, and a non-refundable application fee of $50.00 (U.S. currency only) payable to Missouri S&T. Other application materials may be required by individual programs, so please refer to the department’s website or entry in the Areas of Study section of this catalog to find out the specific admission requirements for your prospective degree program. All graduate school admissions must be approved by the chair or designate of the appropriate department, as well as the Vice Provost for Graduate Studies.

Application Deadlines for U.S. Students

Application materials must be received by the Missouri S&T Office of Admissions by the following dates:

- Fall semester – July 15
- Spring semester – December 15
- Summer session – May 1

International Student Admission

Students from outside the United States who wish to enroll at Missouri S&T are required to submit all application materials required by their prospective department, as well as to demonstrate a command of English sufficient to pursue graduate work at Missouri S&T. International students for whom English is a second language, or whose schooling has been conducted in another language, must do one of the following:

I. Take the Test of English as a Foreign Language (TOEFL).

The minimum acceptable scores are listed on each department’s website or entry in the Areas of Study section of this catalog.

Students may obtain TOEFL information from:

Test of English as a Foreign Language
Educational Testing Service
Box 899
Princeton, NJ 08540 USA
http://www.ets.org/toefl

The TOEFL Bulletin of Information and registration form may also be obtained in a number of cities outside the United States, and are often available at American embassies and consulates, Offices of the United States Information Service (USIS), United States educational commissions and foundations abroad, and binational centers.

Students seeking Taiwanese editions of the TOEFL should apply to:

Language Center
2-1 Hsuchow Road
Taipei, Taiwan

TOEFL scores should be sent directly to Missouri S&T, using school code 6876.

II. Take the International English Language Testing System (IELTS) exam.

The minimum acceptable overall band score on the IELTS exam is listed on each department’s website or entry in the Areas of Study section of this catalog.

Students may obtain test information from:

IELTS Administration
7900 W. Division
River Forest, IL 60305
http://www.ielts.org

III. Attend and satisfactorily complete an Intensive English Program (IEP) within Missouri S&T’s Applied Language Institute.

Students who enroll in an IEP must complete that program to the satisfaction of its director and academic coordinator (i.e. satisfy all graduation requirements) before they are allowed to enroll in full-time academic coursework. A student enrolled in an IEP may simultaneously enroll for a part-time academic course load with the approval of his or her academic department chair or designate, the director of the Intensive English Program, and the Vice Provost for Graduate Studies.

International Transfer Students

An international student enrolled in another American college or university is eligible to transfer to Missouri S&T if he or she

• has been enrolled full time at the school he or she last attended during the term immediately preceding the transfer or last preceding vacation period, and
• applies to and is accepted at Missouri S&T, and
• plans to be a full-time student at Missouri S&T, and
• is financially able to attend Missouri S&T.

International students must

• Pay all expenses while at Missouri S&T. In most departments, financial assistance, in the form of research and/or teaching assistantships, is available to some qualified applicants. International students are encouraged to apply for these competitive assistantships.
• Submit a health history and immunization record to the Missouri S&T Health Services office.

International students are encouraged to seek transfer for the fall semester, if possible, so that they can complete the International Student Questionnaire during the summer months after finishing their previous academic program.

Application Deadlines for International Students

Application materials for overseas students and international students who are already in the U.S. but who want to transfer to Missouri S&T
into a different degree level or into a different degree program must be received in the Missouri S&T Office of Admissions by the following dates:

- Fall semester – June 15
- Spring semester – November 15
- Summer session – April 1

Application materials for stateside applicants transferring to Missouri S&T at the same degree level and the same degree program (straight transfer) must be received in the Missouri S&T Office of Admissions by the following dates:

- Fall semester – July 15
- Spring semester – December 15
- Summer session – May 1

Applications, transcripts, English proficiency test scores (if applicable), Missouri S&T’s International Student Questionnaire, and any other materials required by an individual degree program must be received by the above dates in order to facilitate the student’s admittance to Missouri S&T. Students whose credentials are not complete or are still being processed by the above dates may have their admission delayed. Students are strongly encouraged to submit their complete application package as early as possible, to ensure that all documents can be processed in a timely manner.

Readmission After a Lapse in Enrollment

Main campus students who do not register for one semester must complete and submit a Former Graduate Student Refresh Registration (SRR) Eligibility Form (available at http://registrar.mst.edu) in order to reinstate their registration. Distance education students who do not register for three consecutive semesters must complete and submit the SRR form to reinstate their registration. A returning student can use this form to reestablish his or her admission status, provided that the student:

- has a graduate GPA greater than 3.0, and
- has received fewer than nine credit hours of F and/or C grades, and
- has taken his or her first graduate course within the past six years, and
- has taken fewer than twelve credit hours under probational M.S. status.

All these criteria must be met in order for the student to reestablish active status as a regular graduate student. If any of these criteria are not met, the student must reapply for graduate admission to his or her former department. A student who wishes to change departments or change from non-degree status to regular or probational graduate status must submit a complete graduate admissions application package to his or her prospective department.

Admission Categories and Graduate Student Classifications

Graduate students at Missouri S&T are admitted or classified in one of the following categories:

**Regular Status**

Admission as a regular graduate student is normally limited to those who ranked in the upper third of their baccalaureate graduating class or who have done quality work at the graduate level. For this requirement, a cumulative B average (3.0 GPA on a 4.0 scale), or a B average (3.0 GPA on a 4.0 scale) for the student’s last sixty credit hours of undergraduate coursework is considered equivalent to an upper one-third standing. If the student’s undergraduate coursework does not meet the standards of the graduate degree granting department, the student may be required to take additional courses, for non-graduate credit, as determined by the chair or designate of the major department. For more specific information about minimum GPA requirements, please consult your prospective department’s website or entry in the Areas of Study section of this catalog.

**Probational Status**

Any person not eligible for admission as a regular graduate student may be considered for admission as a probational graduate student. Probational graduate admission is normally limited to those students who ranked in the upper one-half of their baccalaureate graduating class, or who have achieved at least a cumulative 2.75 GPA (on a 4.0 scale) for their entire undergraduate career, or a 2.75 GPA (on a 4.0 scale) for their last sixty credit hours of undergraduate coursework. Minimum GPA requirements for particular departments may be set higher, so please consult your prospective department’s website or entry in the Areas of Study section of this catalog for more specific information.

Any probational graduate student who subsequently desires to pursue a degree as a regular graduate student may apply to change his or her status from “probational” to “regular.” However, such consideration is not permitted until the probational graduate student has completed a minimum of twelve credit hours of graduate coursework with a cumulative grade point average of 3.0 or higher. After these initial twelve hours are completed satisfactorily, the probational student may, with the concurrence of his or her advisor, apply for regular student status by submitting Form 1. The approval of Form 1 by the department chair and the Vice Provost of Graduate Studies confers “regular” status to a formerly “probational” graduate student.

Only those credits completed as a probational graduate student that are subsequently approved by the student’s advisor, department chair, and Vice Provost for Graduate Studies may be applied toward a graduate degree. However, all coursework completed as a probational graduate student, as well as the student’s GRE scores, will be considered relevant to this change-of-status decision. Probational graduate students may retain their probational status for no more than one additional semester after completing their first twelve hours of graduate coursework. Regardless of the student’s admission status, all completed graduate coursework (excluding research and special problems) will apply toward the student’s cumulative GPA. Students with probational status are not allowed to register for 490 credit until the semester in which the minimum of twelve credit hours of graduate coursework that form the proposed schedule on Form 1 will be completed.

**Non-degree Status**

Any prospective student who wishes to study at the graduate level but who does not intend to pursue a graduate degree may be considered for admission as a non-degree graduate student. Typically, this category of admission applies to, but is not restricted to, individuals who have a job-related need for a particular graduate-level course. Admission to non-degree graduate student status requires an application form, official transcripts, and an application fee, but neither GRE nor GMAT scores are required. Prospective students seeking admission in this category are encouraged to refer to their prospective department’s website or entry in the Areas of Study section of this catalog for further department-specific information regarding non-degree status admission requirements.

Up to nine hours of graduate coursework taken as a non-degree student may be counted toward a Missouri S&T graduate degree program, if applicable. Furthermore, if a student initially enrolls as a non-degree
student and is subsequently accepted into a graduate degree program before completing a particular course, that course may be accepted toward the graduate degree program subject to approval by the student’s advisor, department chair, and the Vice Provost for Graduate Studies.

Non-degree students may enroll in any graduate course. Coursework taken to fulfill the requirements of an approved certificate program can, in some cases, be transferred into a degree program with the approval of the department chair and the Vice Provost for Graduate Studies. Additional information about graduate certificate programs is available on the department websites and in the Areas of Study section of this catalog.

Students who must take particular undergraduate courses due to their different or deficient undergraduate degree, or for any other reason, but who otherwise meet graduate admission requirements are encouraged to apply for graduate admission by the first semester that they plan to take one or more graduate courses. These students must receive permission from their department in order to enroll in these graduate courses.

Dual Student Status
Undergraduates may apply for dual enrollment as both an undergraduate and a graduate student for the second semester of their senior year. A student who seeks dual enrollment must submit an application to the Director of Admissions. Admission for dually enrolled students is granted by the department chair and the Vice Provost of Graduate Studies. Admission is normally limited to those students who rank in the upper third of their undergraduate class. As an alternative to class rank, students are eligible to dually enroll when they have obtained senior status, with a minimum GPA of 3.5 if two semesters remain or a 3.0 in their final semester. A form for this purpose can be obtained at http://registrar.mst.edu/documents/dualenrolled.pdf. Students must declare which courses are to be taken for graduate credit within the first two weeks of the semester. A dually enrolled student must take at least three hours of undergraduate credit from Missouri S&T each semester.

Dually enrolled students are limited to sixteen total credit hours per semester, but petitions for additional credit hours will be considered by the Provost. Petition forms are available at http://registrar.mst.edu/documents/dualenrolled.pdf. If a dually enrolled student fails to meet minimum undergraduate scholastic standards, his or her resulting academic probationary status will be that of an undergraduate and will be evaluated without reference to the student’s grades in his or her graduate course(s).

Graduate Student Forms
With the help of their advisors and department chairs, all graduate students must complete and submit a series of forms to the Office of Graduate Studies throughout the course of their degree programs. These forms are used to indicate academic intentions, details of degree programs, membership of advisory committees, and performance on various examinations. All graduate student forms are available online at: http://grad.mst.edu/currentstudents/

Graduate Student Appeals
Graduate students at Missouri S&T have the right to appeal decisions made about their performance or their status. For details regarding the appeals procedure, please refer to the Student Academic Regulations Handbook, available online at http://registrar.mst.edu/academicregs/.

Graduate Student Registration
The graduate student registration guidelines are outlined in Policy Memorandum No. II-20, which is available at http://chancellor.mst.edu/media/administrative/chancellor/documents/policy/II-20.pdf. The policies below are taken directly from that document.

A. Registration Guidelines for All Graduate Degree Candidates
1. The full-time load for graduate students is a minimum of nine credit hours for a semester and three credit hours for a summer session.
2. Students possessing an F-1 or J-1 student visa may be subject to additional course enrollment requirements in order to retain their student visas.
3. Students may also be subject to the registration requirements of other agencies, such as federal financial aid, etc.
4. All graduate students employed and conducting research or teaching shall hold the titles of graduate teaching and research assistants (GTA/GRA), including graduate assistants (GA), graduate instructors, and teaching fellows, are required to enroll for at least nine credit hours each semester and three credit hours during the summer session.
5. Graduate students using campus resources will enroll for credits consistent with their use of campus resources, as determined by their department and their own needs for credit. But in no case shall they be enrolled for less than three hours each semester or summer. Graduate students not using campus resources during a summer session are not required to be enrolled.
6. On-campus graduate students conducting off-campus research for credit must obtain advance approval from the department chair and the Office of the Vice Provost for Graduate Studies.
7. If an on-campus graduate student defends his or her thesis or dissertation during the intersession, then an examination-only fee is appropriate. Inter session, for the purposes of this section, refers to the specific interval of time between the closing date of one academic session (a semester or summer session) and one week before the commencement of classes in the academic session that immediately follows.
8. A one-time only, exit semester exemption of full-time enrollment is available to students in the terminal semester of studies at Missouri S&T. If a student does not graduate at the end of the semester of reduced enrollment, full-time enrollment will be required in each and every subsequent semester until the student graduates. Full-time enrollment consists of at least nine credit hours in each regular semester and at least three credit hours for each summer session until the student graduates. This may adversely affect the student’s availability for co-op or Curricular Practical Training.

B. Other Registration Guidelines for Candidates for a Doctoral Degree
1. After completing the residency requirement and passing the comprehensive examination for the doctoral degree, the doctoral student must remain enrolled until the degree is completed or the candidacy is cancelled. A student actively engaged in research work toward the degree at an off-campus location must be enrolled for credit commensurate with this activity, but in no case fewer than three credit hours each semester or summer session.
2. When all requirements except the dissertation have been completed and the candidate is not using the university facilities, he or she must enroll for at least one credit hour for each registration period until the degree is completed. Failure to do so may invalidate the candidacy.

3. Registration and billing will be automatic after the student passes the comprehensive examination, once application for continuous registration is made and approved on the Continuous Registration form. Continuous Registration 495 for F-1 and J-1 visa holders may be allowed only during summer sessions if the student is finishing the degree requirements prior to the beginning of the next fall semester.

4. Interruption of continuous registration due to failure to comply (e.g., non-payment) may result in the need for readmission under requirements then in effect.

C. Other Registration Guidelines for Candidates for a Master’s Degree

An examination-only fee is an appropriate substitute for the three-credit-hour minimum requirement when a master’s degree student who has (in a previous session) completed all other requirements for the degree and is no longer an on-campus student returns at any time during the semester to defend the thesis or take the M.S. comprehensive examination.

D. Other Registration Considerations

Students enrolled in oral examination only during an intersession but who fail to submit the library copy of thesis/dissertation before the next semester begins must register for at least one hour of research (490) through the end of the fourth week of the semester or the second week of the summer session. All non-resident students on appointment during the previous semester may enroll at the in-state educational fee rate. If Thesis/Dissertation Approval and Report on Examination for Master’s Degree and the library copy of the thesis/dissertation are not submitted by that time, the student will enroll in at least three but no more than nine credit hours, depending on the student’s individual circumstances.

Graduate Assistantship Permissible Schedules

Graduate students enrolled in a full-time academic program may enroll in no more than sixteen credit hours of coursework during any regular semester and nine credit hours during the summer session, except for those students enrolled in the eighteen-credit-hour MBA core semester. Graduate students who are employed by the university as graduate instructors, teaching fellows, or graduate teaching and research assistants may not exceed a total of eighteen credit hours during a regular semester or nine credit hours for the summer session of combined coursework and employment assignment. The credit-hour equivalent for graduate teaching appointments varies according to how many hours the student teaches. The chart below outlines permissible schedules for graduate instructors, teaching fellows, and graduate teaching and research assistants. The “Appointment” column indicates the level of employment assigned to a graduate student. FTE stands for Full Time Equivalent. A 0.25 FTE appointment requires approximately ten hours per week of effort; a 0.375 FTE appointment requires approximately fifteen hours per week of effort; a 0.5 FTE appointment requires approximately twenty hours per week of effort; and a 0.75 FTE appointment requires approximately thirty hours per week of effort. Graduate Instructors accept the responsibilities of a full-time position that requires forty hours per week of effort. The time commitment of Teaching Fellow varies. The “Credit Hours of Coursework” columns indicate the maximum number of academic credit hours in which a student with a particular appointment may enroll during a semester or summer session.

Credit Hours of Coursework

<table>
<thead>
<tr>
<th>Appointment</th>
<th>Regular Semester</th>
<th>Summer Session</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.250 FTE Grad. Asst.</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>0.375 FTE Grad. Asst.</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>0.500 FTE Grad. Asst.</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>0.625 FTE Grad. Asst.</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>0.750 FTE Grad. Asst.</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Graduate Instructor</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Teaching Fellow</td>
<td>9</td>
<td>0</td>
</tr>
</tbody>
</table>

In addition to the above schedule, any graduate student may enroll for no more than one credit hour in graduate seminar courses in a given semester.

Enrollment Requirements for Students on GTA/GRA/GA or Graduate Fellowships of 0.25 FTE or More

Graduate assistants employed by Missouri S&T as Graduate Teaching Assistants, Graduate Research Assistants, or who receive university or departmental fellowships at the 0.25 FTE or higher level, are expected to enroll in at least nine credit hours per academic semester. Students hired in these positions will pay regular educational fees for the first six hours; the educational fees for all hours beyond the first six hours will be covered by a fee waiver. This policy is known as the 6/9 rule. All other charges and fees, including the engineering course supplementary fee, are not covered by this fee waiver. Furthermore, only courses for the graduate degree that are approved on Forms 1.1-A, or 5.5-A, or prerequisites for these courses, shall be covered by the fee waiver under the 6/9 rule.

Grading System for Graduate Students

Grades in graduate courses, with the exception of 490 research, are A, B, C, and F. “A” is an honor grade and indicates outstanding work. “B” means that the work is entirely satisfactory. “C” means that the work will be considered satisfactory, to a limited extent, in fulfilling the requirements for advanced degrees. “F” means that the student has not earned credit for the course. Research (490), internship (491), and continuous registration (495) grades are Satisfactory (S) and Unsatisfactory (U). Grades of “S” and “U” are also permitted for Special Problems (300 and 400) and Seminar (310 and 410). For ongoing research (490), a delayed grade (DL) can be used. Delayed grades are sometimes assigned to students enrolled in 490 until all of the research has been satisfactorily completed and the thesis or dissertation is successfully defended. Delayed grades may be changed to “S” upon satisfactory completion of the research or “U” if the research is not satisfactorily completed.

The grade of Incomplete (I) is given only at the end of a semester or session in which the student is prevented from completing a course due to sickness or unavoidable absence within the last four weeks of a semester or session (three weeks of class plus finals week). Incomplete grades can be assigned only if the student had earned a passing grade in the course up to the time of such sickness or unavoidable absence. Effective Winter 2001, students must complete the work in which they
are deficient within one year from the close of the semester in which the Incomplete (I) grade was recorded. Failure to do so will cause the Incomplete grade to be changed automatically to an “F” or a “U.” Effective Fall 1992, a student may not withdraw from a course in which he or she receives a grade of Incomplete.

GPA Requirements for Graduate Students

In order to earn a graduate degree, all students must achieve a cumulative GPA of 3.0 or higher in all graduate work taken at Missouri S&T, as well as for all graduate courses listed on the program of study (Form 1 for master’s students and Form 5 for doctoral students). This 3.0 GPA requirement does not apply to courses taken for undergraduate credit, nor does it apply to courses taken so long ago that they cannot be counted toward a graduate degree. No substitutions may be made on the program of study for courses in which the student has earned less than a B grade. All graduate students are encouraged to maintain at least a 3.0 cumulative GPA at all times, and certain departments may even require this minimum GPA. In cases where a graduate student repeats a course, both the original and repeat grades will be used in calculating the student’s GPA, and both will appear on the student’s transcript.

A graduate student who accumulates ten or more credit hours of C or F grades shall no longer be a candidate for an advanced degree from Missouri S&T. This rule does not apply to courses taken for undergraduate credit, nor does it apply to courses taken so long ago that they cannot be counted toward a graduate degree. This limit is cumulative over all degree programs (M.S. plus Ph.D., M.S. plus a second M.S., etc.) and is not per degree program.

Graduate Learning Outcomes

The Graduate Learning Outcomes for Missouri University of Science and Technology as required by the higher Learning Commission are listed below:

1. Knowledge: an ability to apply knowledge of subject matter within their field of study
2. Communication: an ability to communicate effectively within their field of study
3. Critical Thinking: an ability to engage in productive critical thinking within their field of study
4. Professional development: an ability to develop professionally within their field of study.

Certification of Enrollment Status

Students who must send certification of enrollment status to their lending agencies may apply for these certifications at the Registrar’s Office, using the form located at: http://registrar.mst.edu/documents/certlet.pdf. Certification of full-time or half-time status is based upon the number of credit hours for which the student is enrolled and includes courses in which the student is enrolled as a hearer. Full-time status is granted to students enrolled in at least nine credit hours during a regular semester; half-time status is granted to students enrolled in at least four credit hours during a regular semester. For the summer session, at least three credit hours is considered full-time and two credit hours is considered half-time. Hours committed to fulfilling GRA and GTA appointments are not included in enrollment certifications.

Masters Degrees

Master’s Degree Programs at Missouri S&T

Missouri S&T offers three programs leading to Master of Science degrees: the Master of Science with thesis (a minimum of thirty credit hours; some programs require more), the Master of Science without thesis (a minimum of thirty credit hours; some programs require more), and the Master of Science for Teachers. In addition, Missouri S&T offers a Master of Business Administration degree (MBA), a Master of Engineering degree, and a Master of Arts degree (the M.A. is offered in cooperation with the University of Missouri-St. Louis).

The beginning graduate student should choose an appropriate degree program in consultation with his or her advisor and with the approval of the department chair. Within the first six weeks of the semester in which the student takes his or her fifteenth graduate credit hour, the student must formally plan the remainder of his or her graduate program in consultation with his or her advisor and selected committee members. For students pursuing the M.S. with thesis, the advisor will also serve as the chairperson of the three-person thesis advisory committee. The chairperson and at least half of the other thesis advisory committee members must be members of the graduate faculty.

After consulting with his or her advisor, the student will complete and submit Form 1 (http://grad.mst.edu/currentstudents/index.html), which outlines the student’s intended program of study. A minimum of one-half of the course requirements for the degree should be completed after the student submits for approval the typed original Form 1 to the department chair and the Vice Provost for Graduate Studies. Students who fail to comply with the deadline to submit Form 1 will have a registration hold placed on their account by the Office of Graduate Studies. If changes to the approved Form 1 occur at any time, the student must submit Form 1-A to revise his or her approved plan of study.

Time Limits for Earning a Master’s Degree

Students may earn a master’s degree only if all graduate credit counted toward the degree has been earned within the previous six years. When recommended by the student’s advisory committee, however, the committee may validate by examination as many as six credit hours of coursework completed outside this six-year time limit.

Transferring Credits Toward a Master’s Degree

A maximum of nine credit hours of coursework for M.S. degrees may be transferred from outside the University of Missouri system. Such credits must have been registered as graduate courses when they were taken. Students must have earned at least a B grade for all courses to be transferred to a Missouri S&T graduate program, and these transferred courses must be entered as part of the student’s program on Form 1 or 1-A. The Missouri S&T equivalent should be stated, and a transcript that includes the course(s) to be transferred should accompany Form 1. Approval of Form 1 or Form 1-A will allow the transferred course(s) to be entered on the student’s Missouri S&T transcript, but only after the Registrar’s Office has received the student’s official transcript(s) from his or her previous school(s).
Earning a Second Master’s Degree

A student who has earned a master’s degree at Missouri S&T or elsewhere in one major shall be eligible to earn a second master’s degree in another area upon the satisfactory completion of a minimum of 24 additional credit hours of graduate academic work (thesis or non-thesis). At least three credit hours of required coursework must be from the group of lecture courses bearing numbers in the 400-series. A maximum of three credit hours of 200-level courses can be accepted in a second M.S. program. The total credit hours earned in special problems, special investigations, special readings, and graduate seminars must not exceed four hours. In planning dual, or simultaneous, master’s degrees, students must clearly define on Form 1 which degree is to be completed first. A change in order will require the submission of Form 1-A. International students must contact the International Affairs Office before attempting to pursue dual master’s degrees.

Master of Science Degree With Thesis

The Master of Science degree program with thesis requires a minimum of thirty hours of graduate credit over and above any prerequisites, but some programs may require more than thirty hours. Please refer to individual program websites or entries in the Areas of Study section of this catalog for information about particular programs. A minimum of six hours of the required coursework must come from the group of 400-level lecture courses, and a maximum of six credit hours of 200-level coursework may be applied toward certain master’s degree programs, although not all programs will accept 200-level coursework. Please consult your program for specific details. Students are encouraged to take at least six credit hours of coursework outside their major program. In addition, the program of study (Form 1) must include at least six hours of 490 (Graduate Research) and a minimum of eighteen hours of 300- and 400-level lecture courses (some programs will also accept 200-level coursework). The program of study may also include up to nine credit hours of coursework transferred from universities outside of the University of Missouri system. When a student has co-advisors in different departments, the student’s 490 credit may be shared by all departments involved. Research will normally be conducted on the Missouri S&T campus, but in special cases, all or part of the research may be conducted elsewhere. Off-campus research must be supervised by a member of the Missouri S&T faculty, and must have the prior written approval of the student’s graduate advisor, department chair, and the Vice Provost for Graduate Studies (the “Application to do Non-Resident Research” is available at http://grad.mst.edu/documents/NonResident_Research_Application.pdf). Care must be taken to ensure that an off-campus research endeavor will result in educational experiences equivalent or superior to those that a student might expect to have at Missouri S&T.

Master’s Thesis

The findings and results of research undertaken by the candidate for a master’s degree must be presented in a written thesis. A manual entitled “Specifications for Thesis and Dissertations (T/D)” is available at http://grad.mst.edu/currentstudents/thesesdissertations/ this manual outlines the specific requirements for the thesis. Students should be encouraged to prepare a minimum of one original and three copies according to these specifications, unless a different format is approved in advance by the student’s advisor.

Oral Examination, or Master’s Thesis Defense

When the thesis is completed, the candidate distributes a copy to each member of his or her advisory committee and arranges a time and place for the oral examination, or defense, of the thesis. These oral examinations are normally scheduled when the University is officially in session, and the candidate must be enrolled at the time of the examination. An on-campus candidate for a graduate degree may enroll during the intersession for the final examination only (course 493) for no hours of credit and pay the examination fee. Each committee member should be allowed to examine the thesis for at least seven working days before the oral defense. The defense may be comprehensive in character, and the candidate should be able to demonstrate an acceptable level of knowledge of a professional area, as defined by his or her degree program.

In order for the candidate to pass the examination, every member of the examining committee must vote affirmatively. If any member votes not to pass the candidate, the Vice Provost shall appoint a new examining committee on which the dissenting member may be replaced, and the new committee will administer a second examination. A student who fails a second time will no longer be eligible to receive a graduate degree from that program. However, the student is still eligible to pursue a graduate degree from any other graduate degree program willing to accept him or her.

Immediately following the thesis defense, the chair of the examining committee will report the action of the committee (on Form 2) first to the department chair and then to the Vice Provost for Graduate Studies. Approval of Form 2 signifies that the members of the committee examined the thesis closely for both scientific content and format, and determined that it meets the requirements for a master’s degree and is worthy of acceptance by the graduate faculty of Missouri S&T.

Approval and Filing of the Thesis

At the close of a successful thesis defense, the members of the examining committee will sign the Form 2 to signify that they have read and approved the thesis. If the committee indicates that corrections must be made to the thesis, the student must make such corrections and then seek approval of the revised thesis from the committee members and obtain the necessary signatures. The final approved copy of the thesis is then taken to the Office of Graduate Studies, where it is carefully checked to ensure that the document is properly formatted according to the specifications available online. After the Office of Graduate Studies approves the document, it is forwarded to the Missouri S&T Library. Liberal choices are allowed relative to the style manual selected, and must reflect a level of quality suitable for professional publication. The student will present one copy of the approved thesis to the department chair and one to the thesis advisor, and will retain one copy for his or her personal records.
Procedures for Earning the Master of Science Degree With Thesis

All master's degree students must have fulfilled all admissions requirements, including English proficiency test scores, if necessary. Students admitted to a Master of Science degree program and who are writing a thesis must adhere to the following procedures.

1. The student will consult with the graduate advisor about course scheduling and registering for classes.
2. The student will select an advisor and committee, and complete Form 1 (typed original) within six weeks of the beginning of the semester in which the student takes his or her fifteenth graduate credit hour. Students who fail to comply with this deadline will have a registration hold placed on their account.
3. The student will complete academic requirements.
4. The student will check with the Registrar to make application for graduation within four weeks of the beginning of the student’s final semester, or within two weeks of the beginning of the summer session. The graduation application form for graduation is available at: http://registrar.mst.edu/documents/gradgraduationappl.pdf.
5. The student will arrange a date, time, and place for the oral examination, or thesis defense, and forward this information to the Office of Graduate Studies electronically. The student must be enrolled at the time of oral examination.
6. The student will distribute copies of the thesis to all members of the examining committee at least seven working days before the oral examination.
7. The chair of the examining committee will report the action of the committee to the Office of Graduate Studies by submitting a typed original Form 2, accompanied by a copy of the approved thesis.
8. The Vice Provost of Graduate Studies will forward the approved thesis to the Missouri S&T Library after the student fulfills all academic requirements and pays all enrollment or examination fees. At this point the student must complete the Scholars’ Mine Online Thesis and Dissertation Submission Form, available at https://scholarsmine-contribute.mst.edu/rrapp/.
9. The student will present one copy of the approved thesis to the department chair and one to the advisor, and will retain one copy for his or her personal records.
10. The Board of Curators will, upon the recommendation of the graduate faculty, grant the student the Master of Science degree when all degree requirements are met.

Master's Comprehensive Examination

Most master's degree programs at Missouri S&T do not require students to take a comprehensive written examination. Please consult your department’s website or Areas of Study section of this catalog to determine if the comprehensive examination is required for master’s degree candidates.

The master's degree candidate must successfully complete a final written comprehensive examination that is administered by an examining committee. The members of this committee are chosen by the candidate, in consultation with his or her advisor and department chair. The department chair then submits for approval the names of four faculty members and that of the major advisor to the Vice Provost for Graduate Studies, using Form 1-B. The committee must consist of at least five members, including at least one person from outside the candidate’s major department who is knowledgeable about the student’s chosen out-of-department coursework. The chair and at least one half of the members of this committee should belong to the graduate faculty.

The comprehensive written examination will be given only once each semester or summer session and not earlier than six weeks before the last Friday of the semester or three weeks before the end of the summer session. The candidate will receive a passing grade if all, or all but one, of the members’ votes to pass. A student who fails the examination must take it again at the next regularly scheduled examination time. A student who fails the examination a second time will no longer be eligible to receive a graduate degree from that program. However, the student is still eligible to pursue a graduate degree from any other graduate degree program willing to accept him or her.

Procedures for Earning the Master of Science Degree Without Thesis

All master's degree students must have fulfilled all admissions requirements, including English proficiency test scores, if necessary. Students admitted to a Master of Science degree program who are not writing a thesis but who are taking a comprehensive examination must adhere to the following procedures.

1. The student will consult with the graduate advisor about course scheduling, and register for classes.
2. The student will select an advisor and committee, and complete Form 1 (typed original) within six weeks of the beginning of the semester in which the student takes his or her fifteenth graduate credit hour. Students who fail to comply with this deadline will have a registration hold placed on their account.
3. The student will complete academic requirements.
4. The student will check with the Registrar to make application for graduation within four weeks of the beginning of the student’s final semester, or within two weeks of the beginning of the summer session. The graduation application form for graduation is available at: http://registrar.mst.edu/forms/
5. The student will work with the graduate advisor and the department chair to complete and submit Form 1-B, which identifies potential members of the student’s examining committee.
6. The Vice Provost for Graduate Studies will formally appoint the student’s examining committee.
7. The student will take the written comprehensive examination.
8. The chair of the examining committee will report the action of the committee to the Office of Graduate Studies, using Form 3.
To be admitted into this program, the prospective student must have:

- advisory committee approved by the Vice Provost of Graduate Studies.

The program of each admitted student will be planned and supervised by an academic advisor and must be approved by the Vice Provost of Graduate Studies. For special situations, the Board of Curators may modify or waive these requirements, if necessary, on a case-by-case basis.

9. The Board of Curators will, upon the recommendation of the graduate faculty, grant the student the Master of Science degree when all degree requirements are met and all enrollment or examination fees have been paid. An on-campus candidate for a graduate degree may enroll during the intersession for the final examination only (course 493) for no hours of credit and pay the examination fee.

Procedures for Earning the Master of Science Degree, Coursework Only

All master's degree students must have fulfilled all admissions requirements, including English proficiency test scores, if necessary. Students admitted to a Master of Science degree program who are not writing a thesis and who are not required to pass a comprehensive examination must adhere to the following procedures.

1. The student will consult with the graduate advisor about course scheduling and register for classes.

2. The student will select an advisor and complete Form 1 (typed original) within six weeks of the beginning of the semester in which the student takes his or her fifteenth graduate credit hour. Students who fail to comply with this deadline will have a registration hold placed on their account.

3. The student will complete academic requirements.

4. The student will check with the Registrar to make application for graduation within four weeks of the beginning of the student's final semester, or within two weeks of the beginning of the summer session. The graduate application form for graduation is available at: http://registrar.mst.edu/documents/graduationappl.pdf.

5. The Board of Curators will, upon the recommendation of the graduate faculty, grant the student the Master of Science degree when all degree requirements are met and all enrollment or examination fees have been paid.

Master of Science Degree For Teachers

The Master of Science for Teachers degree program is primarily designed for high school teachers in the sciences and mathematics who want to further their education and earn an advanced degree. The Master of Science for Teachers degree is offered through the departments of Chemistry, Geological Sciences and Engineering, Mathematics, and Physics. More information about these specific degree programs is available on the departmental websites and in the Areas of Study section of this catalog.

Admission to the Master of Science for Teachers Program

Because of possible variation in the preparation and academic background of prospective Master of Science for Teachers students, the program of each admitted student will be planned and supervised by an advisory committee approved by the Vice Provost of Graduate Studies. To be admitted into this program, the prospective student must have:

- A degree from an accredited college.
- A teaching certificate for mathematics, biology, earth science, physics, or unified sciences.
- Previous training totaling a minimum of 36 credit hours in mathematics and sciences, including at least 24 credit hours in any of the following areas: biology, chemistry, geology, mathematics, or physics. The department chair may modify or waive these requirements, if necessary, on a case-by-case basis.
- A complete application package, including an application form, official undergraduate and graduate transcripts, Graduate Record Examination (GRE) score (if required), and an application fee.

General Requirements for the Master of Science for Teachers Program

Students admitted to the Master of Science for Teachers program must complete at least thirty credit hours of courses numbered 200 or higher in sciences and mathematics. These must include at least one course of three hours or more numbered 400 or above, exclusive of seminars, special problems, and research courses. A maximum of nine credit hours may be transferred from other colleges or universities. The entire program must be outlined on Form 1 and submitted to the Vice Provost of Graduate Studies for approval. The cumulative GPA for all courses on the student's Form 1 must be 3.0 or higher.

Upon or near completion of the student's coursework, the student must satisfactorily pass comprehensive oral and written final examinations. A committee, appointed by the Vice Provost for Graduate Studies, will administer and evaluate both examinations for each candidate.

Specific requirements for individual majors enrolled in the Master of Science for Teachers program are described on each department's website and in the Areas of Study section of this catalog.

Master of Engineering Degree

The Master of Engineering (M.E.) degree program is designed for full-time students who are able to complete the degree requirements on campus within a single year, as well as for students who have jobs in industry and who thus choose to access this program through distance education. This degree program is practice oriented, and students are expected to complete a significant project in the course of their studies. Currently, the departments of Geotechnics, Manufacturing Engineering, and Mining Engineering offer the Master of Engineering degree. Students interested in pursuing the Master of Engineering degree should consult with an academic advisor and seek approval of the program director in the department of their choice.

General Requirements for the Master of Engineering Degree

The Master of Engineering degree program with project requires a minimum of thirty hours of graduate credit over and above any prerequisites (Mining Engineering requires at least 33 hours). A minimum of six credit hours of the required coursework must come from the group of 400-level lecture courses in the major field of study (not required for Mining Engineering). A maximum of six hours of 200-level coursework can be applied toward the M.E. Degree (the Geotechnics program does not accept 200-level coursework). A minimum three-hour practice-oriented project is required for all M. Eng. candidates, through taking at least three credit hours of graduate course 300/400: Special Problems. The findings and results of the practice-oriented project must be presented in a written report, and some programs may require the candidate to make an oral presentation as well. Care will be taken to provide distance education students with an industrial project that promises education experiences equivalent or superior to those that students working on the campus of Missouri S&T might expect to have. Specific requirements for individual Master of Engineering degree programs are described on each department's website and in the Areas of Study section of this catalog.
Procedures for Earning the Master of Engineering Degree

All students in a Master of Engineering degree program must have fulfilled all admissions requirements, including English proficiency test scores, if necessary. Students admitted to a Master of Engineering degree program must adhere to the following procedures.

1. The student will consult with the graduate advisor about course scheduling, and register for classes.
2. The student will select an advisor, and complete Form 1 (typed original) within six weeks of the beginning of the semester in which the student takes his or her fifteenth graduate credit hour. Students who fail to comply with this deadline will have a registration hold placed on their account.
3. The student will complete academic requirements.
4. The student will check with the Registrar to make application for graduation within four weeks of the beginning of the student’s final semester, or within two weeks of the beginning of the summer session. The graduate application form for graduation is available at: http://registrar.mst.edu/documents/gradgraduationappl.pdf.
5. The student will submit the practice-oriented project report to the graduate advisor. (Some programs may also require the student to make an oral presentation based on the report.)
6. The advisor will advise the program director of the results of the report. The program director will complete Form 3 and submit it to the Vice Provost of Graduate Studies. The Board of Curators will, upon the recommendation of the graduate faculty, grant the student the Master of Engineering degree when all graduation requirements are met and all enrollment or examination fees have been paid. An on-campus candidate for a graduate degree may enroll during the intersession for the final examination only (course 493) for no hours of credit and pay the examination fee.

Master of Business Administration (MBA) Degree

The Master of Business Administration (MBA) is a professional degree that combines core business knowledge with specialization tracks that include the newest technology trends, all in an environment of team based project work, business plan development, live simulations, and employer networking. In addition to influential presentation skills and advanced problem solving competencies, MBA’s develop advanced strategic thinking skills that are required of the leaders of today and tomorrow.

The MBA requires 36 hours of coursework and students can complete the degree program in as little as 18 months of full-time study or 3 years in our part-time Executive MBA track. Students take 21 hours of core course work and choose 15 hours of electives.

Our MBA program is unique in that we offer 5 graduate certificates that may be completed within the MBA Program requirements. The part-time Executive MBA is offered on-campus or entirely through distance education. Students in the full-time MBA may apply for entry into the part-time Executive MBA only upon successful placement and only in the last semester of the 18 month program.

General Requirements for the MBA Program

The Master of Business Administration program requires a minimum of 36 credit hours of graduate coursework for successful program completion. Please note that the MBA Program does not accept transfer credits from other institutions.

Within the 36 credit hours of graduate coursework, students must complete 21 credit hours of core classes and 15 credit hours of electives. These elective credits allow candidates to pursue a Graduate Certificate in business sustainability, enterprise resource planning (ERP/SAP), information technology management, data warehousing, or project management. Additionally, MBA candidates may choose to develop an area of specialization.

Procedures for Earning the MBA

All Master of Business Administration students must have fulfilled all admissions requirements established by the MBA Admissions Committee. Students admitted to the MBA program must adhere to the following procedures.

1. The student will consult with the MBA Director regarding their course schedules and register for classes.
2. The student will complete a Form MBA 1 (typed original) before the end of the first week of the semester in which they begin the MBA Program. Students who fail to comply with this deadline will have a registration hold placed on their account.
3. The student will complete the application for graduation within a week of the beginning of the student’s final semester. The graduate application form for graduation is available at: http://registrar.mst.edu/documents/gradgraduationappl.pdf.
4. The student will complete all academic requirements as presented by the MBA Academic Committee.
5. The student will sign and return to the MBA Director the MBA Honor Code on the first day of the term in which they begin, as well as honor the terms outlined in the signed MBA Honor Code document.
6. The Board of Curators will, upon the recommendation of the graduate faculty, grant the student the Master of Business Administration degree when all graduation requirements are met and all enrollment fees have been paid.

Master of Arts Degree in Economics and English

The departments of Economics and English at Missouri S&T have entered into a cooperative agreement with the corresponding departments at the University of Missouri-St. Louis to offer the Master of Arts in Economics and English. This agreement permits students to take up to twelve hours of graduate credit on the Missouri S&T campus. However, students may take only nine credit hours at the 300-level. Students interested in enrolling in a Master of Arts program are required to fulfill all admissions requirements, including English proficiency test scores, if necessary. Specific requirements for individual majors enrolled in the Master of Arts degree are described on each department’s website and in the Areas of Study section of this catalog.

Doctorate Degrees

Doctor of Philosophy (Ph.D.) Degree

The degree of Doctor of Philosophy is awarded to students who have pursued graduate study without serious interruption, submitted an acceptable dissertation, passed all prescribed examinations, and satisfactorily met all requirements described below. The Missouri S&T graduate faculty attests that recipients of this degree have attained a high level of learning through extensive study in some specialized area
of knowledge, and have developed the ability to conduct independent research. Students interested in pursuing the Ph.D. at Missouri S&T must first submit a complete application package. Please consult your prospective department’s website or entry in the Areas of Study section of this catalog for further information about admissions requirements for particular programs.

Shared Doctoral Programs

Through its identification of faculty qualified to direct doctoral candidates on all four University of Missouri campuses, Missouri S&T provides a unique opportunity for doctoral students to attain a remarkable breadth of academic experience. Candidates admitted to doctoral status at Missouri S&T may plan, with the consent of their committee, either coursework or research on another University of Missouri campus. Advisory committee membership may also involve more than one campus, and dissertations may be pursued under the direction of an appropriate graduate faculty member on a campus other than Missouri S&T. Residency and other routine requirements of Missouri S&T must be followed. The Vice Provost for Graduate Studies should be involved in planning shared doctoral programs as early as possible, to prevent potential misunderstandings or complications.

Acceptance of Candidates for the Ph.D.

Technically, a student is considered a doctoral-level student only after he or she satisfactorily completes thirty credit hours of graduate study. Students must pass a Ph.D. qualifying examination before they can be formally considered candidates for the doctoral degree, and several departments require the qualifying examination to be passed by the end of the second semester after completion of the M.S. degree. The proposed Ph.D. program of study (Form 5: http://grad.mst.edu/currentstudents/) must be submitted by the end of the semester in which the student passes his or her qualifying examination. This examination may be taken after the student has been accepted to Missouri S&T, but prior to the student’s initial enrollment, if the student desires. The department chair will report the results of the qualifying examination to the Vice Provost for Graduate Studies using Form 4 (http://grad.mst.edu/currentstudents/index.html).

A student will be formally accepted as a candidate for a doctoral degree after (1) he or she passes the qualifying exam; and (2) his or her program of study (Form 5) has been approved by the advisory committee, the department chair, and the Vice Provost for Graduate Studies.

After passing the qualifying exam, the doctoral candidate will consult with an advisor of his or her choice to select an advisory committee. The committee will consist of at least five members, and at least four of the members should belong to the graduate faculty. The advisory committee must include at least one member from outside the candidate’s major department. One member of the committee should also be designated to represent the department most closely associated with any minor field of study elected by the student. The names of the proposed members of the advisory committee will be listed on Form 5 (http://grad.mst.edu/currentstudents/) and sent by the student’s department chair to the Vice Provost for Graduate Studies for formal appointment. Additional members and replacement members may be appointed using Form 5-A.

Doctoral candidates are encouraged to make effective use of their advisory committee by:

- submitting a written description of the proposed research to the members of the committee as soon as the dissertation topic is decided;
- obtaining written approval of the committee indicating that the proposed research is of Ph.D. caliber;
- submitting periodic progress reports to the committee and discussing them with individual committee members or with the committee as a group (the frequency of the reports and the method of discussion should be determined by the committee).

A person who has held the rank of assistant professor or higher at Missouri S&T is not eligible to become a candidate for the Ph.D. at this institution.

Proposed Program of Study for the Ph.D.

Any student admitted to a doctoral program who has not already received a master’s degree should consult with his or her advisor about a proposed program of study. An advisory committee (listed on Form 5, available at http://grad.mst.edu/currentstudents/), shall be submitted for approval by the Vice Provost for Graduate Studies during the second semester of the student’s graduate coursework. The committee will aid the student in preparing an outline of his or her coursework and the research investigation proposed for the dissertation; this information will be included on Form 5 (http://grad.mst.edu/currentstudents/) and must be submitted by the end of the semester in which the student passes his or her qualifying examination.

A doctoral student who has already received a master’s degree should also consult with his or her advisor about a proposed program of study, and complete and submit Form 5 to the Vice Provost for Graduate Studies for approval before the student enrolls for a second semester. For Ph.D. students who have already earned a master’s degree, Form 5 will designate all appropriate graduate work beyond the baccalaureate level to be applied to the doctoral program requirements.

Residency Requirement for the Ph.D.

The candidate for the Ph.D. will normally complete three years of residency, which is the equivalent of six semesters and a minimum of 72 credit hours of full-time academic work beyond the bachelor’s degree. At least half of those credit hours must be taken at Missouri S&T. For those holding a master’s degree from Missouri S&T or another institution, this three-year residency requirement can be met by completing the equivalent of two years (four semesters) of full-time academic work beyond a first master’s degree, including at least two consecutive semesters in residence at Missouri S&T while enrolled in at least nine graduate credit hours per semester. If the student has spent any years of graduate work away from Missouri S&T, the Vice Provost for Graduate Studies, upon recommendation of the student’s advisory committee, will decide in each case whether these years may be properly regarded as having been spent under suitable guidance and favorable conditions, and thus be applied to the student’s residency requirement at Missouri S&T. At least fifteen hours of graduate coursework, exclusive of research (490), special problems, special investigations, and seminars, must be taken on the Missouri S&T campus.

Please use the following chart to determine how to calculate residency.

<table>
<thead>
<tr>
<th>Credit hours per session</th>
<th>Residency equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 to 16</td>
<td>0.500 year</td>
</tr>
<tr>
<td>9 to 11</td>
<td>0.375 year</td>
</tr>
<tr>
<td>6 to 8</td>
<td>0.250 year</td>
</tr>
<tr>
<td>(6 to 9, summer)</td>
<td>0.250 year</td>
</tr>
</tbody>
</table>
3 to 5 0.125 year  
0 to 2 0.00 year

The Ph.D. student’s residency requirements are to be included on Form 5.

For Ph.D. degrees being offered wholly through distance education, such as the one available in Systems Engineering, residency requirements are calculated differently. Please consult your department’s website or the entry in the Areas of Study section of this catalog for further details.

**Ph.D. Qualifying Examination**

A qualifying examination will be administered by the faculty of the candidate’s major department no later than the student’s fifth semester of enrollment. The results of this examination will allow the student’s advisory committee to assess the student’s level of preparation for the Ph.D. degree, and will assist the committee in helping to plan the student’s program of study (Form 5). The results of the qualifying examination will be reported on Form 4 and submitted by the department chair to the Vice Provost for Graduate Studies.

**Subjects of Study for the Ph.D.**

The subjects of study for the Ph.D. may be chosen from one or more departments, as determined by the advisory committee, but shall constitute a definite plan of training for research or scholarly investigation in some particular field. Students must designate a major field of study, and are encouraged to select one minor field of study consisting of at least twelve credit hours of work outside their major area of study.

The doctoral program will include at least 24 credit hours of dissertation research (490) and a minimum of 24 credit hours of coursework (exclusive of 300, 400, and 490) as part of the degree requirements. Deviations from this requirement must receive special approval from the Vice Provost for Graduate Studies. Students are encouraged to enroll in at least fifteen credit hours of 400-level lecture courses during the span of their doctoral program.

Correspondence and extension courses do not form part of the program for the Ph.D. degree, except as they constitute a part of a master’s program. Correspondence and extension courses beyond those allowed for a master’s degree may not be applied to a doctoral degree program. Graduate faculty recognize that distance sections of Missouri S&T approved courses number may be applied to the doctoral degree program.

Doctoral research will normally be conducted on the Missouri S&T campus. In special cases, all or part of the research may be conducted elsewhere, but must be supervised by a member of the Missouri S&T faculty. Students who conduct off-campus research must have the prior written approval of their advisor, the department chair, and the Vice Provost for Graduate Studies, as indicated on the Non-Resident Research Application (http://grad.mst.edu/documents/NonResident_Research_Application.pdf).

**Time Limits for Earning the Ph.D.**

The Ph.D. degree will be granted only if all graduate credit counted toward the degree has been earned in the previous eight years, unless a formal request for an extension is initiated by the advisor and approved by the department chair and the Vice Provost for Graduate Studies. An extension, if granted, may involve revising the candidate’s program of study to update coursework and research. Students who are enrolled in a documented Ph.D. distance program, such as the one available in Systems Engineering, must also complete their graduation requirements within eight years. Candidates who have already earned a master’s degree or its equivalent (first thirty hours of graduate credit), or who passed the qualifying examination, must have earned all remaining credit toward their degree within the last six years.

Applying prior credits from a master’s degree program or its equivalent toward a doctoral degree program is up to the discretion of the student’s advisory committee.

**Foreign Language Requirements for the Ph.D.**

The decision as to any foreign language requirement rests with the department and the doctoral candidate’s advisory committee, and descriptions of any foreign language requirement can be found on the departmental websites or in the Areas of Study section of this catalog. Candidates may fulfill their foreign language requirement, if any, either before or after they take their comprehensive examination.

**Ph.D. Comprehensive Examination**

The Vice Provost for Graduate Studies will authorize the student’s advisory committee to administer a comprehensive examination after the student has completed at least 75% of the coursework required for a doctoral degree, as listed on the student’s approved program of study (Forms 5 and 5-A). Some departments require students to complete 100% of their coursework before they are permitted to take the comprehensive examination; consult your department’s website or entry in the Areas of Study section of this catalog for additional details. The format of the comprehensive examination is both written and oral.

With the approval of the student’s advisory committee, the written portion of the examination may be administered by the candidate’s department, but the final judgment of the candidate’s performance will be left to the advisory committee. Upon satisfactory completion of the written examination, the advisory committee will administer the oral examination. It is recommended that the oral examination take place within thirty days of the written examination.

The results of the comprehensive examination will be sent to the Vice Provost for Graduate Studies, using Form 6 (http://grad.mst.edu/currentstudents/index.html). A student will be considered to have passed the examination if all, or all but one, of the advisory committee members vote that the student pass.

If the student fails the comprehensive examination, the advisory committee will recommend additional work or other remedial measures to the candidate. A second comprehensive examination may be scheduled no sooner than twelve weeks after the student’s first attempt. A student who fails the examination a second time will no longer be eligible to receive a graduate degree from that program. However, the student is still eligible to pursue a graduate degree from any other graduate degree program willing to accept him or her.

**Ph.D. Dissertation**

The dissertation, embodying the results of an original investigation, must be written upon a subject approved by the student’s major advisor and be formatted in accordance with "Specifications for Theses and Dissertations (T/D)," a manual available online at: http://grad.mst.edu/currentstudents/thesesdissertations.
Final Examination, or Ph.D. Dissertation Defense

The final examination is an oral defense of the dissertation and may be attended by any interested person. Attendees may question the candidate with the permission of the chair of the advisory committee. The Vice Provost for Graduate Studies will authorize the student’s advisory committee to administer the final examination, which may be scheduled no sooner than twelve weeks after the completion of the comprehensive examination. Notice of the final examination, along with the dissertation abstract, shall be publicized by the Office of Graduate Studies at least one week prior to the examination.

The advisory committee shall closely examine the dissertation for both scientific content and format, in order to determine that it meets the requirements for a doctoral degree and is worthy of acceptance by the graduate faculty of Missouri S&T. A report of the examination results will be sent to the Office of Graduate Studies using Form 7 (http://grad.mst.edu/currentstudents/index.html).

A candidate will be considered to have passed the final examination if all, or all but one, of the advisory committee members vote that the student pass. If the student fails the final examination, the committee will recommend additional work or other remedial measures to be taken before another examination is scheduled. At the close of a successful final examination, the members of the examining committee will sign the Form 7 to signify that they have read and approved the dissertation. If the committee indicates that corrections must be made, the student must make such corrections and then seek approval of the revised dissertation from the committee members and obtain the necessary signatures.

The final approved copy of the dissertation is then taken to the Office of Graduate Studies, where it is carefully checked to ensure that the document is properly formatted according to the specifications available online. After the Office of Graduate Studies approves the document, it is forwarded to the Missouri S&T Library. Liberal choices are allowed relative to the style manual used in the preparation of the dissertation. However, approval of the dissertation requires strict adherence to the style manual selected, and must reflect a level of quality suitable for professional publication. The student will present one copy of the approved dissertation to the department chair and one to the dissertation advisor, and will retain one copy for his or her personal records.

Procedures for Earning the Ph.D.

All doctoral students must have fulfilled all admissions requirements, including English proficiency test scores, if necessary. Students admitted to a Ph.D. program must adhere to the following procedures.

1. The student initiates his or her candidacy for the doctoral degree by meeting both of the following requirements
   A. The student passes a qualifying examination administered by the department in which the student intends to become a doctoral degree candidate.
   B. The student satisfactorily completes the first thirty hours of graduate study in his or her designated program.

   In the case of students who do not have a relevant master’s degree, requirement (B) will normally be fulfilled when the student satisfactorily completes thirty credit hours of suitable graduate coursework toward his or her doctoral degree. Requirement (B) will normally be fulfilled automatically for students who have already earned a relevant master’s degree. In both cases, the department determines when the second requirement for candidacy is satisfied. Candidacy must be established prior to the beginning of the fifth semester (not counting summer sessions) of enrollment as a graduate student in a doctoral program. Graduate Forms 4 and 5 must be completed and submitted no later than six weeks into the student’s fifth semester.

2. The candidate consults with his or her academic advisor about possible members of the advisory committee. The advisor, with the approval of the department chair, submits Form 5 to the Vice Provost for Graduate Studies, requesting the formal appointment of the advisory committee.

3. The candidate solicits the aid of his or her committee members in preparing an outline of courses and research, and, with the help of his or her advisor, completes and submits Form 5 to the Office of Graduate Studies.

4. The candidate completes 75% of the coursework outlined on the doctoral program of study (Form 5). At this point, the advisor requests the Vice Provost for Graduate Studies to authorize the advisory committee to administer the Ph.D. comprehensive examination, using the Request for Authorization of Ph.D. Comprehensive Examination form (http://grad.mst.edu/currentstudents/index.html). (Some departments, including Geological Sciences and Engineering, Materials Science and Engineering, and Mining and Nuclear Engineering, do not require this authorization.)

5. The candidate takes the Ph.D. comprehensive examination, and the advisory committee reports the results of the examination to the Vice Provost for Graduate Studies by completing and submitting Form 6 (http://grad.mst.edu/currentstudents/). After the candidate passes the comprehensive examination, he or she must maintain continuous enrollment until the degree is completed or the candidacy is cancelled.

6. The candidate checks with the Registrar to make application for graduation within four weeks of the beginning of his or her final semester, or within two weeks of the beginning of the summer session. The graduate application form for graduation is available at: http://registrar.mst.edu/forms/.

7. The candidate, in consultation with his or her advisor, selects the date, time, and place of the final examination and informs the Office of Graduate Studies electronically, so that the examination can be publicized at least one week in advance. Note: The candidate must be enrolled at the time of his or her examination. An on-campus candidate for a graduate degree may enroll during the intersession for the final examination only (course 493) for no hours of credit and pay the examination fee.

8. The candidate takes the Ph.D. final exam, and the advisory committee reports the results of the examination to the Vice Provost for Graduate Studies by completing and submitting Form 7 (http://grad.mst.edu/currentstudents/), accompanied by an approved copy of the dissertation, the “Scholars’ Mine Online Thesis and Dissertation Submission Form” (http://scholarsminecontributor.mst.edu/rapp/), the “UMI/ProQuest Doctoral Dissertation Publishing Agreement” form: (http://grad.mst.edu/media/administrative/grad/documents/umi_agreement.pdf), and the “Survey of Earned Doctorates” form: (http://grad.mst.edu/media/administrative/grad/documents/SED11-12.pdf).
9. The Vice Provost of Graduate Studies forwards the approved dissertation to the Missouri S&T Library after the candidate fulfills all academic requirements and pays all enrollment or examination fees.

10. The candidate presents one copy of the approved dissertation to the department chair and one to the advisor, and retains one copy for his or her personal records.

11. The Board of Curators, upon the recommendation of the graduate faculty, grants the candidate the Doctor of Philosophy degree.

Doctor of Engineering (D.E.) Degree

The Doctor of Engineering degree, like the Doctor of Philosophy degree, represents the highest attainable educational level in engineering study and practice. This degree is awarded to candidates who have pursued a broad program of study, completed an acceptable engineering internship, passed all prescribed examinations, submitted satisfactory practice-oriented dissertation, and met all graduation requirements described here. The D.E. degree requires a minimum of ninety graduate credit hours.

Following admission to graduate study, a student can initiate candidacy for the D.E. degree by consulting with the advisor about the selection of an advisory committee. The committee should include the candidate’s major advisor plus at least four other faculty members. The committee members should be representative of the departments included in the candidate’s intended plan of study. This committee will aid the student in preparing the plan of study, which will include coursework, an engineering internship, an outline of the proposed dissertation project, and a program for completing residence requirements. The student is accepted as a candidate for the D.E. degree only after the Vice Provost for Graduate Studies approves the student’s plan of study.

A person who has held the rank of assistant professor or higher at Missouri S&T is not eligible to become a candidate for the D.E. degree at this institution.

Residency Requirements for the D.E.

The D.E. candidate will normally complete three years of residency as a graduate student, which is the equivalent of six semesters and a minimum of 72 credit hours of full-time academic work beyond the bachelor’s degree. For those holding a master’s degree from Missouri S&T or another institution, this three-year residency requirement can be met by completing the equivalent of two years (four semesters) of full-time academic work beyond the master’s degree, including at least two consecutive semesters in residence at Missouri S&T while enrolled in at least nine graduate credit hours per semester. If the student has spent any years of graduate work away from Missouri S&T, the Vice Provost for Graduate Studies, upon recommendation of the student’s advisory committee, will decide in each case whether these years may be properly regarded as having been spent under suitable guidance and favorable conditions, and thus be applied to the student’s residency requirement at Missouri S&T. Please use the following chart to determine how to calculate residency.

<table>
<thead>
<tr>
<th>Credit hours per session</th>
<th>Residency equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 to 16</td>
<td>0.500 year</td>
</tr>
<tr>
<td>9 to 11</td>
<td>0.375 year</td>
</tr>
<tr>
<td>6 to 8</td>
<td>0.250 year</td>
</tr>
<tr>
<td>(6 to 9, summer)</td>
<td>0.250 year</td>
</tr>
</tbody>
</table>

| 3 to 5                   | 0.125 year           |
| 0 to 2                   | 0.00 year            |

The D.E. candidate’s residency requirements are to be included on Form 5.

Time Limits for Earning the D.E.

The Doctor of Engineering degree will be granted only if all graduate credit counted toward the degree has been earned in the previous eight years, unless a formal request for an extension is initiated by the advisor and approved by the department chair and the Vice Provost for Graduate Studies. An extension, if granted, may involve revising the candidate’s program of study to update coursework and research.

Qualifying Examination for the D.E.

A qualifying examination will be administered by the faculty of the candidate’s major department no later than the fifth semester of the student’s enrollment. The results of this examination will allow the student’s advisory committee to assess the student’s level of preparation for the Doctor of Engineering degree, and will assist the committee in planning the student’s program of study (Form 5). The results of the qualifying examination will be reported on Form 4 (http://grad.mst.edu/currentstudents/index.html) and submitted by the department chair to the Vice Provost for Graduate Studies.

Coursework for the D.E.

The coursework for D.E. students normally includes two areas of emphasis in engineering. A third technical area of emphasis should be selected from the physical sciences, computer science, mathematics, or another field of engineering. In addition, a non-technical group of courses, comprising nine to twelve credit hours, should also be included in the student’s program of study. These non-technical courses could be selected from such areas as foreign language, engineering managements, or psychology. D.E. students are expected to take at least 65 hours of graduate coursework (not including 490 credit for research), and most students average around 72 hours. The allocation of the credit hours between the three technical emphasis areas will be at the discretion of the student’s advisory committee; however, at least nine credit hours in each technical area must be included to provide students with the appropriate depth of study.

Correspondence and extension courses may not be applied to a Doctor of Engineering degree program, except as they may constitute part of a master’s program.

Internship for the D.E.

The internship for the Doctor of Engineering degree involves a minimum of one year of planned and approved high-level engineering experience. The candidate and the major advisor will plan the internship in cooperation with the interning organization (normally an industrial concern or government laboratory). The candidate then prepares a detailed proposal that describes the goals of the internship, the tasks to be accomplished, and the facilities at the intended site. This proposal must be approved by the candidate’s advisory committee, the major department chair, and the Vice Provost for Graduate Studies prior to the start of the internship. At the time the internships is approved, the candidate’s internship advisor (the supervisor at the interning organization) will be added to the advisory committee (using Form 5-A). The internship advisor is to be selected on the basis of his or her thorough education and experience, qualifications that suggest
doctoral equivalency credentials. The organization must allow visits to the internship site by the candidate’s major advisor and/or advisory committee members. The internning organization must also agree that any results of the internship may be published by the candidate, although reasonable proprietary rights of the internning organization will be protected. Responsibility for arranging the internship, including site selection and financial compensation during the period of the internship, lies with the candidate.

Graduate credit earned from the internship (graduate course 490) that leads to the candidate’s preparation for his or her dissertation work will apply toward the total required credit hours. Approximately 18 to 25 hours of 490 credit for this phase of the degree will be regarded as an appropriate portion of the ninety total credit hours required for the Doctor of Engineering degree.

Comprehensive Examination for the D.E.
The D.E. student is required to pass a comprehensive examination during his or her candidacy. The comprehensive examination is planned and administered by the student’s advisory committee, and has both a written and an oral component. The comprehensive examination covers coursework contained in the candidate’s plan of study.

A candidate is considered to have passed if all, or all but one, of the advisory committee vote that the student pass. If the student fails the comprehensive examination, the advisory committee will recommend additional work or other remedial measures to the candidate. A second comprehensive examination may be scheduled no sooner than twelve weeks after the student’s first attempt. A student who fails the examination a second time will no longer be eligible to receive a graduate degree from that program. However, the student is still eligible to pursue a graduate degree from any other graduate degree program willing to accept him or her.

Dissertation for the D.E.
The dissertation embodies the results of an original engineering investigation, and must be written upon a subject approved by the major advisor. Normally, the dissertation will relate directly to the candidate’s engineering internship. The dissertation must represent significant, creative, and independent engineering work, and must be prepared in accordance with the “Specifications for Theses and Dissertations (T/D),” an online manual available at http://grad.mst.edu/currentstudents/thesesdissertations/.

Final Examination, or Doctoral Dissertation Defense
The final examination is an oral defense of the dissertation and may be attended by any interested person. Attendees may question the candidate with the permission of the chair of the advisory committee. The Vice Provost for Graduate Studies will authorize the student’s advisory committee to administer the final examination, which may be scheduled no sooner than twelve weeks after the completion of the comprehensive examination. Notice of the final examination, along with the dissertation abstract, shall be publicized by the Office of Graduate Studies at least one week prior to the examination.

The advisory committee shall closely examine the dissertation for both scientific content and format, in order to determine that it meets the requirements for a doctoral degree and is worth of acceptance by the graduate faculty of Missouri S&T. A report of the examination results will be sent to the Office of Graduate Studies using Form 7 (http://grad.mst.edu/currentstudents/index.html).

A candidate will be considered to have passed the final examination if all, or all but one, of the advisory committee members vote that the student pass. If the student fails the final examination, the committee will recommend additional work or other remedial measures to be taken before another examination is scheduled. At the close of a successful final examination, the members of the examining committee will sign the Form 7 to signify that they have read and approved the dissertation. If the committee indicates that corrections must be made, the student must make such corrections and then seek approval of the revised dissertation from the committee members and obtain the necessary signatures.

The final approved copy of the dissertation is then taken to the Office of Graduate Studies, where it is carefully checked to ensure that the document is properly formatted according to the specifications available online. After the Office of Graduate Studies approves the document, it is forwarded to the Missouri S&T Library. Liberal choices are allowed relative to the style manual used in the preparation of the dissertation. However, approval of the dissertation requires strict adherence to the style manual selected, and must reflect a level of quality suitable for professional publication. The candidate will present one copy of the approved dissertation to the department chair and one to the dissertation advisor, and will retain one copy for his or her personal records.

Procedures for Earning the D.E.
All Doctor of Engineering students must have fulfilled all admissions requirements, including English proficiency test scores, if necessary. Students admitted to D.E. program must adhere to the following procedures.

1. The student takes and passes, as early in the program as possible, a qualifying examination administered by the faculty of his or her major department. The department chair reports the results of this qualifying examination to the Vice Provost for Graduate Studies using Form 4.

2. The D.E. candidate consults with his or her advisor to select an advisory committee of at least five members. This should be undertaken only after the candidate has completed thirty graduate credit hours or has already earned a relevant master’s degree. However, a tentative program of study may be planned much earlier.

3. The D.E. candidate’s graduate advisor, with the approval of the department chair, submits Form 5 to the Vice Provost for Graduate Studies, requesting the formal appointment of the advisory committee. Any changes in committee membership are to be recorded using Form 5-A.

4. The D.E. candidate solicits the aid of his or her committee members in preparing a plan of study and internship, using Form 5-DE. Form 5-DE should not be sent to the department chair or to the Vice Provost for Graduate Studies for approval until the student has passed the qualifying examination.

5. The D.E. candidate completes all the courses outlined on his or her program of study (Form 5-DE). At this point, the candidate’s advisor requests the Vice Provost for Graduate Studies to authorize the advisory committee to administer the comprehensive examination, using the Request for Authorization of Ph.D. Comprehensive Examination form (http://grad.mst.edu/currentstudents/). Some departments, including Geological Sciences and Engineering, Materials Science and Engineering, and Mining and Nuclear Engineering, do not require this authorization.
6. The D.E. candidate takes the comprehensive examination, and the advisory committee reports the results of the examination to the Vice Provost for Graduate Studies by completing and submitting Form 6 (http://grad.mst.edu/currentstudents/). After passing the comprehensive examination, the candidate must maintain continuous enrollment until the degree is completed or the candidacy is cancelled.

7. The D.E. candidate completes his or her engineering internship. The candidate’s industrial supervisor should be added to the advisory committee at the beginning of the internship (Form 5-A).

8. The D.E. candidate checks with the Registrar to make application for graduation within four weeks of the beginning of the student’s final semester, or within two weeks of the beginning of the summer session. The graduate application form for graduation is available at: http://registrar.mst.edu/forms/.

9. The D.E. candidate, in consultation with his or her advisor, selects the date, time, and place of the final examination and informs the Office of Graduate Studies electronically, so that the examination can be publicized at least one week in advance. Note: The candidate must be enrolled at the time of his or her examination. An on-campus candidate for a graduate degree may enroll during the intersession for the final examination only (course 493) for no hours of credit and pay the examination fee.

10. The candidate takes the D.E. final exam, and the advisory committee reports the results of the examination to the Vice Provost for Graduate Studies by completing and submitting Form 7, (http://grad.mst.edu/currentstudents/), accompanied by an approved copy of the dissertation, the “Scholars' Mine Online Thesis and “Dissertation Submission Form:” (http://scholarsmine-contribute.mst.edu/frapp/) the “UMI/ProQuest Doctoral Dissertation Publishing Agreement” form: (http://grad.mst.edu/media/administrative/grad/documents/umi_agreement.pdf), and the “Survey of Earned Doctorates” form: (http://grad.mst.edu/media/administrative/grad/documents/SED11-12.pdf).

11. The Vice Provost of Graduate Studies forwards the approved dissertation to the Missouri S&T Library after the candidate fulfills all academic requirements and pays all enrollment or examination fees.

12. The candidate presents one copy of the approved dissertation to the department chair and one to the advisor, and retains one copy for his or her personal records.

13. The Board of Curators, upon the recommendation of the graduate faculty, grants the candidate the Doctor of Engineering degree.

### Graduate Certificate and Minor Programs

#### Graduate Certificate Programs

Missouri S&T offers a number of graduate certificates that are designed to appeal to those working professionals who are interested in furthering their education and who seek the knowledge to understand and contribute to an emerging area of their professional lives. Once admitted to a certificate program, the student must complete four of the designated courses; at least three must be taken from Missouri S&T. The student must have a cumulative GPA of 3.0 or higher in these four courses in order to receive a graduate certificate. Students admitted to a graduate certificate program will have non-degree student status, but will earn graduate credit for the courses they complete. If the four-course sequence is completed with a grade of B or better in each of the courses taken, the student, upon application, will be admitted to the M.S. degree program sponsoring the graduate certificate. The certificate courses taken by students admitted to the M.S. program will apply toward their master’s degrees.

Up to three credit hours of special problems courses (numbered 300 or 400) are allowed as part of all Missouri S&T Graduate Certificate programs. In order for a special problems course to be included in a graduate certificate program, a determination must be made by the offering department(s) that the focus of the special problems course is academically aligned with the general focus of the graduate certificate for which it is being used. The special problems course must be supervised by a full member of the graduate faculty and a letter grade (A, B, C, or F) must be assigned each time a special problems course is taken for the purpose of completing a graduate certificate. In determining whether the graduate certificate program has been successfully completed for the purpose of entry into a graduate degree program, grades received in special problems courses will be considered in the same manner as grades received in lecture courses.

Some graduate certificate programs are sponsored by more than one department. If this is the case, the entering student will identify one of the sponsoring departments as his or her “home” department. Upon successful completion of the certificate program, the student may then apply and be admitted to the master’s degree program in his or her “home” department.

Students who do not have all of the prerequisites necessary to take the courses in their chosen certificate program will be allowed to take “bridge” courses at either the graduate or the undergraduate level in order to prepare for the necessary certificate courses.

Once admitted to a certificate program, a student will be given three years to complete the program so long as he or she maintains at least a B average in the courses taken.

Students meeting the certificate requirements to be admitted into an M.S. program are not required to take the GRE or the GMAT. Students not meeting the certificate requirements may still apply to the M.S. program of their choice, but normal admission requirements (including minimum GRE or GMAT scores) must be met.

Additional information on graduate certificates at Missouri S&T is available at http://dce.mst.edu.

### Designated Graduate Minors

Students enrolled in masters or doctoral degree programs at Missouri S&T may designate a graduate minor, if they choose. Designated graduate minors are offered by individual degree-granting departments, are listed with the Graduate Degree Programs in this catalog. Requirements for the graduate minor are determined by the department offering the minor. Graduate minors can only be awarded when the major degree is awarded, and all requirements for the graduate minor must be completed while the candidate is working toward his or her major degree.

Any graduate student interested in pursuing a graduate minor should consult with his or her academic advisor. Applications for a designated graduate minor must be completed and submitted for approval to the minor-granting department, and must be approved at least one full semester prior to the candidate’s planned graduation date. The application form for designated graduate minors is available at http://registrar.mst.edu/forms/.
Career Opportunities and Employer Relations (COER)

Career Opportunities & Employer Relations (COER) is located on the third floor of Norwood Hall and provides a variety of services to assist Missouri S&T students and alumni in their search for employment.

Employment Opportunities

- **On-campus Interviews** - Hundreds of employers interview each semester for full-time, co-op and summer positions in our professional interview suites. The interview scheduling system, MinerJobs, is online and allows electronic submission of resumes to job postings and allows a student to sign up for an interview with employers who are conducting on-campus interviews.
- **Career Fairs** - Two career fairs are held each year where students and alumni meet recruiters face-to-face to distribute resumes and network.
- **Resume Referrals** - Thousands of resumes are forwarded each year to employers. The employers directly contact the students they are interested in for interviewing.
- **Resume Drop** - Some employers do not plan to interview on-campus, but will post positions in MinerJobs and students have the option of submitting their resume.
- **Alumni Services** - Entrance into career fairs and workshops are free of charge to Missouri S&T alumni. Resume critiquing, advising, alumni resume referral system, and access to MinerJobs listings are available for a $60 annual fee ($10/semester if within one year postgrad). Alumni upload their resumes into the database to be referred to requesting employers.

Advising Services

- **Workshops** - A variety of professional development workshops are presented every semester to help students prepare for employment. All workshops are held at COER in 305 Norwood Hall.
- **Appointments** - Appointments with an advisor are available for one-on-one assistance in writing an effective cover letter and resume or to discuss any job search concerns.
- **Practice Interviews** - Videotaped practice interviews are available with a career advisor to improve interviewing skills.
- **Etiquette Dinners** - A special 5 course dinner to teach sensible strategies on dining and business etiquette is available to all students. Reservations are required and there is a $10.00 charge.
- **Employer Seminar Series** - A series of workshops that host professionals from industry speaking on various career related topics.
- **Life After S&T Seminar Series** - A series of workshops that help seniors prepare for the "real world" upon graduation. Topics include "Paying Back Student Loans" and "Investing Options."
- **Interview Evaluations** - Student interview evaluation forms may be filled out by recruiters to assess student's interviewing skills. These evaluations are an invaluable tool indicating areas of strength and needed improvement.

Council of Graduate Students

The Council of Graduate Students (CGS) is the authorized governing body for the graduate students on the Missouri S&T campus. As such, it provides a liaison between the school administration and the graduate student population. Representatives of the council serve on various committees on the campus and represent the graduate community to advocate their opinions and concerns on various campus policies. CGS deals with the procedural matters on campus and exists to share and discuss the information pertinent to all Missouri S&T and other UM System campuses. CGS strives to maximize the quality of life, develop leadership skills and foster higher academic standards for graduate community at Missouri S&T.

All graduate students who are in good academic standing at Missouri S&T are automatically the members of Council of Graduate Students. The Executive Board of CGS is elected through student voting and holds office for a year. The board consists of the president, vice-president, secretary and treasurer. The department representatives are elected from each graduate degree-granting department. One representative serves for each 25 graduate students in a single department. The information on department representative and the executive board can be obtained from CGS website http://cgs.mst.edu/.

The Office of CGS is in Pine Building, room 309. You can email your inquiries to cgs@mst.edu. Please visit CGS website http://cgs.mst.edu to learn more about the organization’s mission and its activities.

Counseling, Disability Support, and Student Wellness

Counseling, Disability Support, and Student Wellness (CDSW) offers a variety of services to the Missouri S&T campus community including individual, group, and crisis counseling; consultation; programming on many topics; the Van Matre Resource Center of self-help materials; the Faculty and Staff Assistance Program; and assistance for students with disabilities.

Missouri S&T’s Disability Support Services ensure that students with disabilities have equal access to academic classrooms and curricula by coordinating services and academic support. Accommodations can make a difference in academic success.

Personal and career counseling is provided on a time-limited basis to Missouri S&T students and benefit-eligible employees. Services, which are provided by licensed counselors and psychologists, are free and confidential within ethical and legal limitations. Concerns commonly addressed in personal counseling include self-exploration, college adjustment, family issues, feelings of depression and anxiety, interpersonal issues, communication skills, and self-esteem. Relaxation strategies and methods to cope with the many stressors of daily living may also be addressed. Overcoming test anxiety or procrastination, improving self- and time- management, and developing other skills related to success at Missouri S&T may be a focus in counseling.

Individuals wondering about their majors and career options may benefit from career counseling, which typically explores personal and professional goals and how to achieve them.

Group counseling is an interactive, supportive, and interpersonal form of therapy. Counseling Services offers several groups based on campus life, develop leadership skills and foster higher academic standards for graduate community at Missouri S&T.
need and interest. Some current and past groups are General Therapy, Family Issues, ADD/ADHD Support Group, and Test Anxiety.

CDSW actively promotes student learning and professional development through its learning enhancement and outreach programming services. The staff offers programs to campus groups on topics such as teamwork, stress management, conflict resolution, and time management.

The Van Matre Resource Center, a self-help library, contains excellent audio, video, and reading materials. Topics range from communication skills to parenting, career exploration issues to dealing with depression, anxiety, and abuse. Materials are available for checkout.

The Faculty Staff Assistance Program (FSAP) offers a variety of services such as counseling, consultation, organizational development, and programming for faculty and staff. For more information, call (573) 341-6655 or visit http://counsel.mst.edu and http://dss.mst.edu.

Student Wellness

The Student Wellness Program promotes healthy behaviors to create a campus environment conducive to academic, professional, and personal success. Wellness is an active, continuing process of becoming more conscious of and making choices towards a fulfilling and thriving life. S&T’s Student Wellness Program takes an environmental approach to address the well-being of the campus community because individuals are influenced both positively and negatively by the behaviors of others and the environment in which they live. The Student Wellness Program topic areas include: alcohol and other drug prevention; stress management and mental health promotion; healthy eating and physical activity promotion; sexual health; and sexual violence prevention. The Student Wellness Program provides workshops on various health and wellness topics; social norms and health marketing campaigns; special events; information tables; on-line education; and one-on-one wellness consultations. The Health Educator for the Student Wellness Program advises Joe’s P.E.E.R.S. (Providing Education, Encouragement, and Resources for Students) Peer Education Group. Joe’s P.E.E.R.S. is a student group that promotes healthy behaviors among S&T students through interactive programming, awareness campaigns, and distribution of health and wellness information. More information about Joe’s P.E.E.R.S. and the Student Wellness Program can be found at: http://counsel.mst.edu/wellness. If you have questions, you may contact the Health Educator at healthed@mst.edu.

Disability Support Services

This policy statement relating to otherwise qualified persons with disabilities outlines the roles and responsibilities of students, faculty, staff and the Coordinator of Disability Support Services (Coordinator/Advisor) in making Missouri University of Science and Technology programs and services available to all persons. The University places specific emphasis on accommodating the needs of matriculated students with a disability, providing related services, and ensuring the academic integrity of Missouri S&T. This policy statement is in accordance with Section 240.040 E, Policy Related to Students with Disabilities, Collected Rules and Regulations of the University of Missouri, the Missouri Human Rights Act, Section 504 of the Rehabilitation Act of 1973, and the Americans with Disabilities Act of 1990.

I. Confidentiality

A. In accordance with the requirements of the Family Educational Rights and Privacy Act, medical information concerning a disability will be treated with utmost confidentiality. It will be:

1. treated like other medical information
2. maintained in secure files under the jurisdiction of the Coordinator/Advisor
3. released only on a need-to-know basis within the university community

II. Responsibilities of the Student

A. All disabled students seeking reasonable accommodations and provision of disability-related services must:

1. identify himself or herself to the Coordinator/Advisor as desiring accommodations
2. provide current and adequate documentation of his/her disability and of appropriate accommodations to the Coordinator/Advisor
3. request needed classroom accommodations and related services of the Coordinator/Advisor

B. All of the above requirements must be met by the student in a timely manner to ensure full resolution of accommodations and related services prior to the student’s entrance into the program or course of study. The student should provide the necessary documentation at least six weeks prior to the first semester for which accommodations are being requested and should provide the Coordinator/Advisor with a copy of his/her class schedule as soon as it is available for each semester during which s/he is seeking accommodations. Waiver of these deadlines may be made by the Coordinator/Advisor on a case by case basis. Failure to meet the specified deadlines and requirements may result in a denial of accommodations.

III. Documentation Procedure

A. Documentation of a specific disability provided to the Coordinator/Advisor must be adequate and up to date. Diagnosis and evaluation costs shall not be the responsibility of the university.

1. Current medical or other diagnostic documentation of a disability must be provided by a qualified physician or other qualified diagnostician.
2. Current documentation of the need for reasonable accommodations and related services must also be provided to the Coordinator/Advisor.
3. If existing documentation is incomplete or outdated, the Coordinator/Advisor may require the student to provide additional documentation at the student’s expense.

IV. Collaborative Responsibilities of the Coordinator, Faculty, and Staff

A. The Coordinator/Advisor shall review the documentation provided by the student and discuss the accommodation and related services requested.

B. The Coordinator/Advisor shall make an initial determination as to whether requested accommodations and related services are required.

C. The Coordinator/Advisor shall provide the student with a letter describing recommended accommodations and related services.

D. The faculty or staff member responsible for a specific class, program, or service shall then determine accommodations of the disability and provision of related services in consultation with the Coordinator/Advisor if necessary.
E. Any disagreement relating to accommodations shall be described in writing and submitted to the Chancellor or his/her designee for resolution in a prompt manner. This appeal must specify why the accommodation request is considered unreasonable or unworkable.

F. In any disagreement related to IV.5, the Chancellor or his/her designee shall take into consideration all relevant factors including but not limited to:
1. current documentation of the specific disability
2. the need for the requested services or accommodations
3. the essential elements of the academic program or course of study being pursued
4. the fact that no applicable law requires Missouri S&T to substantially alter essential elements of its academic program or course of study or to otherwise compromise its academic standards

G. The written judgment of the Chancellor or his/her designee shall be presented to the faculty member or department administrator within ten working days following receipt of the written notice of disagreement.

V. Specific Responsibilities of the Faculty

A. It is the responsibility of the faculty to:
1. establish curriculum requirements and uphold the academic standards of Missouri S&T
2. determine that the essential elements of these curricula, as well as those of an individual course are being fulfilled
3. work with the Coordinator/Advisor to determine the provision of reasonable accommodations and related services for disabled students when requested by the Coordinator/Advisor
4. follow applicable rules with respect to individual privacy and confidentiality

B. If the faculty member concerned opposes the determination made by the Coordinator/Advisor, he or she should proceed as follows:
1. He or she initiates a review of this determination with the Coordinator/Advisor.
2. If after this review the faculty member or department administrator still does not agree with the Coordinator’s/Advisor’s determination, he or she may have recourse to the procedures outlined by Section IV, subsections 5 and 6.

VI. Grievance & Complaint Process

A. A student who believes that the determination of the Coordinator/Advisor for the provision of reasonable accommodations and related services is not being fulfilled by a faculty or staff member must contact the coordinator in a timely manner to discuss the concerns.

B. A student who is not satisfied with the accommodation plan or the initial determination of the Coordinator/Advisor may file a grievance under the University of Missouri Discrimination Grievance Procedure for Students (Section 370.010). A copy of this policy can be obtained from the following sources:
1. The UM system web page at http://www.umsystem.edu/
2. The Affirmative Action/EEO office in 106 Harris Hall (573) 341-6314
3. Office of the Vice Chancellor for Student Affairs, 106 Norwood (573) 341-4292

Contact Information
Coordinator/Advisor of Disability Support Services:
Counseling, Disability Support, and Wellness
204 Norwood Hall
Phone: (573) 341-4211; TTY: (573) 341-6645
Fax: (573) 341-6179
E-mail: dss@mst.edu
Web: http://counsel.mst.edu

Curtis Laws Wilson Library

As the primary learning resource center for the Missouri S&T Campus, Wilson Library provides services and materials to support the University’s academic programs. In addition to providing students with access to research resources, the library is a place where students can develop the information seeking and management skills that are necessary to excel in an information-based society.

Missouri S&T is known as Missouri’s premier technological research university. Wilson Library is equally well known for its strong science and technology collection. In addition, the humanities and social science collections have grown to support programs in these areas. The print collection consists of approximately 477,000 volumes and subscriptions to scholarly journals. Print resources are supplemented by many other materials, including DVDs, CDs, and CD-ROMs. Numerous online resources, including databases and electronic journals, are available via the Web from the library homepage. Professional research assistance is available to help with using all of the library resources.

Wilson Library makes every effort to provide students with access to state-of-the-art library technologies. The library catalog, called MERLIN, shows the library holdings and links to electronic full-text items. The library catalog allows students to search, view, and borrow from the three other University of Missouri campuses. In addition, patrons can use MOBIUS, through which they are able to borrow from over 60 other Missouri libraries. A daily courier service links all MOBIUS libraries to allow them to exchange materials. These catalogs are complemented by databases that cover a wide range of subject areas. They are available through the library’s webpage or in the library. The library also provides access to research materials through Summon, a search tool that allows users to retrieve items in databases, electronic journals, and the library catalog with a single search.

In the library’s Multimedia Center, which was made possible by a grant from the Emerson Electric Company, the library becomes a laboratory where students are active participants in the creation and manipulation of information. Students have access to state-of-the-art technologies, including non-linear video editors, scanners, illustration packages, graphics manipulation programs, and poster printing and laminating.

Missouri S&T is a selective depository for United States and Missouri government documents. The library receives a wide selection of materials from the Government Printing Office and other agencies. A large percentage of all new government publications are now available online. The full text of many online government documents is also accessible through the library catalog.

Through interlibrary loan, the Missouri S&T collection is supplemented by materials owned by other libraries throughout the United States. Wilson Library is able to borrow most materials needed by students from other libraries.

Yesterday’s library was a collection of books, and the information universe was fairly static. Today’s library has become a dynamic resource center, where books and journals coexist with online databases and
Web-based resources. The information universe is no longer limited to Missouri S&T’s physical campus. As student and faculty information skills become ever more important, Wilson Library will continue to be Missouri S&T’s gateway to the ever-expanding world of information. Students are encouraged to explore the library’s homepage at http://library.mst.edu/.

Fees

“The University reserves the right to modify by increase or decrease the fees charged for attendance and other services at the University, including but not limited to tuition, at any time when in the discretion of the governing board the same is in the best interest of the University, provided that no increase can or will be effective unless approved by the governing board not less than thirty (30) days prior to the beginning of the academic term (semester, etc.) to which the fees are applicable with all modification of fees to be effective irrespective as to whether fees have or have not been paid by or on behalf of a student prior to the effective date of the modification.”

Electronic Billing Statements

Electronic billing is the official billing method for currently enrolled students at Missouri University of Science and Technology. Students will be notified by e-mail at their Missouri S&T e-mail account when monthly billing statements are available. Currently enrolled students will be able to view, print, and pay their student fee bill online at Joe’Ss.

Currently enrolled students can also authorize others (parents, grandparents, guardians) to view and pay their student fee bill. Authorized users can be established and maintained on Joe’Ss under Campus Finances, Billing Authorized Users. Authorized users have access to electronically view and print the monthly billing statement and make payment online. They are also notified when the statement is available at the e-mail address entered by the student during set-up. For further information, visit the Missouri S&T Cashier’s Office web site at: http://cashier.mst.edu.

Tuition

All students enrolled at Missouri S&T are required to pay tuition and will be charged per credit hour. Visit the Missouri S&T Cashier’s Office website for fee information at http://cashier.mst.edu.

Courses audited and courses taken for reduced credit will be counted at their normal credit value in computing the amount of fees to be paid. Students enrolling in zero credit courses are required to pay fees according to the equivalent credit for the course.

Information Technology Fee

All students enrolled at Missouri S&T (which includes the Engineering Education Center of St. Louis) are required to pay an Information Technology Fee per credit hour.

Supplemental Fees

An additional Supplemental Fee will apply to the following and will be charged per credit hour:

• An Engineering Supplemental Fee will be charged to all students enrolled in engineering courses, except for courses offered by the Department of Geology & Geophysics. Co-listed courses are subject to the Engineering Supplemental Fee.

• A Science Supplemental Fee will be charged to all students enrolled in Computer Science, Biological Sciences, Chemistry, Geology, and Geophysics courses. Co-listed courses are subject to the Science Supplemental Fee.

• A Science Supplemental Fee will be charged to all students enrolled in Physics courses. Co-listed courses are subject to the Science Supplemental Fee.

• A Business, IS&T, and M&IS Course Fee will be charged to all students enrolled in Business, IS&T, and M&IS courses. Co-listed courses are subject to the Business Supplemental Fee.

Student Activity/Facility Fee

A Student Activity/Facility Fee is charged to students each semester to pay for a variety of activities, services, and bonded debt on student fee funded buildings. The activity/facility fee is determined and approved by the Student Council. The activity/facility fee includes fees for the Havener Center, intramural and recreational facilities and programs, campus events, the student newspaper, radio station and yearbook, and funding for a variety of student organizations. The Rollamo Yearbook fee will be charged during the fall semester to all undergraduate students enrolled for seven or more hours and will remain optional for all undergraduate students enrolled for less than seven hours and all graduate students. Graduate students pay to fund the Council of Graduate Students.

The activity/facility fee is prorated for students enrolled in less than 10 hours. The activity/facility fee is charged to all students, undergraduate and graduate. Students attending the Engineering Education Center in St. Louis pay the designated UMSL student activity fee.

Additional information concerning the Missouri S&T Student Activity/Facility Fee is available at: http://cashier.mst.edu.

Health Service Fee

The Health Service Fee is charged to all students, graduate and undergraduate (full or part time enrolled). This fee does not apply at the Engineering Education Center of St. Louis.

Time of Payment of Tuition and Fees

All tuition and fees must be paid in full, or payment arrangements made, at the time of registration at the opening of each semester or term as a condition of admission to classes. Registration is not complete until all tuition and fees are paid. Consult the academic calendar for date of registration and payment of tuition and fees.

Minimum Payment Plan

The student’s account (to include tuition, fees, housing, traffic violations, etc.) will be billed for the full amount each month with a minimum payment allowed. The minimum payment is derived by dividing the full account balance by the number of scheduled payments remaining in the semester. If a student chooses to pay the minimum payment amount, a 1% per month interest charge will be assessed on the remaining unpaid account balance.

Late Payment Fee

Student fee accounts will be subject to a late fee of $10.00 for unpaid amounts billed when payment is not received by the scheduled due date as communicated on the student’s monthly billing statement. If the minimum payment or billed balance due is paid on or before the
scheduled due date, as it appears on the student’s monthly billing statement, no late fees will apply.

Past due amounts owed the University must be satisfied by payment in full. Failure to pay may result in transcripts or diplomas being withheld. The University will pursue appropriate collections practices which may include referrals to a collection agency for accounts that remain past due. The account may be assessed an additional collection charge of up to 33% of the balance if referral to a collection agency becomes necessary.

**Fall Semester Payment Due Dates**
Preregistered students: five installments due July, August, September, October and November 15th. Regular registration students: four installments with the first one due at registration and the remaining due October, November and December 15th.

**Spring Semester Payment Due Dates**
Preregistered students: five installments with December, January, February, March and April 15th. Regular registration students: four installments with the first one due at registration and the remaining due February, March and April 15th.

**Summer Term Payment Due Dates**
Preregistered students: 50% of fees due May 15th and 50% due June 15th. Regular registration students: total fees due at registration.

**Financial Aid**
Approved financial aid is applied directly to a student’s account. The entry will appear as a credit on the billing statement and will reduce the current term balance due. The balance remaining after application of financial aid will be billed to the student and will be subject to the minimum payment process and interest charge calculation.

**Personal Checks**
Personal checks will be accepted only for the amount due from the student. A late registration fee will be assessed if a check presented in payment of student fees is returned unpaid and remains unpaid after the close of regular registration.

**Credit Card Payments**
The University of Missouri Cashier’s offices do not accept Visa-branded credit cards for payments to the student account. If you choose to make payments on the student account using MasterCard, Discover or American Express cards, the third-party vendor will add a service charge of 2.75% to the transaction. To avoid the service charge, students are able to make payments directly from any checking account by using the web payment option (Electronic Funds Transfer) through Joe’Ss, simply by entering the bank/financial institution routing and account number information at the time of online payment. The student will need his or her single sign-on and password in order to make payment. The student is the only one that would have this information. Parents are able to make a credit card payment by going to the cashier’s office web site at http://cashier.mst.edu and clicking on the “Make a Parental Credit Card Payment.” This option requires only the student ID number and the birth date of the student. Currently enrolled students can also authorize others (parents, grandparents, guardians) to view and pay their student fee bill. Authorized users have access to electronically view and print the monthly billing statement and make payment online. Because of FERPA laws, financial information is not shown. The 2.75% service charge will apply to any credit card payments made.

**Late Registration Fee**
A student who registers later than the regular registration day for a semester will be charged the late-registration fee equivalent to one hour undergraduate tuition. Also, by registering late a student may find certain sections or entire courses closed to registration. Each school reserves the right to close sections or courses, or even to close enrollment in a department, when the capacity of the class is reached.

**International Student Sponsored Student Program Fee**
A full range of services for sponsored international students is provided through the Office of International Affairs. International students sponsored by international agencies receive special services and pay an administrative fee per semester. Individual students desiring to take advantage of these special services may apply for them.

Details on the current sponsored student program and costs are available upon request from:

Office of International Affairs
103 Norwood Hall
Rolla, Missouri 65409-0160

**Mandatory Health Insurance for International Students**
All international students, as a condition of their enrollment, are required to purchase mandatory health insurance. This includes all F-1 and J-1 visa students. In addition, J-1 visa students whose spouse and/or children are living in the U.S. are required to carry health insurance. An independent carrier, working through the International Affairs (IA) office, provides an insurance policy at a reasonable cost. Premiums will be charged during the Fall and Spring semesters. (Summer premiums are included in the Spring Semester.)

For more information on the mandatory health insurance requirements for international students, contact:

International Affairs Office
103 Norwood Hall
(573) 341-4208

**Offset of Missouri Income Tax**
For those non-residents who pay Missouri income tax, the non-resident tuition may be credited in an amount equal to the actual Missouri income tax paid for the previous calendar year except that the remaining obligation shall not be less than the amount of the resident tuition. Unemancipated minor or adult dependent students are eligible for reason of payment of Missouri income tax by the non-resident individual or individuals having legal custody of said students. Students entering in January shall be regarded as entering in the fall for purposes of determining previous calendar year. For students entering after January, previous year means immediate past calendar year.

For those non-resident students who have non-resident scholarships, the amount of this scholarship will be deducted first from their non-resident
fee. If a student qualifies, the remainder of the non-resident balance may be offset by Missouri income taxes paid. (See above.)

To affect an offset, the student shall furnish to the Cashier a copy of the state income Tax return, together with cancelled checks (if any) or photo copies thereof: or if all taxes were withheld, the MO-WH-2 form, or photo copy there of, showing amount of tax withheld must be presented, and a photocopy of the front page of the federal return as evidence of eligibility. After reviewing the evidence submitted, the Cashier may request other evidence of payment of tax.

Tax credit thus established may be used only once as an offset against the non-resident tuition, but any tax credit not used in a given term may be carried forward to be used in a subsequent term, subject to the time limitation stated above. If several students from the same family claim allowable tax credit, the tax credit shall be applied as the taxpayer directs. If the taxpayer does not direct application, the Cashier shall make such application. Tax credit may be offset against the Non-resident tuition only, and may not be offset against any other tuition fees or obligations.

Refund of Fees

Fees subject to refund include: tuition, information technology fees, engineering, science, and business supplemental fees, student activity/faculty fees, health service fees and any instruction-related miscellaneous fees that may be assessed.* Students who have registered for credit courses, and made payment of fees, and whose registration is subsequently canceled, or who withdraw from the university or reduce their course load, will, subject to certain exceptions, receive a refund of the fees in accordance with the following schedule: class day of cancellation, withdrawal, or change of course load. The official Missouri S&T refund policy can be found from the Chancellor’s Policy Memorandum site at: http://chancellor.mst.edu/documents.

Fall/Spring Semester - 16 weeks

<table>
<thead>
<tr>
<th>Elapsed Days</th>
<th>Percent of Refund</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the first day of classes</td>
<td>100%, less an enrollment cancellation fee of $20.00</td>
</tr>
<tr>
<td>Class days 1-5</td>
<td>90%</td>
</tr>
<tr>
<td>Class days 6-10</td>
<td>70%</td>
</tr>
<tr>
<td>Class days 11-25</td>
<td>50%</td>
</tr>
<tr>
<td>After class day 25</td>
<td>NO REFUND</td>
</tr>
</tbody>
</table>

Summer Session - 8 weeks

<table>
<thead>
<tr>
<th>Elapsed Days</th>
<th>Percent of Refund</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before the first day of classes</td>
<td>100%, less an enrollment cancellation fee of $20.00</td>
</tr>
<tr>
<td>Class days 1-3</td>
<td>90%</td>
</tr>
<tr>
<td>Class days 4-5</td>
<td>70%</td>
</tr>
<tr>
<td>Class days 6-13</td>
<td>50%</td>
</tr>
<tr>
<td>After class day 13</td>
<td>NO REFUND</td>
</tr>
</tbody>
</table>

Class days are counted by excluding Saturdays, Sundays, and holidays.

* Deductions may be made from any refund of fees for any financial obligation due the university.

Cap and Gown Fee

Candidates for a Master’s degree are able to purchase their cap, gown, hood, and tassel through the Missouri S&T Bookstore for a total of $55.97 plus tax. Gowns are also able to be purchased and shipped through our website www.mstbookstore.com (http://www.mstbookstore.com).

Candidates for doctoral degrees are able to rent their PhD regalia through the bookstore. The tam, gold tassel, PhD hood, and gown can be rented for $69.97 plus tax. PhD graduates wanting to purchase their hood can do so for $109.00 plus tax. All doctoral candidates wishing to rent must submit their order at least three weeks in advance. Orders received after the three week margin will be subject to late fees and expedited shipping costs. The above prices are current and subject to change. Doctoral candidates can also purchase their PhD regalia at the Missouri S&T Bookstore. These orders must be placed at least eight weeks prior to commencement to allow for custom tailoring. Additional information is available at the Missouri S&T Bookstore (573) 341-7901.

Examination Fee

A candidate for a graduate degree who, before the end of a semester, has submitted to the Office of Graduate Studies his/her thesis/dissertation, may enroll during the intersession for the final examination only (course 493) for no hours credit and pay the examination fee equivalent to one credit hour graduate, in-state tuition. If the submission of Graduate Form 2/7 and library copy of the thesis/dissertation are not completed before the next semester begins, the student may register in one hour of research (490) good through the end of the fourth week of the semester or second week of a summer session. If the submission of graduate Form 2/7 and library copy of the thesis/dissertation are not completed by then, the student must enroll in a minimum of three credit hours for the semester. The one hour of 490 should be approved by the advisor, department chair, and the Vice Provost of Graduate Studies (following the same approval process as 493). A candidate for a graduate degree beyond commuting distance of campus who returns to defend his/her thesis/dissertation may enroll for the final examination only (Course 493), for no hours credit and pay the examination fee equivalent to one credit hour graduate, in-state tuition.

Fellowships, Research Assistantships, Teaching Assistantships and Graduate Assistants

Institutional financial assistance of four types is available to graduate students at Missouri S&T: graduate teaching assistantships, graduate research assistantships, graduate assistants, and fellowships.

Chancellor’s Fellowships

A limited number of these fellowships are available to highly qualified graduate students to encourage them to begin and complete a Ph.D. course of study at Missouri S&T. Non-thesis master’s students are not eligible. Students apply for these fellowships through the department of Graduate Studies at http://grad.mst.edu/. The fellowship shall consist of a waiver of the resident and applicable non-resident tuition for the Fall, Spring and Summer semesters, and may be renewed for as many as six semesters (and intervening summer sessions) as long as the graduate student maintains a 3.50 cumulative GPA and meets other criteria. The Chancellor’s Fellowships are administered by the Vice Provost of Graduate Studies.
National Science Foundation Fellowships

NSF Fellowships are awarded to the successful applicants directly. NSF pays the fees of the fellows. Part-time teaching by NSF fellows may increase the appointment; some departments require this teaching experience.

Graduate Teaching Assistantships

Part-time teaching is mandatory in some departments, to help students achieve professional experience and self-development. Departmental policies on this matter vary and inquiry should be made to the appropriate chair. Permissible schedules for graduate students holding part-time teaching appointments are described under “Permissible Schedules.” Remuneration varies according to the number of academic hours taught. Half-time assistantships for the academic year require 20 hours per week of effort. In-state student status for fee purposes is awarded to all graduate assistants employed 25 percent time or more.

Graduate Research Assistantships

Graduate research assistantships are offered in all departments. Half-time graduate assistant stipends may be available. Holders of assistantships devote approximately 20 hours per week to laboratory effort and are, therefore, limited to a maximum of 12 credit hours of academic study per semester. Graduate instructorships require full-time teaching effort and are appointed only under exceptional circumstances. Research credits toward a degree may require effort beyond that required of the appointment. A number of positions are available during the summer months. In-state student status for fee purposes is awarded to all graduate assistants employed 25 percent time or more.

Radcliffe Graduate Scholarships

The Geology and Geophysics program offers the Radcliffe Graduate Scholarship to qualified M.S. and Ph.D. students. To be considered for this scholarship, students should have a minimum grade point average of 3.0/4.0, high GRE scores (1100 quantitative + verbal; 3.5 analytical) and a minimum TOEFL score of 550. International students should see International Student Admission requirements. The deadlines for application are Feb. 15 and Oct. 15 for admissions in the fall and spring semesters, respectively.

State and Federal Fellowships

Missouri S&T receives grants from various agencies.

United States Department of Education Fellowships

Under a cooperative agreement between the United States Department of Education and Missouri S&T, fellowships are offered for graduate study leading to a doctor of philosophy degree. DOE fellows receive a yearly stipend of $15,000. DOE pays the fees for the fellow.

Stephen P. Gorman Scholarship

Gorman applicants must have lived in St. Louis City or County and graduated from a St. Louis City high school. Need is a factor. An application may be obtained from the Student Financial Aid website http://sfa.mst.edu.

Industrial Fellowships

Several industrial fellowships are available, the number varying with the problems and support given by the industry. Industrial fellowship holders are required to work part time on the project to which they are assigned. The exact amount of time is governed by the character of the project and its applicability to thesis requirements. The stipend for industrial fellowships is variable, depending on support from industry, but appointments are ordinarily effective for a year at a time. Both academic and research work may be applied as credit to fulfill the requirements of the master of science or doctor of philosophy degrees.

Complete information concerning the fellowships currently available may be obtained from the chair of the department concerned.

Student Diversity and Academic Support Programs

The Student Diversity and Academic Support programs are designed to promote and support under represented minority (African American, Hispanic American, and Native American) students with special emphasis on those who are pursuing engineering or science degrees.

The Student Diversity and Academic Support Office also provides opportunities for professional development activities, networking events, and opportunities to participate in regional and national conferences. Missouri S&T is also a member of the National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM). To learn details about these opportunities contact:

Graduate Studies
118 Fulton Hall
mstgrad@mst.edu
(573) 341-4141

Miscellaneous Grants and Awards

Several miscellaneous awards also are available for graduate students in various disciplines. Research programs are carried on in a variety of fields and are sponsored by such donors as the National Science Foundation, various government agencies, and industrial companies. The periods of award and the amounts of the stipends vary according to the qualifications of the applicant and the funds available.

All graduate teaching assistants, graduate research assistants, graduate assistants, fellows, and holders of industrial fellowships must pay the regular fees required for enrollment as graduate students at Missouri S&T. However, many of the fellowships do provide for payment of these fees from fellowship funds and waive out-of-state fees.

Research Assistantships

A number of research projects sponsored by federal agencies or other donors carry graduate research assistantships. The stipends and tenures vary according to the particular grant, but they are usually comparable with other assistantship figures. Specific information can be obtained from the department involved. Recipients work on a specified research program under the supervision of a member of the professional staff.

Other Research Assistantships

A number of research assistantships are offered each year in conjunction with Missouri S&T research centers. The research performed may
supplement other credited research in the preparation of theses and dissertations.

Applicants must have a bachelor of science degree or its equivalent, have had the proper training in the required field of study and be qualified for admittance to graduate standing while doing research work. Fellows must register as candidates for one of the advanced degrees (master of science or doctor of philosophy).

Financial Assistance

Our Mission

The Student Financial Assistance Office is dedicated to helping families obtain financial funding to pay for college education at the Missouri University of Science and Technology. The Student Financial Assistance Office coordinates many federal, state, and agency resources, facilitates a vast number of university awards based on performance to interested parties.

The Student Financial Assistance office continually strives to provide high quality service to all students, families, faculty, and staff while using automated systems for timely delivery of financial aid funds.

Federal Aid Policies and Procedures

To apply for federal financial aid, (loans and work study), you must complete a need analysis form (i.e. Free Application for Federal Student Aid or FAFSA). Preference will be given to those students whose FAFSA has been received by March 1. If you apply for federal financial aid at any other time of the year, Missouri S&T will attempt to fill your financial needs to the extent that funds or opportunities are available.

Federal aid is contingent upon students meeting Satisfactory Academic Progress (SAP). SAP requirements are listed on the Student Financial Assistance website: http://sfa.mst.edu.

The Student Financial Assistance Office strongly encourages students to keep their expected graduation date current. Having an incorrect expected graduation date could affect a student receiving financial aid for a given semester. Contact the Registrar’s Office if you wish to change your expected graduation date.

Graduate Certificate Programs and Gainful Employment Program Disclosure

Effective July 1, 2011, the Department of Education requires that all certificated programs must disclose particular Gainful Employment information to current and prospective students. The information that is provided in the disclosure includes the estimated cost of the certificate program as well as on-time graduation and job placement rates for this particular certificate program. Information on graduate certificate programs, including Gainful Employment Disclosures, may be found at http://dec.mst.edu/

Global Learning

Global Learning

Global Learning's mission is to bring Missouri S&T’s teaching, research, and service capabilities to a global market. Through its programs, you can earn an advanced degree or a graduate certificate via distance education, connect as a youth with Missouri S&T’s summer camps, or attend a technical conference for professional development.

Global Learning blends technology and education to enhance learning. Programming is available both face-to-face and online through live streaming video. With collaborative learning tools and archived classes, Global Learning provides an education that fits your needs. Go online to http://dce.mst.edu for a current list of graduate degrees and certificate programs offered through distance education. Graduate certificates are a great way to earn college credit toward a master’s degree.

Global Learning includes:

- **Distance and Continuing Education**: administers and coordinates a wide variety of credit and non-credit programs. Contact (573) 341-6222, http://dce.mst.edu, dce@mst.edu
- **Engineering Education Center (St. Louis)**: provides educational services to the greater St. Louis, Rolla, & distance locations. Contact (341) 516-5431, http://eec.mst.edu, eec@msst.edu
- **Video Communications Center**: manages communication technologies that bring together Missouri S&T instructors and students. Contact (573) 341-4526, http://vcc.mst.edu, vcchelp@mst.edu

For further information, contact:

Global Learning
216 Centennial Hall
300 West 12th Street
Phone: (573) 341-6222
Fax: (573) 341-4992
Web: http://global.mst.edu

Video Communications Center

The Video Communications Center located in G-8 Library offers a variety of video production services to the campus community. This is achieved through several specialized video-equipped classrooms, teleconference rooms and a selection of recording and transmitting technologies.

For the student - especially those pursuing advanced degrees -- the VCC offers an array of communication tools for extending the traditional classroom and laboratory out into “the real world.” Services include:

- Multimedia classroom use for thesis defense and project presentation
- DVD or web-streaming video recording of the above
- Video teleconferencing for project presentation to sponsoring companies and for student organizations meeting between campuses, and for job interviews
- Assistance in setting up, capturing, and converting research lab project videos for documentation and presentation
- Participation in advanced coursework carried over and stored on the Web for later access
- The opportunity to take courses “at a distance” while away from or after leaving Missouri S&T

For more information on these and other services, contact the Video Communications Center at (573) 341-4526; or e-mail: vcc@mst.edu or visit our website at: http://vcc.mst.edu.
Information Technology (IT)

Getting Started
Missouri S&T’s Information Technology (IT) Department provides a variety of computing tools and resources to assist with academic and administrative work done at the University. Faculty, staff and students use computers daily to register for classes, communicate with friends, send e-mail, collaborate on group projects and research, publish web pages, write reports, and find course schedules.

Computer Accounts
Computer accounts are assigned to students and are used to access various resources at Missouri S&T, such as the computing network and the computers and software in Computer Learning Centers (CLCs). Most Missouri S&T IT services require an authorized computer account (User ID and password) to gain access. The following services are available through IT computer accounts.

- Joe’Ss (student web portal)
- Blackboard (learning management system)
- Network file storage
- Personal website storage folders
- Access to the campus network, including wireless networks on campus

University Communications to Students
Each student, once initially registered for classes, will be issued a Missouri S&T e-mail account with an address on the mst.edu domain. This is the account used for official University business and official University communications to students. Students are expected to check their Missouri S&T e-mail account regularly for University communications and are responsible for communications sent to this account. Therefore, communications sent to this account will be considered to have fulfilled any University obligation for notification.

Students must activate their email account online at: http://it.mst.edu/current_students/emailoptions.html

Leaving Missouri S&T
Assigned computer accounts remain active and available for use as long as a student is enrolled in classes at Missouri S&T. Additional information regarding account maintenance may be found at http://it.mst.edu/about/policies/index.html and then clicking the “User ID Maintenance” link.

Following graduation, Missouri S&T students retain access to their student email accounts. Local account access is removed one semester after students graduate or stop attending. If the student was also employed by the university, account removal may occur sooner.

Students are responsible for creating a backup of any data on their network storage prior to leaving the university.

Systems and Software
Missouri S&T IT provides a wide variety of computing and networking facilities and support. These facilities include, but are not limited to the following:

- Windows-based PCs
- Macintosh systems
- Linux systems
- Computer Learning centers (CLCs)
- General Purpose Cluster computing

Computer Learning Center
Computer labs, called Computer Learning Centers or CLCs, provide computers and specially software for students to use for in-class, homework, and project related work.

CLCs are located in various buildings around campus. Use of computers and technology in these locations is restricted to Missouri S&T faculty, staff and students. The list of CLC locations, hours of operation, and equipment is available online at http://edtech.mst.edu/clc/index.html.

Instructional Technology
To support teaching and learning, IT supports a broad set of instructional technologies. In addition to CLCs, classroom presentation technology, such as podium computers, laptop connections, projectors, and speakers, are provided to enhance the ability of instructors and teaching assistants to present course materials and use student response systems (clickers) in the classroom.

Blackboard, the supported learning management system, is used to enhance the distribution of course materials, assess student learning (e.g., quizzes, exams), enable student discussion and learning collaboration.

Personalized assistance in best practices and usage of these technologies is available to instructors and teaching assistants upon request by calling the IT Help Desk at (573) 341-HELP(4357).

More information about available instructional technologies can be found online at http://edtech.mst.edu.

Privileges and Responsibilities
Missouri S&T IT provides access to computing, networking and information resources in support of teaching, research and other official duties of the university. Access to the computing resources and facilities is a privilege, not a right. The “Missouri S&T Computing and Network Facilities Acceptable Use Policy” describes the ethical and legal responsibilities regarding computing resources.

Other computing policies and procedures, including the University of Missouri policies, can be found at http://it.mst.edu/about/policies/index.html.

Individually Owned Computers
Missouri S&T IT, in partnership with the Missouri S&T Bookstore, provides recommendations for supported hardware and software to those wishing to purchase for personal use.

Academic discounts are available for personally-owned computers and software purchased through the Missouri S&T Bookstore. Most software on university-owned machines is provided through licensing agreements with various vendors.

Connecting to the Network

Computers in campus residence halls and fraternities or sororities connect to the network through an Ethernet connection or via wireless connection. Wireless coverage currently extends to over 80 percent of the campus (including the Residential College), providing great flexibility and convenience for members of the campus community.

To register a machine on the campus network, simply plug-in to an available Ethernet jack and open a web browser. An online registration page will load. Complete the online form and you are ready to access the network. Detailed instructions on connecting to the network, using either wired or wireless Ethernet, are available by supported operating system at: http://it.mst.edu/current_students/tools.html

Virtual Private Network (VPN) connections are available, which allow members of the campus community to connect to the network while away from campus or traveling.

Special usage policies apply to network connections. For more information, see the "Policies and Procedures" web page at http://it.mst.edu/about/policies/index.html. In addition, Ethernet cards (both wired and wireless) and cables may be purchased through the Missouri S&T Bookstore, located in the Havener Center.

Emergency Alert System

Missouri S&T has a system in place to alert the campus community in the event of a campuswide emergency. An e-mail is automatically sent to every university e-mail account, but students, faculty and staff can enter additional contact information and register to receive emergency alerts via cell phone voicemail or text message.

For more information, or to register for the Emergency Alert System, visit: http://alert.mst.edu/

Getting Help

The Missouri S&T IT Help Desk and the IT Walk-In Center are available to assist the students, faculty and staff of Missouri S&T in using the different computing systems on campus.

Help is available on a wide range of items, including Windows-based PCs, Macintosh systems, and Linux workstations, as well as supported software on these systems.

Members of the campus community may call (573) 341-HELP (4357), stop by the IT Walk-In Center on the first floor of the Library, or access the online Help Request system at http://help.mst.edu. Hours of operation are available by visiting http://it.mst.edu/help_index.html.

Internet Resources

- IT Press Blog (breaking IT news, updates, etc.) – http://itpress.mst.edu
- Online Help Request – http://help.mst.edu
- Missouri S&T campus gateway – http://www.mst.edu
- IT Help Desk – http://it.mst.edu/help_index.html
- IT Department Homepage – http://it.mst.edu
- Campus Library – http://library.mst.edu
- Joe’SS (student web portal) – http://joess.mst.edu

International Affairs

The Office of International Affairs (IA), located at 104 Norwood Hall, coordinates international activities, administers all matters involving immigration for international students and scholars, and provides advisement services to the University’s international population.

The Office of International Affairs is responsible for the recruitment of international students and serves as a direct contact with U.S. government agencies, embassies, consulates, and the private sector concerning international activities. The office serves as the campus home for international student exchange programs and study abroad programs (see section on Study Abroad Programs). In addition, the Office assists faculty wishing to travel or work overseas, and offers educational and training programs, both domestically and abroad.

The Office of International Affairs coordinates and administers Missouri S&T’s Applied Language Institute which houses the Intensive English Program. The Office of International Affairs is responsible for the organization of international protocol activities, and monitors the status of Missouri S&T’s international linkage agreements.

International Student Sponsored Student Program

A full range of services for sponsored international students is provided through the Office of International Affairs. International students sponsored by international agencies receive special services and pay a $285 administrative fee per semester. Individual students who are not currently sponsored and are desiring to take advantage of these special services may apply for them.

Details on the current sponsored student program and costs are available upon request from:

Office of International Affairs
104 Norwood Hall
Rolla, Missouri 65409-0160

Mandatory Health Insurance for International Students

All international students are required to purchase Missouri S&T international student health insurance as a condition of their enrollment. This includes all F-1 and J-1 visa holders. In addition, the J-2 dependents of the J-1 visa holders are required to purchase international student health insurance. Student insurance premiums are charged to the student’s Missouri S&T Cashier’s account.

For more information on the mandatory health insurance requirement, contact:

Office of International Affairs
104 Norwood Hall
(573) 341-4208

Study Abroad Programs

The Office of International Affairs coordinates a variety of study abroad opportunities for Missouri S&T students (http://studyabroad.mst.edu).
Credit earned at these foreign universities may transfer back to Missouri S&T degree programs, as long as the student receives approval in advance. Some scholarships are available.

Missouri S&T offers exchange opportunities in most degree fields and 48 countries including Australia, Austria, Belgium, China, Finland, France, Germany, Greece, Hong Kong, Malaysia, South Korea, Spain, and the United Kingdom. A list of countries and universities are available online at http://studyabroad.mst.edu/universities/. Exchange opportunities are available for a semester, academic year, or summer. Faculty-led study abroad programs range from one week to months.

Students interested in studying abroad should make an appointment to consult with a specialist in the Office of International Affairs (http://international.mst.edu or call (573) 341-4208).

Intensive English Program (IEP)

The Intensive English Program (IEP) at the Missouri University of Science & Technology provides intensive instruction in the English language for international students whose proficiency in the language is insufficient for admission into course work at the University.

The IEP offers 20 hours of non-credit course work per week in all aspects of language learning: pronunciation, reading comprehension, vocabulary development, grammar, writing, listening comprehension, speaking interaction, and note-taking. The program provides instruction at four proficiency levels: Beginning English, General English, Introduction to Academic English, and English for Academic Purposes.

All international students who have not satisfied the University’s language proficiency requirements are required to complete IEP’s assessment testing, which is comprised of four parts:

- **Michigan Test of English Language Proficiency (MTELP)** A standardized test that evaluates abilities in grammar, reading comprehension, and vocabulary.
- **Test of Writing Proficiency (TWP)** A locally developed test that evaluates abilities to write clear, well organized English based on nationally developed guidelines.
- **Oral Proficiency Evaluation (ORE)** A locally developed test that evaluates abilities to speak English clearly, based on nationally developed guidelines.
- **Test of Listening Proficiency (TLP)** A standardized test that evaluates abilities to understand spoken English, especially in a classroom setting.

Students who perform well on all tests may be approved immediately for academic course work at the University. Other students are enrolled in IEP course work and may then complete the series of tests again at the end of the semester. Recommendations for promotion into a higher level of the IEP or for advancement into university course work are made by the IEP’s academic coordinator based on student testing and faculty input.

Students who enroll in the IEP must complete that program to the satisfaction of its director and academic coordinator (i.e. satisfy all completion requirements) before being allowed to enroll full time in university course work. A student may enroll in a reduced university load (in conjunction with IEP course work) with the approval of both his/her academic department and the director of the IEP.

Ordinarily, the IEP is open only to students who intend to pursue study at Missouri S&T, and who have been conditionally admitted to the University. If space exists, international students already admitted to Missouri S&T and already taking course work may enroll in IEP courses to improve their English. In addition, international persons with no academic affiliation with the University may be considered for admittance for Intensive English Studies only.

Testing fees and program costs can be obtained by contacting the number below. For more information on the IEP, contact:

**Intensive English Program (IEP)**
1207 N. Elm St.
114 SWBCC
Missouri University of Science and Technology
Rolla, MO 65409-1140
Phone: (573) 341-6640
Fax: (573) 341-4514
E-mail: mstali@mst.edu
Website: http://ail.mst.edu

Leadership & Cultural Programs

Leadership and Cultural Program’s mission is to assist students in developing skills they need to serve as successful leaders in a global community. We realize that in order to be successful citizens and competitive in the job market, students need to be culturally competent and possess strong communication, leadership, and personal management skills. We contribute to student retention and satisfaction by enhancing students’ educational experience through providing quality programs and resources. Our programs include cultural celebrations, skill development workshops, dialogue series, and experiential learning activities on and off campus. For more information visit our website at: http://lcprograms.mst.edu.

Nuclear Reactor

The Missouri S&T Nuclear Reactor is a Nuclear Regulatory Commission (NRC) licensed 200 kilowatt pool-type reactor that is used to support the engineering and science activities on campus. Using the facility, the reactor staff provides hands-on laboratory, research & development, and project opportunities. The reactor itself uses uranium fuel and is cooled by either natural convection or a 400 kilowatt forced cooling system in a pool containing approximately 30,000 gallons of water. The reactor generates a brilliant blue glow (Cerenkov radiation) when operated at higher powers.

The open pool design allows access to the reactor core where experiments and samples to be irradiated can be positioned. The facility is equipped with a pneumatics sample irradiation system, a neutron beam that provides a collimate neutron beam, a thermal column that provides a diffused thermal neutron source, gamma spectroscopy system, computer data acquisition and control systems, and an internet accessible hot cell.

The reactor is open to the greater campus community and offers active (operations) licensure program for interested students and others. The facility hosts numerous projects that actively engage students of various backgrounds; some recent projects include activities in:

1. **applied robotics**,
2. **applied biometrics**,
3. **photolytically-induced material development**,
4. **radiation tolerance of electronic chips**.
5. instrumentation and sensors,
6. convective heat transfer and multiphase flows and so on.

We encourage you to contact the facility for additional information.

Oak Ridge Associated Universities (ORAU)

Since 1981, students and faculty of the Missouri University of Science and Technology have benefited from its membership in Oak Ridge Associated Universities (ORAU). ORAU is a consortium of 101 colleges and universities and a contractor for the U.S. Department of Energy (DOE) located in Oak Ridge, Tennessee. ORAU works with its member institutions to help their students and faculty gain access to federal research facilities throughout the country; to keep its members informed about opportunity for fellowship, scholarship, and research appointments; and to organize research alliances among its members.

Through the Oak Ridge Institute for Science and Education (ORISE), the DOE facility that ORAU operates, undergraduates, graduates, postgraduates, as well as faculty enjoy access to a multitude of opportunities for study and research. Students can participate in programs covering a wide variety of disciplines including business, communications and graphic design, computer science, earth, environmental, and marine sciences, engineering, life, health, and medical sciences, mathematics, physical sciences, social and behavioral sciences. Appointment and program length range from one month to four years. Many of these programs are especially designed to increase the number of underrepresented minority students pursuing degrees in science- and engineering-related disciplines. A comprehensive listing of these programs and other opportunities, their disciplines, and details on locations and benefits can be found at: http://see.orau.org, or by calling either of the contacts below.

ORAU’s Office of Partnership Development seeks opportunities for partnerships and alliances among ORAU's members, private industry, and major federal facilities. Activities include faculty development programs, such as the Ralph E. Powe Junior Faculty Enhancement Awards, the Visiting Industrial Scholars Program, consortium research funding initiatives, faculty research, and support programs as well as services to chief research officers.

For more information about ORAU and its programs, contact:

• K. Krishnamurthy, Vice Provost for Research, Sponsored Programs, ORAU Councillor for Missouri University of Science and Technology (573) 341-4154;
• Monnie E. Champion, ORAU Corporate Secretary (865) 576-3306;
• or visit the ORAU Home Page (http://see.orau.org).

Office of Graduate Studies

Editing Services

The Office of Graduate Studies is pleased to offer free editing services to all on-campus graduate students currently enrolled at Missouri S&T. Our technical editor provides feedback regarding grammar, punctuation, and more to help students improve the quality of their work. If you’d like the editor to review your work, follow these simple instructions.

1. Print a copy of your document*, formatted as follows:
   • Times New Roman
   • Double-spaced
   • 12-point font
   • 1-inch margins
   • Numbered pages
   • No staples

2. Print and fill out a “Graduate Editing Request” form (found at http://grad.mst.edu).
3. Submit both your work and your form to the Office of Graduate Studies.
4. Watch your email. Once received, the editor will email you with an estimated completion date.
5. Meet with the editor once all edits are complete to discuss necessary revisions.

* Due to the demand for editing services, a student may submit no more than one chapter of either a thesis or dissertation per editing session. Students may submit 20 pages of either a journal article or conference paper per editing session.

Writing Resources

The editor at the Office of Graduate Studies has put together a number of resources to help you at every level of writing, from beginning the first draft to revising the final one. Novice writers and advanced writers alike can find information on style guides, literature reviews, document organization, and more. You’ll find tips and techniques from the editor herself on topics like avoiding plagiarism, conducting research, and writing with a reader focus. The editor also invites you to join the conversation by posting questions and comments that address your writing concerns.

In addition to these resources, you will find a current calendar of events the Office of Graduate Studies hosts on a regular basis. These events include upcoming workshops, seminars, and guest speakers. For more information visit the Office of Graduate Studies website at http://grad.mst.edu.

Office of the Registrar

Mission Statement

The primary mission of the Office of the Registrar is to insure the accuracy, integrity, and security of the academic records of the Missouri University of Science and Technology. In addition, the Office will strive to provide quality service to students, alumni, faculty, staff, and other constituents of the University. To this end, the Office will attempt to utilize available technology to deliver services and information in an efficient manner. Further, the Office will seek to interpret and apply the academic policies and regulations of the University for the benefit of the institution and its constituents.

Absence from Class

Work missed due to absence from class must be made up to the satisfaction of the instructor concerned. Excessive absences from class may result in the student being dropped from the course at the request of his or her instructor.

Application for Graduation

Students planning on graduating must do the following:
• Fill out an Application for Graduation form at the Registrar’s office.
• Submit to Registrar’s Office for processing.
• Check application deadlines for semester in which you are applying for graduation.

Certification of Enrollment Status

Certifications of enrollment status to lending agencies should be requested through the Registrar’s Office either by visiting 103 Parker Hall or using the form located at: http://registrar.mst.edu/documents/certlet.pdf. Certification of full-time or half-time status is based on the number of credit hours for which the student is enrolled and includes courses in which the student is enrolled as a hearer, with one exception. Hearer courses are not included for international student status, as defined by SEVIS.

For graduate students, full-time is based on at least nine credit hours; half-time is at least four credit hours in a regular fall and spring term. For the summer term: full-time is three credit hours and half-time is at least two credit hours.


These statements are set forth as guidelines and procedures to implement the University of Missouri Policy on student records developed from The Family Educational Rights of Privacy Act 1974.

The Missouri University of Science and Technology as charged in the Act will annually inform its eligible students by including in the Academic Regulations and the General Catalog the following information:

1. “Educational Records” are those records, files, documents, and other materials which contain information directly related to a student and are maintained by the university. Those records made available under The Family Educational Rights and Privacy Act of 1974 are student financial aid, the student’s mutative advisement file, student health records, disciplinary record, the admissions file and the academic record. The Missouri University of Science and Technology “Educational Records” do not include:
   A. Records of instructional, supervisory, and administrative personnel and educational personnel ancillary thereof which are in the sole possession of the maker thereof and which are not accessible or revealed to any other person except a substitute.
   B. The records and documents of the University of Missouri Police Department that are maintained solely for law enforcement purposes and are not available to persons other than law enforcement officials of the same jurisdiction.
   C. In the case of persons who are employed by the university but are not in attendance at the university, records made and maintained in the normal course of business which relate exclusively to such person and person’s capacity as an employee where the records are not available for any other purpose.
   D. All records on any university students which are created and maintained by a physician, psychiatrist, psychologist, or other recognized professional or paraprofessional acting in his or her professional or paraprofessional capacity, or assisting in that capacity, and which are created, maintained, or used only in connection with the provision of treatment to the student, and are not available to anyone other than persons providing such treatment, provided, however, that such records can be personally reviewed by a physician or other appropriate professional of the student’s choice.

2. The Missouri University of Science and Technology recognizes “Directory Information” to be the student’s name, address, e-mail address, telephone listing, major field of study, participation in officially recognized activities and sports, dates of attendance, degrees and awards received, the most recent previous educational agency or institution attended by the student, student level, and full- or part-time status. All students must inform the Registrar’s Office before the end of the two-week period following the first day of classes that this information should not be released without the student’s prior consent. The information listed above will become directory information as of the first day of classes following the end of the one-week period during the summer session.

3. Missouri University of Science and Technology students have access to the educational records identified in Paragraph 1 above. In accordance with Pub. L. 93-380, as amended, the Missouri University of Science and Technology will not make available to students the following material:
   A. Financial records of the parents of students or any information contained therein.
   B. Confidential letters and statements of recommendation which were placed in the education records prior to January 1, 1975, if such letters or statements are not used for the purpose other than those for which they were specifically intended.
   C. Confidential recommendations respecting admission to the university, application for employment, and receipt of an honor or honorary recognition, where the student has signed a waiver of the student’s rights of access as provided in 6.0404 the University Policy on Student Records.

4. The director of financial aid, the appropriate academic department chair, the director of the student health service, the vice chancellor for student affairs, the director of admissions, and registrar are the officials responsible for the maintenance of each type of record listed in Paragraph 1.

5. Any student may, upon request, review his or her records and if inaccurate information is included, may request the expunging of such information from his or her file. Such inaccurate information will then be expunged upon authorization of the official responsible for the file.

6. Students desiring to challenge the content of their record may request an opportunity for a hearing to challenge the content of his or her educational record in order to ensure that the record is not inaccurate, misleading or otherwise in violation of the privacy or other rights of the student, and to provide an opportunity for the correction of deletion of any such inaccurate, misleading, or otherwise inappropriate data contained therein and to insert into such records a written explanation respecting the content of such records.

7. The university official charged with custody of the records will attempt to settle informally any disputes with any student regarding the content of the university’s educational records through informal meeting and discussions with the student.

8. Upon request of the student or the university official charged with custody of the records of the student, a formal hearing shall be conducted, as follows:
A. The request for a hearing shall be submitted in writing to the campus chancellor who will appoint a hearing officer of a hearing committee to conduct the hearing.

B. The hearing shall be conducted and decided within a reasonable period of time following the request for the hearing. The parties shall be entitled to 10 days prior written notice of the item and place of the hearing.

C. The hearing shall be conducted and the decision rendered by an appointed hearing official or officials who shall not have a direct interest in the outcome of the hearing.

D. The decision shall be rendered in writing within a reasonable period of time after the conclusion of the hearing.

E. Either part may appeal the decision of the hearing official to the campus chancellor. Appeal from the chancellor’s decision is to the president to the Board of Curators.

9. The Missouri University of Science and Technology may permit access to or release the educational records without the written consent to a school official with legitimate educational interest. A school official is determined to have legitimate educational interest if the information requested is necessary for that official to (a) perform appropriate tasks that are specified in his or her position or by a contract agreement; (b) perform a task related to a student’s education; (c) perform a task related to the discipline of a student; (d) provide a service or benefit relating to the student or student’s family, such as health care, counseling, job placement or financial aid.

10. If any material or document in the educational record of a student includes information on more than one student, they may inspect and review only such part of such material or document as relates to him or her or to be informed of the specific information contained in such part of such material.

11. Students desiring reproduction of copies of educational records will be charged $1.10 per page. Official copies of transcripts are $10.00 per copy for currently enrolled students and alumni.

University Communications to Students

Each student, once initially registered for classes, will be issued a Missouri S&T e-mail account with an address on the mst.edu domain. This is the account used for official University business and official University communications to students. Students are expected to check their Missouri S&T e-mail account regularly for University communications and are responsible for communications sent to this account. Therefore, communications sent to this account will be considered to have fulfilled any University obligation for notification.

Missouri S&T Grade Reports on the Web

Students may obtain their grades on the Web through Joe’Ss. Students who desire a paper copy of their grade report should contact the Registrar’s Office.

Grading System

The following system of grades is used:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Grade Points Per Credit Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-Excellent</td>
<td>4</td>
</tr>
<tr>
<td>B-Superior</td>
<td>3</td>
</tr>
<tr>
<td>C-Medium</td>
<td>2</td>
</tr>
</tbody>
</table>

F-Failure
I-Incomplete
S-Satisfactory (Indicates credit has been earned for course scheduled)
U- Unsatisfactory (Indicates credit has not been earned for course scheduled)

Grades of “S” and “U” are used for research (490), internship (491) and continuous registration (495). For ongoing research, a delayed grade (DL), can be used. Grades of S and U are also permitted for special problems (300 and 400) and seminar (310 and 410).

Graduate students cannot take courses with a pass/fail grading option. “D” grades are not permitted for graduate students.

Effective Winter of 2001 the incomplete grade time limit will require the student to complete the course work in which they are deficient within one calendar year from the close of the semester in which the “I” grade was recorded. Incomplete grades recorded prior to Winter Semester 2001 must be removed by the tenth week (five weeks of summer school) of the next term enrolled or they will be changed to “F” grades by the Registrar’s Office.

Schedule of Classes

The most current information regarding the Schedule of Classes is located at: http://registrar.mst.edu/classofferings/index.html.

Course Information

The number in parentheses following the name of the course indicates the number of credit hours given for successfully completing the course. It also reflects the section type; for example, (LEC 3.0) designates a lecture course of three hours credit; (LAB 1.0) designates a laboratory course of one-hour credit and (IND 0.0-15.0) designates independent study or research with variable hours. A lecture credit hour is usually the credit granted for satisfactorily passing a course of approximately 15 classroom hours. A laboratory course of one-hour credit would normally meet three classroom hours per week for 15 weeks.

Three credit hour courses normally meet 50 minutes three times per week, or 75 minutes twice a week, for 15 weeks. The time in class is the same in each case. If you have two classes in succession, there should be at least 10 minutes between classes. Classes meeting Monday-Wednesday-Friday will normally begin on the hour. Classes meeting Tuesday-Thursday will normally alternate between the hour and half hour, beginning at 8:00 a.m. In addition, there is an Academic Free hour 12:00-1:00 on Monday, Wednesday, and Friday.

Students must have completed the stated prerequisite(s) for the course for admission to the course or obtain the ‘Consent of the Instructor’ of the course.

S&T Police Department

Parking

All student-operated vehicles in the Rolla area should be registered with the Parking Lot Operations and should have either a valid campus parking permit or student registration decal affixed properly to the vehicle. Missouri S&T Parking, Security and Traffic Safety Regulations, as adopted by the Parking, Security and Traffic Safety Committee and approved by the Chancellor, provide for the payment of established
fees for parking privileges and set fees for violation of those regulations. The Missouri S&T Police Department has the responsibility of enforcing parking regulations at Missouri S&T.

The size of the student body, faculty, and staff, coupled with the fact that a large number of students live off-campus, leads to a relatively large number of motor vehicles on and near the campus. This traffic load, in turn, complicates parking for the campus citizen and creates a hazard for vehicles and pedestrians. The Committee has prescribed the rules governing the classification and use of parking lots, the qualifications for parking on those lots, and the rules for application, issuance, and use of parking permits.

Specific information on current regulations and other details pertaining to parking can be obtained at Parking Lot Operations, G-10 Campus Support Facility, 341-4303. The regulations may also be found at: http://police.mst.edu/parking/parking.html.

**Missouri S&T Parking-Rules in Capsule Form**

1. All parking on campus requires either a purchased permit or payment at a meter. Decals (permit and registration stickers) must be affixed to the outside of the rear window or bumper on driver’s side of the vehicle. Temporary tags shall be affixed to the inside rear window on the driver’s side of the vehicle.
2. All vehicles shall be parked HEADING into the parking spaces. (Do not back into or pull through the space.)
3. A visitor is anyone OTHER THAN an employee, student or member of their family.
4. Regulations pertaining to area permits and metered parking are enforced YEAR ROUND from 7:30 a.m. to 4:30 p.m. except on Saturdays, Sundays and Official University holidays. Other regulations are enforced at all times as noted below.
5. Permit and metered parking at Thomas Jefferson Residence Hall and the Multi-Purpose Building shall be enforced 24 hours a day 7 days a week.
6. Employees and students lending their vehicle to a visitor will be responsible for any violations occurring on campus.
7. Parking permit owners shall park only in the area to which the purchased permit allows access.
8. Employees and students without parking permits shall use only metered spaces.
9. Specially marked disabled parking, driveways, yellow curbs and zones, spaces marked for 24 hour enforcement, fire lanes, vehicle types and areas not designated as a parking area, etc. shall be enforced 24 hours a day 7 days a week
10. University driveways, yellow curbs and zones and any other area not specifically designated as a parking area shall not be used at any time.
11. The Director of Missouri S&T Police Department, with the concurrence of the Parking Committee Chair, shall have the authority to suspend all or part of the parking regulations for specific periods of time.

The full and complete set of Missouri S&T Parking Rules and Regulations can be found on our website: http://police.mst.edu/parking/parking.html.

**Lost and Found**

The Missouri S&T Police Department is the central “Lost and Found” repository for the campus. Any lost and found items should be turned in to S&T Police Department for reclamation purposes. If an item is lost, information should be filled out with S&T Police, (573) 341-4300, in case the item is turned in at a later date. There is a link on the Missouri S&T Police Department home page to report lost or found items: http://police.mst.edu/lost.html.

**Campus Security**

**Missouri State Uniform Crime Reporting (UCR) Statistics**

Every law enforcement agency in the State is required to report crime data monthly to the Missouri State Highway Patrol (MSHP). MSHP creates and maintains computer files of the Missouri data and supplies information not only to the Federal Bureau of Investigations (FBI) for use in national crime statistics, but also to local agencies and organizations. To access crime data for the Missouri S&T Police Department submitted to the MSHP visit the MSHP Statistical Analysis Center: http://www.mshp.dps.mo.gov/MSHPWeb/SAC/data_and_statistics_ucr.html.


As required by the U.S. Department of Education, the CLERY Act requires higher education institutions to make public certain crime data. Review the annual CLERY Report submitted by the Missouri S&T Police Department. A paper copy of the report can be requested by contacting the Missouri S&T Police Department at (573) 341-4300 or by responding to the department which is located in G-10 Campus Support Facility.

**Daily Crime Report**

The CLERY Act also requires that crime information be made available to the public within two working days. Review the Daily Crime Report in the lobby of the Missouri S&T Police Department located in G-10 Campus Support Facility or at http://police.mst.edu/crimeinfo/ucr/.

**University Police**

The mission of the Missouri S&T Police Department is to support the academic and campus community in fulfilling its commitment to teaching, research, and service. The functions performed by the Missouri S&T Police Department include many services offered by a small municipal police agency, as well as certain service functions unique to the University setting. The Missouri S&T Police Department has an authorized strength of 21 full-time employees, including 12 state-commissioned police officers, 9 security guard/dispatchers, 2 parking control officers and 2 administrative staff members. Missouri S&T Police Officers are empowered under Chapter 172.350 of the Missouri Revised Statutes. As such the Police Officers are commissioned and armed. Additionally all Missouri S & T Police Officers possess Rolla City Police commissions as well. Police Officers patrol on foot and by vehicle all properties owned by the Missouri University of Science and Technology 24 hours 7 days a week. The Security Guards perform additional security checks on the main campus during evening and night hours. In addition to the full-time staff, the department employs 9 Campus Service Officers (CSO’s), who are students that assist on a part-time basis. Missouri S&T Police Department also has a Reserve Police Officer Program where part-time officers are used on an as-needed basis.

Duties of the Missouri S&T Police Department include, but are not limited to, preventative patrols, the investigation of crimes, crime prevention through active campus involvement, service to students and others in
emergencies, special event coverage, overseeing parking lot operations, and the enforcement of state laws, city ordinances, and University rules and regulations.

Reporting Crimes at Missouri S&T

All crime victims are highly encouraged to report incidents to the Missouri S&T Police Department regardless of how seemingly insignificant the crime. Missouri S&T policy requires employees to promptly report all criminal acts occurring on campus. To report a crime, the victim or witness need only call the Missouri S&T Police Department. A police officer will meet with the person to gather information and prepare an official report. A log of all reported crimes is posted at the Missouri S&T Police Department (G10 Campus Support Facility) and on our website, http://police.mst.edu/crimeinfo/ucr/, under Crime Statistics to meet Clery Act requirements.

Security of Campus

Accountability of the security of campus facilities originates with the department chair. Areas of responsibility include, but are not limited to, both interior and exterior entryways, exists, and windows, and items of value within the department. Areas not under a specific department shall be under the responsibility of the next higher level within the division.

The department chair is ultimately answerable for security problems existing within his/her area of control, but can designate a dependable and reliable individual(s) areas of security responsibility.

A particularly sensitive area in building access control is the issuance of keys by departments to faculty, staff, and students. Department key issuance and control shall comply with guidelines set forth in BPM-404 Keys to University Buildings: http://www.umsystem.edu/ums/rules/bpm/bpm400/manual_404.

Buildings shall be secured during the evening hours at the earliest reasonable time. Any facility open for an extended period after normal operating hours for that building shall require a permit to be open for the hours specified on the permit.

During the academic year in which residence halls are open, those halls shall be secured during the evening hours according to Housing Department regulations. Faculty, staff, and students are encouraged to prevent access by unauthorized personnel, in both residence halls and other campus buildings, by verifying any door entered or exited has closed and locked.

Maintenance of campus facilities involving security problem areas, such as broken locks, windows, door, etc., shall involve reporting the security problem as soon as possible to the Physical Facilities department, who shall rectify the security breach within a timely manner.

Alcohol/Illegal Drugs Policies:

Alcoholic Beverages

The use or possession of any alcoholic beverage is prohibited on all University property, except in the President’s residence and the Chancellors’ residences, and the sale, use, or possession may, by appropriate University approval be allowed in approved University Alumni Centers or Faculty Clubs, and for single events and reoccurring similar events in designated conference, meeting, or dining facilities provided by University food services, subject to all legal requirements. Further information pertaining to alcoholic beverages can be obtained from the S&T Alcohol Handbook: http://stuaaff.mst.edu/handbook/alcoholicbeverages/.

Illegal Drugs

University of Missouri regulations prohibit the unlawful possession, use, distribution, and sale of alcohol and illicit drugs by University students and employees on University-owned property and at University or supervised activities. Local, state, and federal laws also prohibit the unlawful possession, use, distribution, and sale of alcohol and illicit drugs. Violation of the University of Missouri regulations and federal and state laws can result in disciplinary action up to and including expulsion for students and discharge for employees.

A variety of resources exist for drug and/or alcohol counseling, treatment, or rehabilitation program. For detailed information concerning University and community resources, students and employees may contact the Substance Abuse Prevention Program, 106 Norwood Hall, (573) 341-4292. Confidential consultation, assessment, short term counseling, and referral services are available free of charge to faculty, staff, and students. A variety of prevention of education programs are also offered.

Victim of Sexual Assault Information

The following information is provided to assist a person who has been the victim of a sexual assault.

Emergency Medical Examination/Evidence Collection

Receiving medical care immediately following a rape, attempted rape, or sexual assault is extremely important for your well-being. It is essential that you obtain:

- Emergency medical exam if you are injured.
- A general medical exam to ensure that you haven’t obtained injuries that you are unaware of or unable to determine.
- A medical/legal examination for the collection of evidence if you think there is any possibility you will want to prosecute the offender. The exam must be conducted within 48 hours of the assault and you must NOT clean up before the exam to avoid loss or contamination of evidence
- Testing for sexually transmitted diseases, AIDS, and possible pregnancy (as part of follow-up treatment).

For medical emergencies, call 911 to have an ambulance dispatched.

Other sources of medical information for victims include Missouri S&T Student Health Services (available during business hours).

Emotional Support

The need for emotional support and assistance after a rape, attempted rape, or sexual assault is great. In the aftermath of such a violation and loss of control, it may be difficult to consider what steps to take.

Contact a close friend or family member to talk with and assist in making decisions. Contact the Missouri S&T Counseling Center whose services are strictly confidential and contacting this support service does not obligate you to take any further action.

Reporting of Incident

You may wish to report the assault in order to have the alleged offender apprehended and/or for the protection of self or others. If this is the case, successful apprehension and or prosecution of the offender depends
greatly on a rapid and accurate report of the crime. Information about the assault can assist law enforcement authorities in providing and improving prevention strategies for the protection of the victim and others in the community.

You have the option of making a report for the purpose of assisting the police in protecting the community without obligation to participate in the prosecution. While the actual prosecution of the offender is pursued by the Phelps County Prosecutor (not by the victim), prosecution is unlikely to occur without the consent and assistance of the victim. You have the right to choose not to contact the Missouri S&T Police, but you are strongly encouraged to report the assault to the police department.

**Anonymous or Third Party Reporting**

Even if you may not want to prosecute the offender to have it known you were the victim of an assault, you can choose to report the assault anonymously. Or somebody who you have told about the assault can report it. This type of reporting will provide the department with general information that may be useful in preventing additional assaults on campus. To make an anonymous report, call the police department and request to speak with an officer.

**Disciplinary Actions**

Whether or not you choose to report the assault to law enforcement or participate in criminal prosecution, you may decide to take action through the campus judicial system. If you were assaulted by another Missouri S&T student, on or off-campus, the accused may be charged under the University of Missouri Standard of Conduct. The judicial officer at Missouri S & T is available to discuss campus judicial procedures. While the judicial officer may investigate the complaint and impose appropriate discipline with or without the victim’s consent, discussing a matter of sexual assault with her/him does not compel the victim to participate actively in pursuing disciplinary charges. The judicial officer’s phone number is (573) 341-4292.

**Contact with Offender**

In situations where the accused and the accuser may be in close contact with each other because of class schedules and/or living arrangements, adjustments to housing or class schedules may be made. The Director of Residential Life has the authority to give the accuser and/or accused the option of changing living arrangements. If the accuser and the accused refuse to change living arrangements, the Director has the authority to change the living arrangements of either person. The judicial officer shall give the parties the option of changing class schedules to avoid contact. However, change of class schedules cannot be required until after disciplinary proceedings have concluded.

**Student Diversity, Outreach and Women’s Programs**

**Student Diversity Programs**

The mission of Student Diversity Programs (SDP) is to actively recruit and retain academically talented students from ethnic populations that are historically under-represented in higher education. In conjunction with the university’s mission, SDP’s ultimate goal is to create an environment that provides the development/guidance and academic support needed to be successful at Missouri S&T; while equipping our students with the knowledge and skills needed to transition effectively into society. SDP, through its programs, partnerships and ongoing assessments of the learning, styles and personality traits will foster an academic environment that will ensure our students success. Through execution of these initiatives, the university will develop a pool of committed and gifted Missouri S&T’s ambassadors that could be utilized to recruit other underrepresented minority students to the campus.

Activities include (but are not limited to) academic recognition events, off and on campus recruitment programs, mentoring, leadership and professional development and scholarships. Such scholarships as the Minority Engineering and Science scholarships are to increase minority representation representation in math, engineering, science or technology degree programs.

For more information about SDP and its events, programs and scholarships, visit our website at: sdowp.mst.edu. Also, you may contact us directly at (573) 341-4212 or via e-mail at asksdp@mst.edu.

**Women’s Leadership Institute (WLI) Women in Engineering and Science (WISE)**

The mission of the WLI/WISE program is to promote diversity and support the needs of female graduates entering our nation’s engineering and science workforce, and to serve as an Educational and Professional Development Resource Center for all Missouri S&T students. The program provides a number of activities and programs for students to learn about leadership from the female perspective. Its goals encourage student involvement and strategic leadership in campus and community organizations through involvement in the following areas: Classes, Residential College Learning Communities, Guest Lecturers, Workshops, Scholarships, WISE, Student Organizations, Resource Center, Mentoring/networking programs, Social Activities.

For more information contact the WLI/WISE office at:

215 Centennial Hall
(573) 341-7286
woli@mst.edu
wise@mst.edu
http://wli.mst.edu

**Student Health Services**

Student Health offers a wide range of primary health care for currently enrolled students at Missouri S&T. Multiple providers are available to deliver care for acute illness and injury as well as provide limited longer term services for ongoing medical issues. The Student Health Fee covers most of the costs but some care and medications may require a copay. Specialty and hospital services can be billed to private insurance. It is highly recommended that all students have some form of health insurance. An Aetna group policy is available and information on this plan may be obtained at the Cashier’s Office or Student Health Complex.

**Measles and Rubella Immunization Policy**

Incoming students born after 1956 must have documented proof of two measles immunizations. Both immunizations must have been given after 1 (one) year of age. Acceptable documentation is defined as an immunization record signed by a doctor or health record from a high school or a branch of the military. A grace period of 6 weeks is allowed to meet this requirement. Students not in compliance with this policy will be notified by e-mail of the need to provide acceptable documentation.
In addition, a "hold" will be placed on the records of the students not in compliance.

Exemptions from immunization are permitted for medical, religious, philosophical reasons. Students who exempt themselves from immunizations for these reasons must sign the Measles Waiver Form (parents must sign for students under the age of 18) available at Student Health. The form must be completed EACH semester and kept on file at Student Health. For their own protection, students who have waived immunizations may be required to leave campus in case of a measles or rubella outbreak.

Students matriculating only in off-campus or continuing education/extension courses are excluded from the measles immunization requirement.

Meningitis Immunization

Beginning with the 2004-05 school year and in compliance with State Law (SB 686), proof of meningitis immunization must be provided by the student in order to move into university approved housing. If the student has not had the immunization, he may sign a waiver (parents must sign for students under the age of 18). Proof of meningitis immunization or a signed waiver will be kept on file at Student Health and will be available to the Residence Halls, Greek Housing and other university housing.

Other Immunizations

The following are recommended by the American College Health Association:

- Diphtheria/Tetanus (in past 10 years)
- Tdap booster (in past 10 years)
- Hepatitis A (series of 2 injections)
- Hepatitis B (series of 3 injections)
- PPD (tuberculosis skin test in past year)
- Varicella (series of 2 injections)
- Human Papillomavirus Vaccine (HPV) (series of 3 injections)

Tuberculosis Policy

Missouri University of Science and Technology takes every reasonable step to protect students from exposure to infectious diseases. Students from endemic areas account for 95% of the risk of tuberculosis (TB) outbreak on campus. Untreated TB can result in serious health problems for the student and for other people who come in contact with him or her.

In order to ensure a healthy campus, beginning with the Winter Semester 2010 and until updated again, all incoming students will be screened for potential TB. Those who do not pass the screening will then be target tested with the QuantiFERON-TB Gold blood test for tuberculosis (QFT-G). This blood test will be accepted from outside the United States if it is completed within 3 months prior to enrollment. Otherwise, the student will be required to complete the screening at the scheduled clinic held on campus or will need to stop by Student Health to pick up the order for the test and will be directed to Quest Laboratory located on Hwy 72 in Rolla, MO.

The QFT blood test will be billed to the student’s insurance. If the blood test comes back positive, there is then a process in place per the Student Health policy on continuing the work up.

All students who test positive will be offered treatment.

Enrollment is contingent upon completion of this screening process and work up. Students who do not complete the above will have a "hold" placed on their account and will not be able to enroll in the following semester until this testing is completed.

Student Organizations

Academic Departmental


Honor and Professional

Alpha Chi Sigma, Alpha Nu Sigma, Alpha Psi Omega, Alpha Sigma Mu, Blue Key, Chi Epsilon, Epsilon Mu Eta, Eta Kappa Nu, Industrial Designers Society of America, Kappa Kappa Psi, Kappa Mu Epsilon, Keramos, National Residence Hall Honorary, Omega Chi Epsilon, Order of Omega, Phi Alpha Theta, Phi Eta Sigma, Phi Sigma Pi, Phi Sigma Pi, Pi Epsilon Tau, Pi Tau Sigma, Psi Chi, Sigma Gamma Epsilon, Sigma Gamma Tau, Sigma Tau Delta, Society of Women Engineers, Tau Beta Pi, Tau Beta Sigma, Upsilon Pi Epsilon

Intercultural

African Student Association, Association for Black Students, Chinese Students Association, Chinese Students and Scholars, India Association, International Student Club, Iranian Students Association, Korean Students Association, Saudi Students Organization, Thai Students Association, Turkish Students Association

Media and Publication

KMNKR Radio Station (89.7 FM), Miner TV, Missouri Miner, Rollamo, Southwinds

Programming and Governing

ASUM, Council of Graduate Students, Interfraternity Council, Panhellenic Council, Residence Hall Association (RHA), St. Pat’s Celebration Committee, Student Council, Student Union Board
Recreation and Sports


Religious

All Nations Christian Fellowship, Baptist Student Union, Campus Crusade for Christ, Catholic Newman Center, Chi Alpha, Christian Campus Fellowship, Common Call Campus Ministry, Fellowship of Christian Athletes, Koinonia (Student Fellowship of Church of Christ), Latter-Day Saint Student Association, Lutheran Student Fellowship, Muslim Student Association, Restoration Campus Ministries, The Navigators, Voices of Inspiration, Wesley House

Residence Hall

Quadrangle Hall Association (QHA), Residential College Association (RCA), Thomas Jefferson Residence Hall Association (TJHA)

Service

Alpha Phi Omega (APO), Circle K International, Engineers Without Borders, Habitat for Humanity, Intercollegiate Knights (IK), Lambda Sigma Pi, Omega Sigma, Rotaract

Social and Special Interest


Student Design Groups

Advanced Aero-Vehicle Group, Concrete Canoe Team, Formula SAE, Human Powered Vehicle Team, Hydrogen Design Solutions, International Genetically Engineered Machines (iGEM), Miner Baja SAE, Miners In Space, Robotics Competition Team, Solar Car Team, Solar House Team, Steel Bridge Team

Fraternities

Alpha Epsilon Pi, Alpha Phi Alpha, Beta Sigma Psi, Delta Lambda Phi, Delta Sigma Phi, Delta Tau Delta, Kappa Alpha, Kappa Alpha Psi, Kappa Sigma, Lambda Chi Alpha, Omega Psi Phi, Phi Beta sigma, Phi Kappa Theta, Pi Kappa Alpha, Pi Kappa Phi, Sigma Chi, Sigma Nu, Sigma Phi Epsilon, Sigma Pi, Sigma Tau Gamma, Tau Kappa Epsilon, Theta Xi, Triangle

Social Sororities

Chi Omega, Delta Sigma Theta, Kappa Delta, Phi Sigma Rho, Zeta Tau Alpha

For more information about any recognized organization, or how to get involved on campus, contact the Department of Student Life at (573) 341-6771, stulife@mst.edu or http://studentlife.mst.edu.

Volunteerism and Service

At Missouri S&T, we realize that our impact goes far beyond our campus. As a result, the Office of Student Life is committed to contributing to the betterment of our local, surrounding, and global communities. We do this by offering students a variety of opportunities to become actively engaged through service. All of which is possible due to the mutually beneficial partnership that exists between community organizations and the University. Annual events such as Make A Difference Day, Martin Luther King Day of Service, and the Miner Challenge Alternative Spring Break program are some of the volunteerism highlights of the academic year. Learn how to get involved in volunteer activities by joining our listserv at http://studentlife.mst.edu/volunteerism involvem enthomepage/ or by watching campus announcements for opportunities scheduled throughout the year. For more information on how you can get involved in volunteerism and service, please contact the Department of Student Life in 218 Havener Center at (573) 341-4329 or stulife@mst.edu.
Graduate Degree Programs

The Missouri University of Science and Technology offers master of engineering, master of science, master of arts (available as a cooperative degree program with UMSL), master of science for teachers, master of business administration, doctor of philosophy, and doctor of engineering degrees. Studies fall into the general areas of business, economics, engineering, English, science and technology.

Master of engineering degree

• geotechnics
• manufacturing engineering
• mining engineering

Master of science degree

• aerospace engineering
• biology, applied and environmental
• ceramic engineering
• chemical engineering
• chemistry
• civil engineering
• computer engineering
• computer science
• electrical engineering
• engineering management
• environmental engineering
• explosives engineering
• geological engineering
• geology and geophysics
• information science & technology
• manufacturing engineering
• materials science and engineering
• mathematics (applied)
• mechanical engineering
• metallurgical engineering
• mining engineering
• nuclear engineering
• petroleum engineering
• physics
• systems engineering
• technical communication

Master of science for teachers degree

• chemistry
• mathematics
• physics

Master of arts degree

Available as a cooperative degree program with the corresponding departments of the University of Missouri-St. Louis. (A maximum of 12 graduate semester hours may be taken at Missouri S&T)

• economics
• English

Master of business administration

• business administration

Doctor of philosophy degree

• aerospace engineering
• ceramic engineering
• chemical engineering
• chemistry
• civil engineering
• computer engineering
• computer science
• electrical engineering
• engineering management
• geological engineering
• geology and geophysics
• materials science and engineering
• mathematics
• mechanical engineering
• metallurgical engineering
• mining engineering
• nuclear engineering
• petroleum engineering
• physics
• systems engineering

Doctor of engineering degree

• chemical engineering
• civil engineering
• electrical engineering
• geological engineering
• mechanical engineering
• mining engineering
• nuclear engineering
• petroleum engineering

Graduate minors

• explosives engineering
• technical communication
Graduate Certificates

Graduate Certificate

Actuarial Science
Business Essentials
Business Intelligence
CAD/CAM and Rapid Product Realization
Composite Materials and Structures
Computational Intelligence
Contemporary Structural Engineering
Control Systems
Electric Machine and Drives
Electrical Power Systems Engineering
Energy Conversion and Transport
Engineering Management
Engineering Mechanics
Enterprise Resource Planning
Explosives Engineering
Financial Engineering
Financial Mathematics
Geoenvironmental Engineering
Geotechnical Earthquake Engineering
Geotechnics
Human Computer Interaction
Human Systems Integration
Information Assurance and Security
Infrastructure Renewal
Leadership in Engineering Organizations
Lean Six Sigma
Management for Sustainable Business
Manufacturing Automation
Manufacturing Systems
Military Construction Management
Military Geological Engineering
Mining Engineering
Multimedia and Information Systems
Network Centric Systems
Project Engineering & Construction Mgt
Project Management
Psychology of Leadership
Psychometrics
Quality Engineering
Safety Engineering
Software Design and Development
Systems Engineering
Systems and Software Architecture
Technical Communication
Wireless Networks and Mobile Systems

Discipline

Mathematics
Business Administration
Information Science & Technology
Manufacturing Engineering
Aerospace Engineering/Mechanical Engineering
Systems Engineering/Computer Engineering/Computer Science
Civil Engineering
Mechanical Engineering
Electrical Engineering
Electrical Engineering
Aerospace Engineering/Mechanical Engineering
Engineering Management
Information Science & Technology
Mining Engineering
Engineering Management/Systems Engineering
Mathematics
Civil Engineering
Civil Engineering
Geological Engineering
Information Science & Technology
Engineering Management/Information Science & Technology
Computer Engineering/Computer Science
Civil Engineering
Engineering Management/Psychology
Engineering Management
Business Administration
Mechanical Engineering
Manufacturing Engineering
Civil Engineering/Engineering Management
Geological Engineering
Mining Engineering
Computer Science
Computer Engineering/Systems Engineering
Civil Engineering/Engineering Management
Engineering Management/Information Science & Technology
Information Science and Technology/Psychology
Mathematics/Psychology
Engineering Management
Chemical and Biochemical Engineering/Engineering Management
Computer Science
Systems Engineering
Computer Science
Technical Communication
Computer Science

The Provost is responsible for the administration of all graduate work at Missouri S&T. In cases where your program can be demonstrably improved, the Provost can approve departures from the graduate faculty rules. Each department may have its own rules beyond the general ones listed and should be contacted if further information is desired at: http://grad.mst.edu/.
Degree Programs

Graduate Faculty

The Graduate Faculty, acting in accordance with the Rules and Regulations of the Board of Curators and campus policy legislated by the General Faculty, is responsible for the establishment of the policies, rules and regulations governing all graduate studies on the campus.

The membership of the Graduate Faculty consists of the following: The President of the University of Missouri, the Chancellor, the Provost, the Vice Provost for Research, the Vice Provost for Graduate Studies, the Vice Provost for Academic Affairs, and the Vice Provost for Undergraduate Studies. Chairs of Departments authorized to offer graduate degree programs and/or graduate courses and other members of the faculty at Missouri University of Science and Technology who are accepted under the rules of the Graduate Faculty to assume the responsibilities and authorities delegated to it.

Graduate Faculty membership will be approved automatically for those newly hired at a position of Assistant Professor or higher and holding the highest degree ordinarily awarded in the candidate’s field. Their membership will be subject to reappointment regulations (Article IV.D).

In this section, Graduate Faculty members are listed under the specific discipline most closely allied with their graduate faculty status which may not necessarily reflect the department in which current appointment is held.

Superscripts 1, 2, 3, 4, 5, and 6 in the faculty listing refer to the following common footnotes:

1Registered Professional Engineer
2Registered Geologist
3Certified Health Physicist
4Registered Architect
5Board Certified, American Academy of Environmental Engineers
6LEED AP Certified

Aerospace Engineering

The Aerospace Engineering Program in the Department of Mechanical and Aerospace Engineering offers comprehensive graduate education in a number of areas. Aerodynamics, gas dynamics, hypersonics, aerospace system design, aerospace propulsion, aerospace structures, plasma aerospace applications, multidisciplinary optimization, and flight dynamics and control are the major areas of emphasis. A wide variety of interdisciplinary programs meeting specific objectives are available. The Aerospace Engineering Program offers the master of science and doctor of philosophy degrees.

The department offers several graduate certificate programs in both Aerospace Engineering and Mechanical Engineering. Details of certificate programs can be found under the Mechanical Engineering program listing.

The master of science thesis program consists of a minimum of 30 semester hours, including at least 21 hours of course work with nine hours from the aerospace engineering core curriculum and at least six hours in mathematics and/or computer science. At least six credit hours of 400-level course work must be from the major field of study. In addition, a thesis from research that is equivalent to at least six credit hours in a major area must be prepared. The master of science non-thesis program consists of a minimum of 30 semester hours, including at least 18 hours of course work within the department, of which six hours must be from the aerospace engineering core curriculum. At least nine credit hours of 400-level course work must be from the major field of study.

The aerospace engineering core curriculum consists of four areas:

- • aerodynamics and propulsion
- • control/dynamics/stability
- • materials and structures
- • mathematics and computer science

A student pursuing the doctor of philosophy degree normally follows a program of 90 semester hours beyond the B.S. degree or 60 semester hours beyond the M.S. degree. For those with the M.S. degree, the 60 hours will consist of 24 hours of course work and 36 hours of thesis research. The Ph.D. course work must satisfy the departmental core course requirements for the M.S. degree. For the 24 credit hours of course work, a minimum of 12 hours must be taken within the department and at least three hours of mathematics/statistics. At least nine credit hours of course work must be at the 400-level in the major field of study. In addition to these course requirements, a candidate must prepare a dissertation based on analytical and/or experimental research in a major area. This research must be equivalent to a minimum of 36 hours beyond the M.S. degree.

There are no foreign language requirements for the doctor of philosophy degree in aerospace engineering. However, a reading knowledge of one foreign language, German, French or Russian, may be required for the doctor of philosophy degree if the candidate’s advisory committee feels that it is necessary.

A candidate for the degree of doctor of philosophy must pass a qualifying examination. The qualifying examination consists of taking a minimum of nine credit hours of approved graduate course work at the 300- and 400-level, including six hours in the major field, of which three hours must be at the 400-level, and three hours of mathematics/statistics. To pass the qualifying examination, a student must have obtained a grade of B or better for all courses with a GPA of at least 3.25.

The comprehensive examination and the final examination, consisting of the dissertation defense, are conducted according to the rules of the Graduate Faculty and the department. The Graduate Faculty has a residency requirement which must be satisfied by all doctoral students.

Typical examples of research activities are: analysis and design of composite structures, structural acoustics, aeroacoustics, smart structures, active and passive vibration control, optimization of systems based on structural dynamics or structural performance, astrodynamics, guidance and control of aircraft and missiles, robust multivariable control, microsatellite design, fabrication, and test, neural network architecture for control, estimation theory, real-time flight simulation, non-equilibrium
shock wave structure, propulsion research with emphasis on how fuel variables influence combustion, atomization of liquid fuels in supersonic flow, flame stability in combustion systems, scramjet and supersonic combustion scramjet studies, computational fluid dynamics, laser interaction problems, free turbulent mixing, unsteady high angle of attack flow configurations, computer simulation of separated flows, low-speed and high-speed aerodynamics, aerodynamics of high-lift devices, aerospace system design, and viscous effects in transonic flows.

The Department of Mechanical and Aerospace Engineering has many well equipped laboratories located on the main campus, and a subsonic flow laboratory in an off-campus facility. Some of the specially equipped laboratories on campus include: a supersonic-flow laboratory with a Mach 4 blow-down wind tunnel, a hot-wire anemometer system, a Schlieren system; an airflow test facility; an acoustics and vibration laboratory; a laser diagnostics laboratory equipped with state-of-the-art lasers to conduct experiments related to aerodynamics and combustion; a composite materials testing laboratory with state-of-the-art material testing system; low velocity impact facility and high speed photography equipment; and extensive computer facilities including a personal computer laboratory, advanced computer graphics laboratory, computer learning center with engineering work stations. The flight simulator program at Missouri S&T incorporates a fixed-base real-time flight simulator without-the-window display.

S N Balakrishnan, Curators Professor
PHD University Of Texas Austin
Control of aerospace and mechanical systems, flight and orbital mechanics, optimization identification and estimation, numerical methods and stochastic processes, neural networks, wavelets.

Victor Birman, Professor
PHD Technion, Haifa, Israel
Director Engineering Education Center in St. Louis. Composite material structures, smart structures.

Douglas A. Bristow, Assistant Professor
PHD University Of Texas Austin

K Chandrashekhara, Curators Professor
PHD Virginia Polytechnic Institute
Composite materials, smart structures, structural dynamics, finite element analysis, composite manufacturing and experimental characterization.

Lokeswarappa R Dharani, Curators Professor
PHD Clemson University
Curators' Professor of Engineering Mechanics and Aerospace Engineering and Senior Investigator in Graduate Center for Materials Research. Micromechanics of bi-material interfaces, composite materials, fracture mechanics, fatigue and failure analysis of welded structures, wear and friction in composites, fracture and failure of laminated glass.

Walter Eversman, Curators Professor
PHD Stanford University
Curators' Professor of Mechanical and Aerospace Engineering. Noise control, acoustics, vibrations, aircraft structural dynamics and aeroelasticity, systems and control.

Leslie Sour Gertsch, Associate Professor
PHD Colorado School Of Mines
Rock mechanics, mechanical mining and excavating, mine design and rock fragmentation.

Kelly O Homan, Associate Professor
PHD University Of Illinois (UIUC)
Fluid dynamics, heat and mass transfer in buoyant flows, second-law and energy analysis, numerical simulation of transport phenomena and experimental methods.

Serhat Hosder, Assistant Professor
PHD Virginia Tech
Computational fluid dynamics, aerodynamics, multidisciplinary design and optimization, uncertainty and error quantification in computational simulations, robust design, micro/nano flows, hypersonic flows, numerical methods.

Kakkattukuzhy M Isaac, Professor
PHD Virginia Polytechnic Institute
Associate Chair for Aerospace Engineering. Fluid dynamics and combustion, aero-structure interaction and control, intelligent aircraft, active flow control, wave-riders, microfluidics, MEMS, flow and combustion in porous media, multiphase flow, emissions from combustion and evaporative systems, lean premixed combustion, combustion instability, active 116 - Graduate Faculty combustion control, atomization and sprays, particle image velocimetry (PIV) and CFD applications in fluid dynamics and combustion problems.

K Krishnamurthy, Professor
PHD Washington State University
Advanced manufacturing systems, intelligent control, micro-electromechanical systems, nanotechnology, robotics.

Robert G Landers, Professor
PHD University Of Michigan Ann Arb
Manufacturing, systems, and control; modeling, analysis, monitoring, and control of manufacturing processes; metal cutting processes; laser metal deposition; friction stir welding; freeze extrusion fabrication; integrated design and control; control of alternative energy systems; digital control applications.

Henry J Pernicka, Associate Professor
PHD Purdue University Main Campus
Astrodynamics, orbital mechanics, spacecraft design, spacecraft mission design, satellite attitude dynamics, nonlinear analysis, dynamics and control, optimization.

David W Riggins, Professor
PHD Virginia Tech
Fluid dynamics, computational fluid dynamics, hyper/sonic propulsion systems, computational analysis of jet mixing, flow losses and mixing enhancement in combustors, aircraft gas turbine scramjet propulsion systems, and scramjet performance.

Joshua Lucas Rovey, Assistant Professor
PHD University Of Michigan Ann Arb
Plasma aerospace applications, advanced plasma space propulsion, Hall thrusters, ion thrusters, plasma aerodynamics and flow control, plasma-enhanced combustion, plasma-based energy systems, hypersonics/ re-entry body plasma interactions, plasma physics and rarefied gas dynamics.

Donald C Wunsch II, Professor
PHD University Of Washington
Mary Finley Missouri Distinguished Professor of Computer Engineering. Adaptive critic designs, neural networks, fuzzy systems, surety, nonlinear adaptive control, intelligent agents, applications.
Biological Sciences

Graduate study in the Department of Biological Sciences encompasses an interdisciplinary approach to problems in applied and environmental biology. The program emphasizes research designed to understand responses and adaptations in biological systems at cellular and molecular levels. Areas of particular interest include microbiology, cell biology, applied plant genetics, toxicology and bioinformatics. Faculty research programs are distinguished by their close association with other science and engineering disciplines on the Missouri S&T campus.

Graduate study in Biological Sciences is characterized by close interactions with faculty members. While courses of study are individualized, they include seminars, laboratory rotations and specialized courses in multiple disciplines. Emphasis is placed on research efficiency and communication skills.

Equipment and Facilities

The department’s office, teaching and research laboratories, equipment rooms (including imaging, histology, lab preparation, and bioanalytical facilities), faculty offices, student study hall and conference room are housed in Schrenk Hall. Equipment required to support graduate research in the biological sciences is available within the department or in the laboratories of collaborators in other disciplines. The Missouri S&T Animal Research Facility (managed by the department) provides access to vertebrate animals for research. The 1,780 square foot facility includes colony rooms, a room for sterile surgery, a cage-washing room, and other support rooms. Faculty and students requiring additional analytical instruments have access to such equipment through the research centers at Missouri S&T. The Department of Biological Sciences is also equipped with instruments for cell and molecular biology, including an Applied BioSystems model 3130 Genetic Analyzer for DNA sequencing, AFLP analysis and other fragment analysis applications, epifluorescent microscopes with CCD cameras and digital imaging software, high speed centrifuges with fixed angle and swinging bucket rotors, laminar flow hoods, microcentrifuges, gel dryer, evaporative centrifuge, thermocyclers, electroporator, protein and DNA gel-electrophoresis units, UV cross-linker, semi-dry and submarine nucleic acid/protein transfer units, numerous general use incubators, growth chambers, shaking incubators, UV-trans-illuminator, assorted teaching and research microscopes, nanopure water purification system, UV-Vis spectrophotometers, scintillation counters, microtiter plate reader, semi-automatic cell-harvester, media prep room with autoclaves, -70°C freezers, and automated media dispenser. Equipment for environmental microbiology includes a Coy anaerobic glove bag.

Course Study

Degree Requirements M.S. - with thesis

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO SCI 402</td>
<td>Problems In Applied And Environmental Biology</td>
</tr>
<tr>
<td>BIO SCI 410</td>
<td>Graduate Seminar</td>
</tr>
<tr>
<td>BIO SCI 475</td>
<td>Techniques In Applied And Environmental Biology</td>
</tr>
<tr>
<td>BIO SCI 490</td>
<td>Graduate Research</td>
</tr>
</tbody>
</table>

Degree Requirements M.S. - without thesis

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</tr>
</tbody>
</table>

Elective courses are chosen with guidance from the advisor and advisory committee. Out-of-department courses comprise at least 6 hours of credit. A minimum of 30 credit hours is required for a MS degree. Up to 6 credit hours may be taken at the 200 level in courses offered by other departments. Candidates for the MS degree with thesis conduct original research that is defended in a final oral examination. Non-thesis MS degree candidates take a comprehensive written final examination.

Robert Steven Aronstam, Professor
PHD University Of Rochester
Department Chair. Neuroscience, synaptic signal transduction.

Roger F Brown, Chancellors Professor
PHD Colorado State University
Mammalian cell biology, biomaterials, tissue engineering.

Ronald L Frank, Associate Professor
PHD Ohio State University
Molecular genetics, molecular biology.

Chen Hou, Assistant Professor
PHD University of Missouri-Columbi
Metabolic basis of aging, energetic basis of animal growth and reproduction.

Yue-Wern Huang, Professor
PHD Univ Of Wisconsin Madison
Environmental toxicology, nanoparticle toxicity.

Melanie R Mormile, Professor
PHD University Of Oklahoma, Norman
Environmental Microbiology.

Dev K. Niyogi, Associate Professor
PHD University Of Colorado Boulder
Ecology, limnology.

Katie B. Shannon, Associate Teaching Professor
PHD Harvard Medical School
Cell biology, mitosis, cytokinesis, cell cycle regulation, genetics, biochemistry, genomics.

Matthew Scott Thimgan, Assistant Professor
PHD The University of NC at Chapel
Biochemistry, genetics and anatomy of the sleep-loss response, sleep biomarkers.

David J Westenberg, Associate Professor
PHD University of CA - Los Angeles
Molecular microbiology, microbial diversity, microbial physiology.

Business Administration

The Business and Information Technology Department offers a unique Master of Business Administration (MBA). The MBA is a professional degree that combines core business knowledge with specialization tracks that include the newest technology trends, all in an environment of team based project work, business plan development, live simulations, and employer networking. In addition to influential presentation skills and advanced problem solving competencies, MBA’s develop advanced strategic thinking skills that are required of the leaders of today and tomorrow.
Business Graduate Certificate

Management for Sustainable Business

This certificate is designed to provide professional training in management for sustainable business.

• Foundations of Sustainable Business
• Teambuilding and Leadership
• Business Innovation for Sustainability
• Plus 1 elective

Admissions Requirements

MBA applicants are required to have a bachelor’s degree from an approved (accredited) institution in addition to the requirements listed for full-time MBA or part-time Executive MBA on our website (http://mba.mst.edu).

Degree Requirements

The Missouri S&T MBA requires a total of 36 credit hours and is offered in two (2) parts: the MBA Core (21 credits) and electives (15 credits). Please note that the MBA Program does not accept transfer credits from other institutions. The MBA core classes include Teambuilding and Leadership, International Marketing, MIS and Databases, Managerial Accounting for Monitoring and Control, Operations, Managerial Finance and Strategy. Core courses may not be waived or substituted for other courses under any circumstances.

In today’s business environment, management requires the ability to leverage information across business functions and knowledge across internal and external boundaries. Students work in teams on comprehensive business cases, live simulations and real company assigned projects throughout the MBA Program.

Students may choose either a certificate track or a specialization area which is comprised of 12 hours of electives. Students may choose from the following options:

• Enterprise Resource Planning (Certificate)
• Human-Computer Interaction (Certificate)
• Information Systems Project Management (Certificate)
• Management (Specialization Area)
• Management for Sustainable Business (Certificate)
• Marketing (Specialization Area)
• Supply Chain Management (Specialization Area)

Bonnie J. Bachman, Professor
PHD Rutgers Univ-New Brunswick
Organizational Creativity, Front End Design and Innovation Processes, Management of Emerging Technological Innovations, Business Sustainability, Entrepreneurship.

Cassandra Carlene Elrod, Assistant Professor
PHD University of Missouri - Rolla

Li-Li Eng, Assistant Professor
PHD University Of Michigan Ann Arbor
Financial and Managerial Accounting, International Accounting.

Edward J Harvey, Lecturer

MBA University of Missouri

Michael Gene Hilgers, Professor
PHD Brown University
Learning information systems, virtual reality, participative simulations.

Bih-Ru Lea, Associate Professor
PHD Clemson University

Ed A. Malone, Associate Professor
PHD Southern Illinois Univ Carbondale

Hong Sheng, Associate Professor
PHD Univ Of Nebraska Lincoln
Human-Computer Interaction, information systems management, E-Commerce, mobile commerce and ubiquitous commerce, strategic implications of mobile technology, trust and privacy issues in information systems, RFID in Health Care.

Keng Leng Siau, Professor
PHD University of British Columbia
Department Chair of Business & Information Technology. Design science, virtual world and 3D web electronic, mobile, and ubiquitous business, business intelligence/analytics.

Sarah Margaret Stanley, Assistant Professor
PHD Saint Louis University
Brand relationships, advertising effectiveness, social marketing and its effects on consumer brand choice.

Ceramic Engineering

The Ceramic Engineering program in the Department of Materials Science & Engineering offers comprehensive graduate education in a number of areas including structural ceramics, electronic materials, high temperature materials, and glass. Further information on these opportunities and facilities available to carry out research in ceramic engineering may be found under Materials Science & Engineering.

Degree Requirements

M.S. and Ph.D. degrees are offered in Ceramic Engineering. The total number of hours required for the M.S. in Ceramic Engineering is 30. A minimum of 6 hours of 400 level lectures and a minimum of 11 hours of graduate research on the Missouri S&T campus are required. A maximum of 6 hours of 200 level lecture credit may be accepted.

The minimum number of hours (beyond the bachelor’s degree) required for the Ph.D. in Ceramic Engineering is 72. At least 12 hours of course work outside of Ceramic Engineering is recommended, a minimum of 24 hours will be dissertation research, and a minimum of 24 hours must be course work. Students will also be required to take and pass qualifying and comprehensive exams in accordance with Missouri S&T rules.

Richard K Brow, Curators Professor
PHD Pennsylvania State University
Curators’ Professor of Ceramic Engineering, and Senior Investigator, Graduate Center for Materials Research.

Fatih Dogan, Professor
PHD Technical University of Berlin

A Curt Elmore, Professor
PHD University Of Arizona
William G Fahrenholtz, Curators Professor
PHD University Of New Mexico Main

Gregory E Hilmas, Curators Professor
PHD Univ. of Michigan - Ann Arbor
Senior Investigator, Graduate Center for Materials Research.

Wayne Huebner, Professor
PHD University Of Missouri-Rolla
Department Chair of Materials Science and Engineering.

F Scott Miller, Associate Teaching Professor
PHD University of Missouri-Rolla

Joseph W Newkirk, Associate Professor
PHD University Of Virginia Main Ca

Mohamed N Rahaman, Professor
PHD University of Sheffield (UK)

Mary R. Reidmeyer, Associate Teaching Professor
PHD University Of Missouri-Rolla
Outreach Coordinator.

Jeffrey D Smith, Associate Professor
PHD University of Missouri - Rolla

Jeremy Lee Watts, Research Assistant Professor
PHD Missouri S&T

Chemical & Biochemical Engineering

The Department of Chemical and Biochemical Engineering offers M.S. and Ph.D. degrees in Chemical Engineering.

A baccalaureate degree in Chemical Engineering with a minimum undergraduate grade point average of 3.0/4.0 or equivalent is required for admission to the graduate program.

The department specializes in research in the areas of fluid mechanics, supercritical fluid technology, reaction engineering, biochemical engineering, mass and heat transfer in porous media, transport and interfacial phenomena, computer-aided design, particle characterization, catalysis, statistical mechanics and nanotechnology.

All students, except for those in their last semester of graduate study, need to register for 1 credit hour of CHEM ENG 410 Seminar.

The master of science thesis program consists of a minimum of 30 semester hours, including 18-24 hours of coursework, in which CHEM ENG 383, CHEM ENG 420, CHEM ENG 433, and CHEM ENG 445 are required. In addition, a thesis from research that is equivalent to 6-12 credit hours in the major area must be prepared and defended.

A master of science non-thesis program consists of 30 semester hours of coursework, including CHEM ENG 383, CHEM ENG 420, CHEM ENG 433, and CHEM ENG 445 and a minimum of 18 hours of coursework within the department.

A candidate for the PhD degree normally follows a program of 90 semester hours beyond the BS degree or 60 semester hours beyond the MS degree. Research for MS and PhD may be coordinated, or a PhD may be pursued without an MS degree. The PhD coursework must satisfy the departmental core course requirements for the MS degree with an additional 6 credit hours of 400-level coursework for a minimum of 15 400-level credit hours. In addition to these course requirements, a candidate must prepare and defend a dissertation based on analytical and/or experimental research.

A grade of A in CHEM ENG 383, CHEM ENG 433, and CHEM ENG 445 will constitute passing the chemical reaction engineering, transport phenomena, and thermodynamics portions of the qualifying examination, respectively.

At least three members of the advisory committee have to be ChE faculty. The comprehensive examination, consisting of a written and oral presentation of a research proposal, should be taken in the semester following the completion of their course work and no later than six months prior to the final examination. The final examination, consisting of the dissertation defense, is conducted according to the rules of the Graduate Faculty, School of Engineering, and the department.

The Department of Chemical and Biochemical Engineering shares Schrenk Hall, a building of four floors, with the Chemistry and Biological Sciences Departments. The department has excellent computer facilities equipped to handle all Chemical Engineering computational, modeling, and simulation requirements.

Special areas for instruction and research are maintained and include excellent and modern facilities for studying simulation, control and optimization; bio-conversion; reaction mechanisms and kinetics; fluid mechanics and mixing; thermodynamics; polymers and polymeric materials; freeze drying; adsorption/desorption processes; computer-aided design; interfacial phenomena; transport phenomena; chromatography; characterization of biomolecules; synthesis of nanoparticles; supercritical fluid technology.

Muthanna Hikmat Al Dahhan, Professor
PHD Washington University
Department Chair. Multiphase reaction and reactor engineering flow systems; transport-kinetic integration; advanced measurement and computational techniques; applications to green technology and sustainable development in energy, products, and environment.

Neil L Book, Associate Professor Emeritus
PHD Univ Of Colorado Boulder
Computer-aided chemical process design, electronic information management, and chemical process safety.

Daniel Forciniti, Professor
PHD North Carolina State Universit
Applications of molecular theories to problems in biochemical engineering and science. Bioseparation. Protein characterization and computer simulations of biological systems.

Xinhua Liang, Assistant Professor
PHD University of Colorado-Boulder
Surface science and catalysis, nano-structured films and devices, energy and environmental applications.

Athanasios I Liapis, Professor
PHD Swiss Federal Institute Of Tec
Modeling of mass and heat transfer mechanisms in separation processes and heterogeneous chemical reaction systems; adsorption/desorption; lyophilization; chromatography; affinity chromatography; perfusion chromatography; transport phenomena; biochemical engineering.

Douglas K Ludlow, Professor
PHD Arizona State University  
Surface characterization, catalysts, adsorption.

Parthasakha Neogi, Professor  
PHD Carnegie Mellon University  
Interfacial and transport phenomena.

Joontaek Park, Assistant Professor  
PHD University of Florida

Oliver Clifford Sitton, Associate Professor  
PHD University Of Missouri-Rolla  
Modeling and scale-up of ultra-sonic systems, effect of ultrasonics on mass transport and chemical kinetics with emphasis on polymer reactions, phase transfer catalysis and oxidation; biotechnology and bioprocessing with emphasis on biochemical reactor design and operation.

Joseph D Smith, Professor  
PHD Brigham Young University  
Laufar Chair of Energy. Hybrid energy generation, gas flare design, process modeling, and control.

Jee-Ching Wang, Associate Professor  
PHD Pennsylvania State University  
Molecular modeling and simulation, nanofluid and nanoparticle technology, interfacial phenomena and dynamics, transport in porous media, parallel computing and new simulation techniques.

David J Westenberg, Associate Professor  
PHD University of CA - Los Angeles  
Molecular microbiology, microbial diversity, microbial physiology.

Yanzhi Zhang, Assistant Professor  
PHD National Univ of Singapore

Chemistry

The Department of Chemistry provides instructional programs in analytical, inorganic, organic, physical, polymer and biochemistry, as well as in more specialized areas. Besides the basic fields, there are programs in bioanalytical chemistry, cancer biology, colloids, corrosion, electrochemistry, environmental chemistry, molecular modeling, kinetics, organometallic chemistry, reaction mechanisms, solid state chemistry, surface, surface coatings, and theoretical chemistry. Interdisciplinary programs in materials science and atmospheric sciences are also available.

The Department of Chemistry encourages its graduate students to teach as part of their training for an advanced degree. The objective is to supplement your education and strengthen your professional preparation in academic practices. Financial support is often available from research grants for advanced students.

The Department of Chemistry shares facilities with the Departments of Chemical & Biochemical Engineering and Biological Sciences. Two connected air conditioned buildings with research, teaching and computer laboratories are available.

The department is well-equipped with state-of-the-art instrumentation for chemical research. The department has a number of support personnel to provide technical assistance with laboratory instrumentation, computers, laboratory hardware, and glassware. Instrumentation in the Department of Chemistry includes Varian and Bruker 200 and 400 MHz FT/NMR spectrometers with multinuclear solids, liquids, diffusion, and variable-temperature capabilities; a Bruker X-ray diffractometer with low-temperature attachment; a Hewlett-Packard 5989 mass spectrometer with gas-chromatograph and direct-insertion-probe inputs; a Hitachi M-8000 mass spectrometer with a high-performance liquid-chromatograph input; a Perkin-Elmer 2400 C-H-N elemental analyzer; Beckman PACE/MDQ capillary-electrophoresis instruments with UV and laser excitation systems; an Applied Color Systems 1800 color-matching/formulating computing spectrophotometer; a TA Instruments differential scanning calorimeter; a TA Instruments thermogravimetric analyzer; Perkin-Elmer, Parr 273, and EG&G potentiostat/galvanostats; a Johnson-Mathes magnetic-susceptibility balance; a Faraday low-temperature magnetic-susceptibility balance; Nicolet Magna and Nexus FT/IR spectrometers with multiple detectors and sample attachments; a TA Instruments rheometer with small-angle light-scattering attachment; TA Instruments dynamic mechanical analyzer with low-temperature attachment; Netzsch Laser Flash Analyzer for flash diffusivity; Rame-Hart goniometer/tensiometer for measuring surface tension and contact angle; Hitachi HPLC with autosampler, column oven, and refractive-index and diode-array detectors; Perkin-Elmer atomic-absorption spectrometer; Hewlett-Packard gas chromatographs with flame-ionization detectors; and a Jasco P-2000 polarimeter. The department houses an extensive collection of additional mass spectrometers. Backing up these instruments are a wide variety of additional chromatographs (GC, LC, IC), infrared spectrometers, dispersive optical spectrometers (UV/VIS, IR, AA), fluorescence/luminescence spectrophotometers, centrifugal partition chromatographs, refrigerated-ultra centrifuges, calorimeters, salt-spray chambers, and radiation counters. In addition, numerous PC/compatible, and UNIX computers are available in laboratories, computer learning centers, and computerized classrooms, as well as access to the campus centralized computing facility which includes numerically-intensive computing support. Powder X-ray diffraction is performed in the Graduate Center for Materials Research on a Scintag 2000 Diffractometer and other supporting equipment while neutron diffraction is on hand at the High Flux Reactor of the Missouri S&T. This also supports nuclear chemistry. Facilities for studying very fast combustions and explosions, as well as a variety of new and innovative techniques for characterizing high energy materials, are provided in the Rock Mechanics and Explosives Research Center.

Amitava Choudhury, Assistant Professor  
PHD Indian Institute Of Science  
Inorganic solid state and materials chemistry. Synthesis of new materials applicable in Li-ion battery, thermoelectrics, solid-state lighting, hydrogen storage, and catalysis. Structure determination employing single-crystal and powder X-ray diffraction methods and investigate structure-property relationships.

Harvest L Collier, Professor Emeritus  
PHD Mississippi State University  
Vice Provost, Undergraduate Studies. Inorganic-organometallic chemistry, synthesis, structural, electronic analysis of macrocyclic-metal complexes, metal binding polymer, kinetics and mechanism of metal-ligand interactions.

Richard Dawes, Assistant Professor  
PHD University of Manitoba  
Theoretical spectroscopy and dynamics. Multireference quantum chemistry and potential energy surfaces. Combustion chemistry.

Nuran Ercal, Professor  
PHD Hacettepe University, Turkey.

William Joseph James, Professor Emeritus  
PHD Iowa State University  
Physical chemistry, mechanisms of anodic dissolutions of metals and alloys, passivation studies using potentiostatic methods, studies of point defects in solid preparations, studies of ferroelectric crystals, studies of the structure of magnetic alloys by neutron diffraction.

Shubhender Kapila, Professor  
PHD Dalhousie University, Halifax  
Missouri Soybean Research Professor of CEST. Gas phase reaction kinetics, application of supercritical fluid in organic analysis, organic mass spectrometry, environmental chemistry.

Nicholas Leventis, Curators Professor  
PHD Michigan State University  
Organic chemistry, materials and surface chemistry, electro-chemistry.

Gary John Long, Professor  
PHD Syracuse University  
Physical inorganic and solid state chemistry, magnetic, electronic, spectral, and structural studies of transition metal complexes, alkaloid and vitamin B6 complexes, X-ray and neutron diffraction, and Mossbauer Effect studies.

Yinfa Ma, Curator Teaching Professor  
PHD Iowa State University  

Paul Ki Souk Nam, Associate Professor  
PHD University Of Missouri-Columbia  
Analytical and environ-mental chemistry. Instrumentation and method for organic and inorganic analyses; chromatography and mass spectrometry; environmental fate and transport of chemical pollutant; supercritical fluid application; environmentally-benign product and process; chemical and physical characterization of particulate matter.

Manashi Nath, Assistant Professor  
PHD Indian Institute Of Science  
Nanomaterials, Inorganic materials and solid-state chemistry, Nanoscience & Technology, nanostructure synthesis, characterization, device fabrication. Designing protocols for production of smart materials and devices. Superconductor synthesis, characterization and morphology control.

V Prakash Reddy, Associate Professor  
PHD Case Western Reserve University  
Organofluorine chemistry. Friedel-Crafts reactions. Carbocation reaction mechanisms. Green chemistry. Protein modifications.

Thomas Schuman, Associate Professor  
PHD University of AL-Huntsville  
Interfacial spectroscopy and chemistry; coatings: adhesion, corrosion protection, adsorption phenomena; organic polymer syntheses; industrial agricultural applications and research.

Honglan Shi, Research Associate Professor  
PHD Missouri S&T  
Sr. Investigator of Environmental Research Center. Bioanalytical chemistry, environmental chemistry, analytical methods development and applications by using state-of-the-art instruments including LC-MS, ICP-MS, LC-ICP-MS, ICP-OES, GFAA, GC-MS, GC, HPLC, HPCE for organic and inorganic compounds quantitative analysis and compounds identifications.

Chariklia Sotiriou-Leventis, Professor  
PHD Michigan State University  
Bioorganic, physical-organic, and analytical organic chemistry; synthesis, structural characterization, kinetics, and mechanisms of organic reactions.

Pericles Stavropoulos, Associate Professor  
PHD Imperial College, London, UK  

Jay A Switzer, Professor  
PHD Wayne State University  
Donald L. Castleman/FCR Missouri Endowed Professor of Discovery in Chemistry and Senior Investigator, Graduate Center for Materials Research. Inorganic materials chemistry and electrochemistry. Research at interface between chemistry and materials science, developing low-temperature chemical processing methods for nanoscale materials and thin-film opto-electronic ceramic materials.

Michael R Van De Mark, Associate Professor  
PHD Texas A&M University  
Organic and polymer chemistry, electrochemistry, surface science, polymer synthesis, corrosion, and polymer/solvent interactions.

Philip D Whitefield, Professor  
PHD University Of London (UK)  
Department Chair. Analytical and physical chemistry, particulate characterization and heterogeneous chemistry of atmospheric and environmental processes.

Jeffrey G. Winiarz, Associate Professor  
PHD SUNY At Buffalo  

Klaus Hubert Woelk, Associate Professor  
PHD Univ Of Bonn-Germany  
NMR Spectroscopy, Physical Chemistry. Chemical reactions in supercritical fluids; torid-cavity rotating-frame NMR microscopy; in situ high-temperature and high-pressure NMR spectroscopy of hydrothermal biomass-to-reaction mechanisms fuel conversion.

Civil, Architectural, and Environmental Engineering

The department offers specialization in construction engineering management, environmental, geotechnical, materials, structural, and water resources engineering. Recent and ongoing funded research includes liquefaction of soils, earthquake mitigation of highway structures, stream stability and storm water detention in urban watersheds, sediment transport, river mechanics, constitutive modeling of reinforced and prestressed structures, blast protection of critical infrastructure real-time instrumentation of civil infrastructure, biofiltration, phytoremediation of organic contaminants, remediation of contaminated buildings, impact
and occurrence of endocrine disrupters, compact low-energy wastewater treatment, fate of metals in fly ash, plants and doll systems, green infrastructure, creep compliance of asphalt mixtures, durability of concrete, resilient modulus of granular material.

Examples of faculty expertise includes phytoremediation and natural treatment systems, site assessment and investigations, biofiltration and bioreactors, fate and transport of heavy metals wastewater treatment technologies, indoor air pollution assessment and control, building systems and environmental controls, satellite survivability, orbital debris protection systems, building collapse, rubble modeling, explosive and blast loads on buildings, penetration mechanics, properties of construction materials (aggregate, asphalt, concrete), pavement analysis and design, stochastic hydrology, urban hydrology, watershed modeling, fluid mechanics, steady and unsteady fluid flow, fluid mechanics, computational fluid mechanics and hydraulics, urban steam morphology, sediment transport mechanics, river mechanics, environmental fluid mechanics, hydrodynamics, geotechnical earthquake engineering, laboratory testing and evaluation of soil materials, and liquefaction of silts.

The basic prerequisite for admission to graduate study in the department is a Bachelor of Science degree in Engineering from an ABET accredited school or equivalent. Students who have a degree from a non-accredited school, or hold a Bachelor of Science degree in a field other than engineering, may be required to take engineering prerequisites to prepare for graduate courses. Specific prerequisites will depend on the student’s academic background and intended area of specialization.

Degree programs offered are the Master of Science in Civil Engineering (MSCE), Master of Science in Environmental Engineering (MSEnvE), the Doctor of Engineering, (DE), and the Doctor of Philosophy (PhD). The MS degrees are also available on-line via streaming video for place-bound students.

All of the department’s programs prepare graduates to provide leadership in their careers by providing a strong foundation in the fundamental and applied engineering principles. Program faculty have diverse backgrounds including civil, environmental, mechanical, aerospace, architectural, and chemical engineering. All programs include strong design and research components, while having the flexibility to tailor curricula to individual needs. Faculty in all programs collaborate extensively with faculty and researchers from other departments, at Missouri S&T and elsewhere.

The department is housed in Butler-Carlton Hall, which is also home to the high-bay structural testing laboratory, the Reese Bituminous Materials Laboratory, concrete materials laboratory, geotechnical laboratory, geodynamics laboratory, Mathes Environmental Research Laboratories, water resources laboratory, The Baker Greenhouse is used to study environmental research on plants for controlling groundwater pollution, wetlands and indoor air pollution. All laboratories are equipped with the latest testing, data acquisition and control equipment. The department has its own machine and electronics shops and trained technical staff used for design, construction and maintenance of specialized mechanical and electronic testing equipment needed to support research and teaching.

The department is also home to the Environmental Research Center for Emerging Contaminants, the W.W. Yu Center for Cold-Formed Steel Structures, the UTC National Transportation Institute, the Center for Infrastructure Engineering Studies, and the Missouri Local Transportation Resource Center.

The mission of the Environmental Research Center for Emerging Contaminants is to establish the infrastructure and coordinated faculty base to conduct a wide range of large-scale externally-funded research initiatives designed to protect public health from emerging contaminants. The Center helps a diverse group of researchers from across the university to share resources necessary to tackle national and global environmental challenges.

The University Transportation Center program was established to advance United States technology and expertise in the many disciplines comprising transportation through the mechanisms of education, research, and technology transfer at university-based centers of excellence. The theme of this center is to address national needs in the areas of transportation infrastructure focusing on advanced materials and non-destructive testing (NDT) technologies.

The mission of the W.W. Yu Center for Cold-Formed Steel Structures Center is to provide an integrated approach for handling research, teaching, engineering education, technical services, and professional activity. The Center brings together the technical resources of interested parties, i.e., university researchers, steel producers, product manufacturers, consultants, building officials, government agencies, and others with a common goal of continued improvement of cold-formed steel design and construction.

The Missouri Local Transportation Resource Center provides a resource center available for use by local agencies throughout the state of Missouri. Its regular activities include the Proactive Training and Customized Transportation Education Programs (PTP and CTEP, respectively), ongoing development of transportation lending and distribution lending libraries, management of MoDOT’s Cooperative Purchasing Program, production of a quarterly newsletter, and functioning as a transportation technical assistance resource for individuals and agencies around the state.

Graduate Certificate Programs

Contemporary Structural Engineering

Choose one course from each of the following three groups (analysis, design, and structural system) and the fourth course from any of the three groups.

I. Structural Analysis Courses:

- CIV ENG 319 Applied Mechanics In Structural Engineering
- CIV ENG 320 Structural Analysis II
- CIV ENG 323 Computer Methods of Structural Analysis
- CIV ENG 384 Structural Dynamics

II. Structural Design Courses:

- CIV ENG 326 Advanced Steel Structures Design
- CIV ENG 327 Advanced Concrete Structures Design
- CIV ENG 328 Prestressed Concrete Design
- CE 3xx Structural Masonry Design
III. Structural System Courses:

CIV ENG 375 Low-Rise Building Analysis And Design
CIV ENG 426 Advanced Design In Steel And Lightweight Structures
AERO ENG 334 Stability Of Engineering Structures
or MECH ENG Stability Of Engineering Structures 334
or EM 334

Geoenvironmental Engineering

A minimum of two of the following geotechnical courses must be taken:

CIV ENG 314 Geosynthetics In Engineering
CIV ENG 315 Intermediate Soil Mechanics
CIV ENG 329 Foundation Engineering II

A minimum of two of the following environmental courses must be taken:

CIV ENG 360 Environmental Law And Regulations
CIV ENG 361 Remediation Of Contaminated Groundwater And Soil
CIV ENG 363 Solid Waste Management
CIV ENG 367 Introduction To Air Pollution
CIV ENG 380 Water Resources And Wastewater Engineering

Geotechnical Earthquake Engineering

The following courses are required:

CIV ENG 316 Geotechnical Earthquake Engineering
CIV ENG 413 Dynamics Of Earth Materials

Two of the following three courses are required:

CIV ENG 315 Intermediate Soil Mechanics
CIV ENG 329 Foundation Engineering II
CIV ENG 412 Computer Modeling in Geotechnical Engineering

Infrastructure Renewal

Two of the following courses are required:

CIV ENG 374 Infrastructure Strengthening With Composites
AERO ENG 311 Introduction To Composite Materials & Structures
or MECH ENG Introduction To Composite Materials & Structures 382
CIV ENG 314 Geosynthetics In Engineering

One of the following courses is required:

CIV ENG 326 Advanced Steel Structures Design
CIV ENG 327 Advanced Concrete Structures Design
CIV ENG 328 Prestressed Concrete Design

One of the following courses is required:

CIV ENG 329 Foundation Engineering II
CIV ENG 345 Construction Methods

CIV ENG 384 Structural Dynamics
AERO ENG 484 Analysis Of Laminated Composite Structures
or MECH ENG Analysis Of Laminated Composite Structures 484
or EM 484

Military Construction Management

(Offered in CE and EMgt disciplines ONLY at the Fort Leonard Wood campus.)

SYS ENG 411 Systems Engineering Capstone
ENG MGT 313 Managerial Decision Making
CIV ENG 345 Construction Methods
CIV ENG 442 Construction Administration, Planning And Control

Project Engineering and Construction Management

(Offered in both CE and EMgt disciplines)

Two of the following civil engineering courses are required:

CIV ENG 345 Construction Methods
CIV ENG 349 Engineering And Construction Contract Specifications
CIV ENG 442 Construction Administration, Planning And Control
CIV ENG 445 Advanced Construction Engineering

Two of the following engineering management courses are required:

ENG MGT 308 Economic Decision Analysis
ENG MGT 314 Management for Engineers and Scientists
ENG MGT 361 Project Management
ENG MGT 362
SYS ENG 368 System Engineering and Analysis I
ENG MGT 461 Global Project Management

Bate Bate, Assistant Professor
PHD Georgia Tech
Soil improvement, beneficial reuse of industrial waste materials, contaminant remediation, physicochemical modeling of fundamental soil behavior, innovative soil characterization tools.

Stuart W Baur, Associate Professor
PHD University of Missouri-Rolla
Integrated building systems, advanced building system technologies, green construction.

Jerry R Bayless, Associate Professor
MASTER Missouri School of Mines

Joel G Burken, Professor
PHD University Of Iowa
Phytoremediation of organic contaminants and heavy metals, biological waste water treatment, constructed wetlands, green infrastructure, biomass energy.

Genda Chen, Professor
PHD State Univ Of New York - Buffa
Structural health monitoring, interface mechanics and deterioration of composite structures, adaptive passive dampers and systems, multi-hazards assessment and mitigation, forensic study, seismic analysis and retrofit, soil-structure interaction, bridge engineering.

Mohamed Abdelmonem ElGawady, Associate Professor
DE Swiss Federal Inst. of Tech.

Kelvin Todd Erickson, Professor
PHD Iowa State University
Chemical process control, advanced control algorithms, digital control, programmable logic controllers, system identification.

Mark W Fitch, Associate Professor
PHD University Of Texas Austin
Bioremediation of recalcitrant pollutants, membrane reactors, genetically-engineered bacteria for bioremediation, constructed wetlands for metals removal.

Kamal Khayat, Professor
DE University of CA - Berkeley

Roger Allen LaBoube, Adjunct Professor
PHD University Of Missouri-Rolla
Curators' Teaching Professor Emeritus of Civil Engineering. Behavior and design of cold-formed steel structures, load and resistance factor design of steel structures, design and behavior of light steel construction, behavior of bolted and welded connections, structural stability, design of plates and shells, application of building code provisions.

Ronaldo Luna, Professor
PHD Georgia Institute of Technolog
Soil mechanics and foundation engineering, geotechnical earthquake engineering, hazard modeling, numerical modeling, geographic information systems, and remote sensing.

Cesar Mendoza, Associate Professor
PHD Colorado State University
Sediment transport, river mechanics, environmental fluid mechanics, hydrodynamics, and mathematical modeling.

Gary T Moore, Adjunct Professor
MASTER University of Missouri Rolla

Charles Darwin Morris, Adjunct Associate Professor
PHD University Of Illinois Urbana
Stochastic hydrology, urban hydrology watershed modeling, fluid mechanics, steady and unsteady fluid flow, mathematical and physical modeling, urban stream morphology.

Glenn Morrison, Associate Professor
PHD University Of CA-Berkeley
Environmental engineering, assessment and control of air pollution, indoor air chemistry, transport and surface interactions, remediation of contaminated buildings.

John J Myers, Associate Professor
PHD University Of Texas Austin
High performance concrete (HPC) behavior and durability performance (PC and RC); development of infrastructure systems and monitoring techniques; fiber-reinforced polymers (FRP) in structural repair and strengthening applications with an emphasis related to structural behavior, blast resistance, bond, substrate characterization, and durability performance.

Daniel B Oerther, Professor
PHD University of Illinois, Urbana
Environmental biotechnology, urban sustainability, global development, ensuring universal access to water and sanitation, combating the obesity epidemic, and eliminating extreme poverty.

David N Richardson, Associate Professor
PHD University Of Missouri-Rolla
Properties of construction materials (aggregate, asphalt, and concrete), pavement analysis and design.

V A Samaranayake, Professor
PHD Kansas State Univ Of Agricultu
Reliability, time series analysis, statistical applications in biology, economics, and engineering.

William P Schonberg, Professor
PHD Northwestern University
Department Chair. Armor/anti-armor, penetration mechanics, spacecraft shielding against meteoroid and orbital debris impacts, hypervelocity impact phenomena, building failure and collapse, design and construction of Moon and Mars habitats.

William Eric Showalter, Associate Teaching Professor
PHD Purdue University Main Campus
Construction engineering and management, cost effectiveness, sustainable design and construction.

Lesley Haynes Sneed, Assistant Professor
PHD Purdue University Main Campus
Reinforced and pre-stressed concrete structural members and systems, structural models and experimental methods, innovative methods of repair and strengthening of structures subjected to seismic loading or other extreme hazards, structural hazard mitigation, design codes and construction specifications for structural concrete.

Jeffery S Volz, Assistant Professor
PHD Pennsylania State University
Durability and fatigue performance of pre-stressed and reinforced concrete, corrosion of metals in cementitious systems, particularly pre-stressed and reinforced concrete, fatigue and fracture of metals, particularly involving the combination of corrosion and fatigue, evolutionary algorithms to predict critical elements in progressive collapse of multistory structures, building facades under extreme loading events, such as hurricanes, earthquakes, and thermal loadings, sustainability applied to building systems, particularly involving new materials and improving the performance of existing materials.

Jianmin Wang, Associate Professor
PHD University Of Delaware
Fate and transport of heavy metals in natural and engineered systems; water and wastewater treatment processes; water chemistry and interfacial phenomena.

Lloyd Christopher Wilson, Adjunct Associate Professor
PHD University Of Missouri-Rolla
Computer Engineering

The mission of the Computer Engineering Program, consistent with the Missouri S&T campus mission statements, is the education of students to fully prepare them to provide leadership in the recognition and solution of society’s problems in the area of Computer Engineering.

The Computer Engineering Program in the Department of Electrical and Computer Engineering offers graduate programs of study which lead to the M.S. degree (thesis and non-thesis options) and the Ph.D. degree. Both the Rolla campus and the Engineering Education Center in St. Louis offer M.S. programs. A great variety of multidisciplinary programs and research areas are available. Most graduate programs in computer engineering normally include some specialization in one or more of the following four emphasis areas of computer engineering.

Emphasis Areas

**Digital Systems Design** topics include computer architecture, digital circuits, high performance systems, parallel processors, testing and VLSI design.

**Electrical Engineering** can be an emphasis area in Computer Engineering or a separate degree. See the section on Electrical Engineering for emphasis areas in Electrical Engineering.

**Embedded Computer Systems** topics include hardware/software co-design, microprocessor systems, real-time systems, and smart sensors.

**Systems, Intelligence, and Software Engineering** topics include computational intelligence, computer networks, dependability, fault tolerance, image processing, neural networks and system security/survivability.

Departmental Requirements

The nominal GPA requirement for admission to the M.S. degree program in this department is an undergraduate GPA of 3.2 on a 4.0 GPA system. In evaluating the academic performance from universities that may use other grading systems, the department may rely upon statistical data gathered in analyzing academic outcomes for recent graduate students to the extent that such statistical data is available. The department will not offer graduate admissions to students who do not have the equivalent of a four year baccalaureate degree in engineering. As an example we cannot accept students who have only a diploma or Engineering Technology degree.

In addition to campus requirements that the sum of GRE-V and GRE-Q be at least 1100 and that the GRE-WR score be at least 3.5, the ECE department recommends a minimum GRE-Q score of 730 and recommends a minimum GRE-WR score of at least 4.0. For applicants who have taken the GRE-A instead of the GRE-WR, the department recommends a GRE-A score of at least 640.

For international students who are required to provide TOEFL scores, this department has no particular preference for the computer based TOEFL, the internet based TOEFL, or the paper based TOEFL. Minimum recommended scores set by the department are 237 on the computer based TOEFL, 580 on the paper based TOEFL, and 92 on the IBT (internet based testing) version of the TOEFL exam. The recommended IELTS score is a minimum of 6.5

Students applying for graduate studies in this department on the basis of degrees in closely related fields may have additional conditions placed on their admission. These conditions are generally imposed to make sure that students lacking a traditional Computer Engineering degree will have sufficient background to ensure a reasonable chance for academic success.

Students seeking admission to the Ph.D. program should meet or exceed all of the above recommendations and should have a graduate GPA of 3.5 or better. All Ph.D. applicants must provide at least three letters of recommendation. Exceptional applicants may apply directly to the Ph.D. program after completing the baccalaureate degree.

Program Requirements

Additional departmental requirements beyond those stated in the section on Admission and Program Procedures are as follows. Thesis option M.S. programs of study, as listed on graduate form I, require a minimum of 21 credit hours of course work exclusive of credit hours earned for thesis research (courses numbered 490). A limited number credit hours for 200 level courses may be counted towards the fulfillment of an M.S. program of study (graduate form I) provided that the courses are taken outside of the Electrical and Computer Engineering Department and that the courses are pre-requisites for at least one 300 or 400 level course also included in the program of study. The doctoral program of study, for the Ph.D. degree or the D.E. degree, should include approximately 90 credit hours beyond the B.S. degree or approximately 60 credit hours beyond the M.S. degree. An M.S. or doctoral student’s advisory committee may impose additional requirements or restrictions as it sees fit.

Ph.D. Language Requirement

As a Computer Engineering Ph.D. student, you are not required to satisfy a language requirement. However, you may have language requirements included in your plan of study if your advisory committee feels that this inclusion would be useful or necessary for your research.

Research

Significant research, suitable for publication, is expected for students pursuing the thesis option M.S. or a doctoral degree. The student should work closely with their major advisor and their advisory committee to determine when these expectations are met. The length of research time and/or the number credit hours earned for thesis research will not automatically satisfy this requirement.

Network Centric Systems Graduate Certificate

(Also offered in the Systems Engineering discipline)

The Graduate Certificate in Network Centric Systems is a joint effort between Computer Engineering and Systems Engineering. It provides practicing engineers with the necessary skills to develop and design the operation of network centric systems. The four courses taken to fulfill the requirements of the graduate certificate program can, under certain circumstances, be counted towards an M.S. degree. However, any pre-requisite or remedial courses taken to provide background for one or more of the four graduate certificate program courses cannot be counted towards an M.S. degree.

In order for a required graduate certificate course in network centric systems to count for graduate credit the graduate certificate program must have been successfully completed, as described in the Admission and Program Procedures section, and. the applicant must apply for
and be accepted into the graduate program (Computer Engineering or Systems Engineering) specified at the time the applicant was accepted into the graduate certificate program in network centric systems.

Core Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>SYS ENG 419</td>
<td>Network Centric Systems</td>
</tr>
<tr>
<td>or COMP ENG 419</td>
<td>Network Centric Systems</td>
</tr>
<tr>
<td>COMP ENG 449</td>
<td>Network-Centric Systems Reliability and Security</td>
</tr>
<tr>
<td>or SYS ENG 449</td>
<td>Network-Centric Systems Reliability and Security</td>
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</tbody>
</table>

Elective Courses

(Select two courses from the following)

Communications Engineering

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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>COMP ENG 317</td>
<td>Fault-Tolerant Digital Systems</td>
</tr>
<tr>
<td>COMP ENG 319</td>
<td>Digital Network Design</td>
</tr>
<tr>
<td>COMP ENG 349</td>
<td>Trustworthy, Survivable Computer Networks</td>
</tr>
<tr>
<td>COMP ENG 348</td>
<td>Wireless Networks</td>
</tr>
<tr>
<td>COMP ENG 448</td>
<td>High Speed Networks</td>
</tr>
<tr>
<td>COMP ENG 401</td>
<td>Special Topics</td>
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<tr>
<td>or SYS ENG 401</td>
<td>Special Topics</td>
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<tr>
<td>CS 483</td>
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<tr>
<td>CS 486</td>
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</table>

Smart Engineering Systems Modeling

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>SYS ENG 433</td>
<td>Distributed Systems Modeling</td>
</tr>
<tr>
<td>SYS ENG 479</td>
<td>Smart Engineering System Design</td>
</tr>
<tr>
<td>SYS ENG 478</td>
<td>Advanced Neural Networks</td>
</tr>
</tbody>
</table>

This program is designed to appeal to working professionals.

Additional Information

Additional information about departmental emphasis areas, requirements, graduate handbook, faculty, research opportunities, financial aid, and facilities can be found by visiting the department's web page at http://eec.mst.edu. We can be contacted by telephone at (573) 341-4519 or email at eec@mst.edu. For information about the Engineering Education Center in St. Louis, visit their web page at http://eec.mst.edu.

Levent Acar, Associate Professor
PHD Ohio State University
Control and systems, intelligent control with applications to robotics, neural network and fuzzy logic systems, large-scale systems and optimization.

Daryl G Beetner, Professor
DSC Washington University
Computer Engineering, parallel processing, hardware-software co-design, skin cancer detection, and electro-cardiology. Interests in electro-cardiology include body-surface mapping, the inverse problem, and risk-assessment.

Minsu Choi, Associate Professor
PHD Oklahoma State University
Computer architecture & VLSI, embedded systems, fault tolerance, testing, quality assurance, reliability modeling & analysis, configurable computing, distributed systems, dependable instrumentation & measurement.

Cihan H Dagli, Professor
PHD University of Birmingham, UK

James L Drewniak, Curators Professor
PHD U. of Illinois at Urbana-Champ
Director of Materials Research Center. Electromagnetic compatibility of high-speed digital electronics, power electronics and electric Machinery; numerical electromagnetic analysis; electronic packaging.

Jun Fan, Associate Professor
PHD University Of Missouri-Rolla
Intra-system electromagnetic compatibility, Radio-Frequency interference, signal/power integrity, high-speed printed circuit boards and packages.

Steven Leslie Grant, Associate Professor
PHD Rutgers State Univ-Coll Of Eng
Telecommunications and signal processing.

Kurt Louis Kosbar, Associate Professor
PHD Univ. of Southern California
Statistical communication theory, spread spectrum systems, computer aided design of communication systems, stochastic process theory, digital signal processing.

Robert G Landers, Professor
PHD University Of Michigan Ann Arb
Manufacturing, systems, and control; modeling, analysis, monitoring, and control of manufacturing processes; metal cutting processes; laser metal deposition; friction stir welding; freeze extrosion fabrication; integrated design and control; control of alternative energy systems; digital control applications.

Bruce M McMillin, Professor
PHD Michigan State University

Randy Hays Moss, Professor
PHD University Of Illinois Urbana-
Machine vision systems including industrial (vision systems for robots) and medical (computer assisted diagnosis) applications, pattern recognition, image processing, digital systems, analog and digital circuits.

Jagannathan Sarangapani, Professor
PHD University of Texas-Arlington
The control of computer/communication networks, embedded systems, MEMS, intelligent systems/control, diagnostics/prognostics, biomedical applications.

Sahra Sedighresarvestani, Associate Professor
PHD Purdue Univ. - W. Lafayette
Component-based software engineering and enterprise integration.

Yiyu Shi, Assistant Professor
PHD University Of California-Los A
VLSI Design Automation, 3D, ICs, and Renewable Energy.

Ronald Joe Stanley, Associate Professor
PHD University Of MO-Columbia
Image processing, pattern recognition software methods, automation and medical informatics.

Ganesh Kumar Venayagamoorthy, Adjunct Professor
PHD Univ of Natal, Durban

Steve E Watkins, Professor
PHD University Of Texas at Austin
Fiber optic sensing, optical and electronic materials, electro-optic devices and Fourier optics.

Cheng Hsiao Wu, Professor
PHD University Of Rochester
Quantum resistor network theory, semiconductor device modeling. DLTS measurement, optical computing.

Donald C Wunsch II, Professor
PHD University Of Washington
Adaptive critic designs, neural networks, fuzzy systems, surety, nonlinear adaptive control, intelligent agents, applications, financial engineering.

Maciej J Zawodniok, Assistant Professor
PHD University of Missouri-Rolla
Embedded systems for cyber infrastructure, wireless sensor and ad hoc networks, and general wireless communications systems.

Graduate Certificates via Distance Education

Graduate certificate programs give students the opportunity to increase their knowledge in specific areas of interest. These courses provide students with the latest knowledge and skills in strategic areas of computing and are presented by Missouri S&T faculty members that are experts in their fields. Most of the courses will be offered through distance education over the internet. Distance education courses use streaming internet video for course delivery. In this setting, students actively participate in classes through viewing the class on their computer while being interactively connected with the class by telephone. Lectures are archived so they may be reviewed at any time during the semester. Instructors are available outside of class time by e-mail and telephone. Where there is sufficient interest, some courses may be taught by traditional instruction methods at Missouri S&T off site locations such as Ft. Leonard Wood, St. Louis, and Springfield, MO.

Software Design and Development Certificate

The Software Design and Development Certificate provides an attractive option for the working professional to expand their experience in Software Engineering. The core of four classes gives a treatment of software project management in its many roles, from overall project management and process improvement to the management of individual lifecycle components, including software deployment and evolution. Specialized coursework gives depth in advanced object-oriented design, requirements, software quality, testing theory and practice, and an advanced treatment of software metrics.

Information Systems & Cloud Computing Certificate

The Information Systems & Cloud Computing certificate is tailored to the working professional who wants to expand their knowledge of advanced data management technologies. Data mining and knowledge discovery, heterogeneous and mobile databases and cloud computing form the core of the study.

Wireless Networks and Mobile Systems Certificate

The Wireless Networks and Mobile Systems Certificate is designed to provide students an intensive treatment in wireless systems and applications. Coverage includes network architecture and protocols, security and privacy wireless network provisioning and deployment, location and mobility management applications, heterogeneous and mobile databases, and pervasive computing.

Computational Intelligence Certificate

This graduate certificate program provides practicing engineers the opportunity to develop the necessary skills in the use and development of computational intelligence algorithms based on evolutionary computation, neural networks, fuzzy logic, and complex systems theory. Engineers can also learn how to integrate common sense reasoning with computational intelligence elective courses such as data mining and knowledge discovery.
Degree Programs

Systems and Software Architecture Certificate
The systems and software architect fills a critical role in today’s development process, transforming market inputs into the requirements and architecture specification of a product that independent (often remote) development teams can implement. Requests from industrial partners have led to a focused graduate certificate training program.

Information Assurance & Security Officer Essentials
Protecting information systems is key to protecting the nation’s critical infrastructures. Only through diligence and a well-trained workforce will we be able to adequately defend the nation’s vital information resources. Missouri S&T’s certificate is Certified by the National Security Agency (NSA) Committee on National Security Systems (CNSS) for National Standards 4011 (National Training Standard for Information Systems Security (INFOSEC) Professionals) and 4014E (Information Assurance Training Standard for Information Systems Security Officers (ISSO)).

Financial Assistance
Financial assistance is available to graduate students in the form of research assistantships, teaching assistantships, and fellowships. Applications for CS assistantships can be found on the department’s web page or by contacting the department directly (see below). In addition, research opportunities for advanced students exist in the department and in the Missouri S&T Intelligent Systems Center as well as other research labs on campus.

Additional Information
Additional information about department emphasis areas, requirements, faculty, labs, and research opportunities can be found at http://cs.mst.edu or email csgradcoord@mst.edu or phone at (573) 341-4491. More information about distance education can be obtained from http://dce.mst.edu.

Admissions Requirements
In addition to those requirements stated in the section of this catalog devoted to Admission and Program Procedures, the Computer Science Department has additional requirements for each of its degree areas.

M.S. in Computer Science (thesis or non-thesis)
A minimum GRE verbal score of 370/144 and for those whom English is not their native language, a TOEFL score of 570/230/89. Minimum GRE Quantitative Score >= 700/155. Written score >= 4.0.

An undergraduate GPA of 3.0/4.0 or better over the last 2 years or successful completion of 12 graduate hours in Computer Science as a “conditional” graduate student at Missouri S&T, with at least a 3.0 GPA, as per graduate requirements.

Applicants are expected to have strong mathematical skills, competency in a modern programming language, and knowledge of the following computer science core subjects:

- Algorithms and Data Structures
- Discrete Mathematics
- Operating Systems

The department offers a Distance M.S. Degree Program via the Internet. (Admissions and degree requirements are the same as the regular M.S. program.)

M.S. in Computer Science
M.S. in computer science (thesis and non-thesis) is a 31 credit hour program. M.S. students are required to take and pass the graduate seminar course COMP SCI 410.

Ph.D. in Computer Science
Application is made to the Missouri S&T admissions office along with the required transcripts, etc. Applicants who do not have a graduate degree will normally request admission to the M.S. program first but, outstanding applications will be admitted directly into the Ph.D. program. Applicants must submit a letter outlining tentative research interests and career goals along with GRE verbal, quantitative, and analytical test scores.

Requirements for the Ph.D. in Computer Science include: Qualifier examination over graduate-level courses in core areas, Research Readiness presentation based on survey of current Computer Science Literature or research publications, Comprehensive examination, and Dissertation and Defense reporting the results of original research which meets the standards of current disciplinary journal-quality research publications. In addition, Ph.D. students are required to take and pass the graduate seminar course COMP SCI 410 for three semesters in their Ph.D. studies.

The Ph.D. program is under the guidance of an advisory committee which is appointed no later than the semester following passage of the qualifying exam.

Sriram Chellappan, Assistant Professor
PHD The Ohio State University

Maggie Xiaoyan Cheng, Associate Professor
PHD Univ Of Minnesota Twin Cities
Wireless Networks.

Fikret Ercal, Professor
PHD The Ohio State University
Parallel Algorithms, Bioinformatics and Computer Vision.

Alireza Hurson, Professor
PHD University Of Central Florida
Department Chair, Parallel and Distributed Systems, Databases, Multi-Databases, Global Information Processing, Mobile Databases, Pervasive and Ubiquitous computing.

Wei Jiang, Assistant Professor
PHD Purdue University Main Campus
Privacy and Security.

Marouane Kessentini, Assistant Professor
PHD University of Montreal

- Database and File Structures
- Discrete Mathematics
- Operating Systems

**Jennifer Lynn Leopold**, Associate Professor
PHD University Of Kansas Main Camp
Database Design and Analysis, Scientific Visualization, Data Mining, Morphological, Phylogenetic, and Biodiversity.

**Dan Lin**, Assistant Professor
PHD National University of Singapore
Database Systems and Information Security.

**Xiaoqing Frank Liu**, Professor
PHD Texas A&M University
Software Engineering, Database Systems, and Intelligent Systems.

**Sanjay Kumar Madria**, Professor
PHD Indian Inst of Tech., India

**Bruce M McMillin**, Professor
PHD Michigan State University

**Robert L. Paige**, Associate Professor
PHD Colorado State University
Saddlepoint approximations, non-parametric methods, biostatistics.

**Chaman L Sabharwal**, Professor
PHD University Of Illinois Urbana
Graphics, Vision and Parallel algorithms.

**Sahra Sedighsarvestani**, Associate Professor
PHD Purdue Univ. - W. Lafayette
Embedded Systems: Environmental and Structural Monitoring; Wireless Sensor Networks; Dependability of Critical Infrastructures; System and Information Quality Assurance.

**Daniel R. Tauritz**, Associate Professor
PHD Leiden University
Evolutionary Computing, Artificial Intelligence, and Cyber-Security.

**Donald C Wunsch II**, Professor
PHD University Of Washington
Adaptive critic designs, neural networks, fuzzy systems, surety, nonlinear adaptive control, intelligent agents, applications.

**Zhaozheng Yin**, Assistant Professor
PHD Pennsylvania State University
Computer Vision, Biomedical Imaging, Machine Learning, Signal Processing, and Robotics.

**Economics**

The Department of Economics has entered into a cooperative agreement with the Department of Economics of the University of Missouri-St. Louis to offer a Master of Arts in Economics. A maximum of 12 graduate semester hours may be taken at Missouri S&T (with no more than 9 credit hours at the 300 level).

**Gregory Gelles**, Professor
PHD West Virginia University

**Electrical Engineering**

The mission of the Electrical Engineering Program, consistent with the Missouri S&T campus mission statements, is the education of students to fully prepare them to provide leadership in the recognition and solution of society’s problems in the area of Electrical Engineering.

The Electrical Engineering program in the Department of Electrical and Computer Engineering offers graduate programs of study which lead to the M.S. degree (thesis and non-thesis options), the Ph.D. degree and the doctor of engineering degree. Both the Rolla campus and the Engineering Education Center in St. Louis offer M.S. programs. Most graduate programs in Electrical Engineering normally include some specialization in one or more of the following six emphasis areas of Electrical Engineering.

**Emphasis Areas**

**Circuits**

Topics include network analysis and synthesis, computer-aided circuit design, communications circuits and linear and nonlinear electronic circuits.

**Electronics**

Topics include circuits and networks containing active devices. Typical applications might include radio frequency amplifiers, oscillators, active filters, and others. These circuits and networks can be either digital or analog in nature.

**Communications-Signal Processing**

Topics include signal design, coding, modulation, detection, and filtering for both analog and digital systems.

**Computer Engineering**

Computer engineering can be an emphasis area in electrical engineering or a separate degree. See the section on computer engineering for emphasis areas in computer engineering.

**Controls**

Our technological demands today impose extremely challenging and widely varying control problems. These problems include control of aircraft, space and underwater vehicles, automobiles, chemical processes, manufacturing, robotics, environmental systems, and smart structural systems. Control systems engineering studies will emphasize linear and nonlinear systems, digital control, process control system simulation, optimal control and estimation, robust control, neural networks and fuzzy logic based control systems, and control of smart structures.

**Electromagnetics**

Electromagnetics, devices, and optics constitute a single emphasis area in the Electrical and Computer Engineering Department. Electromagnetic topics include the generation, propagation, and detection of electromagnetic fields and waves. In addition to the intentional generation of electromagnetic waves, unintentional electromagnetic radiation can occur. This unintentional radiation often accompanies the operation of high-speed digital electronic circuits. Electromagnetic compatibility is concerned with the removal or reduction of these unintentional and undesirable effects. The devices portion of this area is
concerned with modeling and development of new electronic components as well as the characterization and growth of semiconductor materials. Optical topics include applications of fiber optics, optical processing, optical computing, and smart sensing. Fiber optic telecommunications encompass waveguides, photonic sources and detectors, and modulation and control techniques. Smart sensing deals with physical measurements in structures using integral optical devices. Signals at microwave and millimeter wave frequencies can be effectively used for nondestructive testing (MDT), evaluation (NDE) and inspection (NDI) of a variety of materials ranging from low loss dielectric composites for material property and interior flaw determination to highly conducting materials such as metals for surface cracks detection. High spatial resolution microwave images of composite materials can also be produced when operating in the near-field region of a radiator.

Power

Power studies include application of computer methods to power system analysis and control, power system relaying and protection, power quality load management, finite inertia power systems (such as those on ships, hybrid electric vehicles, and spacecraft), and electromechanical energy conversion devices (such as rotating machinery, power electronic converters, and electric drive systems).

Departmental Requirements

Admission Requirements

The nominal GPA requirement for admission to the M.S. degree program in this department is an undergraduate GPA of 3.2 on a 4.0 GPA system. In evaluating the academic performance from universities that may use other grading systems, the department may rely upon statistical data gathered in analyzing academic outcomes for recent graduate students to the extent that such statistical data is available. The department will not offer graduate admissions to students who do not have the equivalent of a four year baccalaureate degree in engineering. As an example we cannot accept students who have only a diploma or engineering technology degree.

In addition to campus requirements that the sum of GRE-V and GRE-Q be at least 1100 and that the GRE-WR score be at least 4.0, the ECE department recommends a minimum GRE-Q score of 730 and recommends a minimum GRE-WR score of at least 4.5. Applicants who have taken the GRE-A instead of the GRE-WR, a GRE-A score of at least 640 is recommended by the department.

For international students who are required to provide TOEFL scores, this department has no particular preference for the computer based TOEFL, the internet based TOEFL, or the paper based TOEFL. Minimum recommended scores set by the department are 237 on the computer based TOEFL, 580 on the paper based TOEFL, and 92 on the IBT (internet based testing) version of the TOEFL exam is 92. The recommended IELTS score is a minimum of 6.5.

Students applying for graduate studies in this department on the basis of degrees in closely related fields may have additional conditions placed on their admission. These conditions are generally imposed to make sure that students lacking a traditional computer engineering degree will have sufficient background to ensure a reasonable chance for academic success.

Students seeking admission to the Ph.D. program should meet or exceed all of the above recommendations and should have a graduate GPA of 3.5 or better. All Ph.D. applicants must provide at least three letters of recommendation. Exceptional applicants may apply directly to the Ph.D. program after completing the baccalaureate degree.

Program Requirements

Additional departmental requirements beyond those stated in the section on Admission and Program Procedures are as follows. Thesis option M.S. programs of study, as listed on graduate form I, require a minimum of 21 credit hours of course work exclusive of credit hours earned for thesis research (courses numbered 490). A limited number credit hours for 200 level courses may be counted towards the fulfillment of a M.S. program of study (graduate form I) provided that the courses are taken outside of the electrical and computer engineering department and that the courses are pre-requisites for at least one 300 or 400 level course also included in the program of study. The doctoral program of study, for the Ph.D. degree or the D.E. degree, should include approximately 90 credit hours beyond the B.S. degree or approximately 60 credit hours beyond the M.S. degree. An M.S. or doctoral student’s advisory committee may impose additional requirements or restrictions as it sees fit.

Ph.D. Language Requirement

As an Electrical Engineering Ph.D. student, you are not required to satisfy a language requirement. However, you may have language requirements included in your plan of study if your advisory committee feels that this inclusion would be useful or necessary for your research.

Research

Significant research, suitable for publication, is expected for students pursuing the thesis option M.S. or a doctoral degree. The student should work closely with their major advisor and their advisory committee to determine when these expectations are met. The length of research time and/or the number credit hours earned for thesis research will not automatically satisfy this requirement.

Graduate Certificates

Electrical Machine and Drives

This graduate certificate program is designed to provide specialized graduate level education in the area of Electric Machine and Drives.

Admission

The Electric Machine and Drives Program is open to all persons holding a B.S. degree in any field of engineering from an ABET accredited undergraduate program and having a minimum of 24 months of post B.S. professional work experience that would normally require an engineering degree or a degree in a closely related technical field such as Physics or Mathematics. The minimum overall GPA in the B.S. degree program should be at least 2.5.

Once admitted to the program, the student must take four designated courses as given below. In order to receive a graduate certificate, the student must have an average graduate grade point average of 3.0 or better in the certificate courses taken.

Students admitted to the certificate program will have non-degree graduate status; however, if they complete the four-course sequence with a grade of B or better in each of the courses taken, they will be admitted to the M.S. program in electrical engineering if they apply. The Certificate courses taken by students admitted to the M.S. program will count towards their master’s degrees. Students who do not have all of the prerequisite courses necessary to take the courses in the certificate
program will be allowed to take "bridge" courses at either the graduate or undergraduate level to prepare for the formal certificate courses.

Once admitted to the program, a student will be given three years to complete the program so long as he/she maintains a B average in the courses taken.

**Curriculum**

The following two courses must be taken:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELEC ENG 305</td>
<td>Electric Drive Systems</td>
</tr>
<tr>
<td>ELEC ENG 402</td>
<td>Advanced Theory Of Electric Machines</td>
</tr>
</tbody>
</table>

A minimum of two of the following electric power systems courses must be taken:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELEC ENG 304</td>
<td>Electric Power Quality</td>
</tr>
<tr>
<td>ELEC ENG 331</td>
<td>Digital Control</td>
</tr>
<tr>
<td>ELEC ENG 353</td>
<td>Power Electronics</td>
</tr>
<tr>
<td>ELEC ENG 371</td>
<td>Interference Control in Electronic Systems</td>
</tr>
<tr>
<td>ELEC ENG 401</td>
<td>Special Topics</td>
</tr>
<tr>
<td>ELEC ENG 406</td>
<td>Power System Stability</td>
</tr>
<tr>
<td>ELEC ENG 431</td>
<td>Linear Control Systems</td>
</tr>
</tbody>
</table>

Other courses approved by the electric machines and drives faculty may be substituted for any of the above listed courses on a case-by-case basis. The department’s Associate Chair for Graduate Affairs must approve the substitution prior to enrolling in the course.

**Administrative Coordinator**

Dr. James L. Drewniak,
Associate Chair for Graduate Affairs
Department of Electrical and Computer Engineering

**Technical Coordinator**

Dr. Badrul Chowdhury

**Contributing Faculty**

Dr. Levent Acar, Dr. Badrul Chowdhury, Dr. Keith Cozine, Dr. Mariesa Crow, and Dr. Mehdi Ferdows.

**Electrical Power Systems Engineering**

This graduate certificate program is designed to provide specialized graduate level education in the area of Electric Power Systems Engineering.

**Admission**

The Electrical Power Systems Engineering Program is open to all persons holding a B.S. degree in any field of engineering from an ABET accredited undergraduate program and having a minimum of 24 months of post B.S. professional work experience that would normally require an engineering degree or a degree in a closely related technical field such as Physics or Mathematics. The minimum overall GPA in the B.S. degree program should be at least 2.5.

Once admitted to the program, the student must take four designated courses as given below. In order to receive a Graduate Certificate, the student must have an average graduate grade point average of 3.0 or better in the certificate courses taken.

Students admitted to the Certificate program will have non-degree graduate status; however, if they complete the four-course sequence with a grade of B or better in each of the courses taken, they will be admitted to the M.S. program in electrical engineering if they apply. The certificate courses taken by students admitted to the M.S. program will count towards their master’s degrees. Students who do not have all of the prerequisite courses necessary to take the courses in the Certificate program will be allowed to take “bridge” courses at either the graduate or undergraduate level to prepare for the formal certificate courses.

Once admitted to the program, a student will be given three years to complete the program so long as he/she maintains a B average in the courses taken.

**Curriculum**

The following two electric power systems courses must be taken:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELEC ENG 304</td>
<td>Electric Power Quality</td>
</tr>
<tr>
<td>ELEC ENG 307</td>
<td>Power Systems Engineering</td>
</tr>
</tbody>
</table>

A minimum of two of the following electric power systems courses must be taken:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELEC ENG 302</td>
<td>Extra High Voltage Engineering</td>
</tr>
<tr>
<td>ELEC ENG 304</td>
<td>Electric Power Quality</td>
</tr>
<tr>
<td>ELEC ENG 352</td>
<td>Photovoltaic Systems Engineering</td>
</tr>
<tr>
<td>ELEC ENG 404</td>
<td>Power System Operations</td>
</tr>
<tr>
<td>ELEC ENG 405</td>
<td>Power System Protection</td>
</tr>
<tr>
<td>ELEC ENG 406</td>
<td>Power System Stability</td>
</tr>
<tr>
<td>ELEC ENG 407</td>
<td>Surge Phenomena In Power Systems</td>
</tr>
<tr>
<td>ELEC ENG 408</td>
<td>Computer Methods In Power System Analysis</td>
</tr>
<tr>
<td>ELEC ENG 431</td>
<td>Linear Control Systems</td>
</tr>
</tbody>
</table>

Other courses approved by the electric power systems faculty may be substituted for any of the above listed courses on a case-by-case basis. The department’s Associate Chair for Graduate Affairs must approve the substitution prior to enrolling in the course.

**Administrative Coordinator**

Dr. James L. Drewniak
Associate Chair for Graduate Affairs
Department of Electrical and Computer Engineering

Technical Coordinator
Dr. Badrul Chowdhury

Contributing Faculty
Dr. Levent Acar, Dr. Badrul Chowdhury, Dr. Keith Cozine, Dr. Norman Cos, Dr. Mariesa Crow, and Dr. Mehdi Ferdowsi.

Additional Information
Additional information about departmental emphasis areas, requirements, graduate handbook, faculty, research opportunities, financial aid, and facilities can be found by visiting the department’s web page at http://eec.mst.edu. We can be contacted by telephone at (573) 341-4519 or e-mail eec@mst.edu. For information about the Engineering Education Center in St. Louis, visit their web page at http://eec.mst.edu.

Levent Acar, Associate Professor
PHD Ohio State University
Control and systems, intelligent control with applications to robotics, neural network and fuzzy logic systems, large-scale systems and optimization.

Daryl G Beetner, Professor
DSC Washington University
Computer Engineering, parallel processing, hardware-software co-design, skin cancer detection, and electro-cardiology. Interests in electro-cardiology include body-surface mapping, the inverse problem, and risk-assessment.

Minsu Choi, Associate Professor
PHD Oklahoma State University
Computer architecture & VLSI, embedded systems, fault tolerance, testing, quality assurance, reliability modeling & analysis, configurable computing, distributed systems, dependable instrumentation & measurement.

Badrul H Chowdhury, Adjunct Professor
PHD Virginia Polytechnic Institute
Power System analysis and control, artificial intelligence and neural network applications, power electronics, power quality quality-integration of photovoltaic and wind power sources.

Keith A. Corzine, Adjunct Professor
PHD University Of Missouri-Rolla
Power electronics, motor drives, Naval ship propulsion systems, and electric machinery analysis.

Mariesa L Crow, Professor
PHD University Of Illinois Urbana
Fred Finley Distinguished Professor. Power systems analysis, dynamic stability, computational algorithms, and power electronics.

Kristen Marie Donnell Hilgedick, Assistant Professor
PHD University Of Missouri-Rolla

James L Drewniak, Curators Professor
PHD U. of Illinois at Urbana-Champ

Director of Materials Research Center. Electromagnetic compatibility of high-speed digital electronics, power electronics and electric Machinery; numerical electromagnetic analysis; electronic packaging.

Richard E Dubroff, Professor
PHD University Of Illinois Urbana
Electromagnetics, wave propagation, signal processing, acoustics, geophysics.

Kelvin Todd Erickson, Professor
PHD Iowa State University
Department Chair. Chemical process control, advanced control algorithms, digital control, programmable logic controllers, system identification.

Jun Fan, Associate Professor
PHD University Of Missouri-Rolla
Intra-system electromagnetic compatibility, Radio-Frequency interference, signal/power integrity, high-speed printed circuit boards and packages.

Mehdi Ferdowsi, Associate Professor
PHD Illinois Inst. of Tech. (IIT)
Power electronics, power converters and electric drives.

Steven Leslie Grant, Associate Professor
PHD Rutgers State Univ-Coll Of Eng
Telecommunications and signal processing.

Chang-Soo Kim, Associate Professor
PHD Kyungpook National University
Micro-and nano-sensors, bio-MEMS (Micro Electro Mechanical System), engineering of electrogenic (neural and cardiac) cells, single cell analysis.

Jonathan William Kimball, Assistant Professor
PHD University Of Illinois Urbana
Power electronics, energy harvesting, alternative energy, multi-phase converters.

Marina Yurjevna Koledintseva, Research Associate Professor
PHD Moscow Power Eng. Inst. -TU

Kurt Louis Kosbar, Associate Professor
PHD Univ. of Southern California
Statistical communication theory, spread spectrum systems, computer aided design of communication systems, stochastic process theory, digital signal processing.

Robert G Landers, Professor
PHD University Of Michigan Ann Arb
Manufacturing, systems, and control; modeling, analysis, monitoring, and control of manufacturing processes; metal cutting processes; laser metal deposition; friction stir welding; freeze extrusion fabrication; integrated design and control; control of alternative energy systems; digital control applications.

Charles Farrell Landy, Adjunct Professor
PHD Univ of the Witwatersrand

Randy Hays Moss, Professor
PHD University Of Illinois Urbana-
Machine vision systems including industrial (vision systems for robots) and medical (computer assisted diagnosis) applications, pattern recognition, image processing, digital systems, analog and digital circuits.

**David Pommerenke**, Professor  
PHD Technical University Berlin  
Electromagnetic compatibility with emphasis on measurement techniques and the application of numerical methods and the application of FR methods to high voltage problems.

**Maciej J Zawodniok**, Assistant Professor  
PHD University of Missouri-Rolla  
Environments, optical spectroscopy, and machine vision.

**Von L Richards**, Professor  
PHD University Of Michigan Ann Arbor  
Metal casting, mold materials, property enhancement of cast alloys.

**Jagannathan Sarangapani**, Professor  
PHD University of Texas-Arlington  
The control of computer/ communication networks, embedded systems, MEMS, intelligent systems/control, diagnostics/prognostics, biomedical applications.

**Sahra Sedighsarvestani**, Associate Professor  
PHD Purdue Univ. - W. Lafayette  
Component-based software engineering and enterprise integration.

**Yiyu Shi**, Assistant Professor  
PHD University Of California-Los A  
VLSI Design Automation, 3D, ICs, and Renewable Energy.

**Ronald Joe Stanley**, Associate Professor  
PHD University Of MO-Columbia  
Image processing, pattern recognition software methods, automation and medical informatics.

**Ganesh Kumar Venayagamoorthy**, Adjunct Professor  
PHD Univ of Natal, Durban  
Component-based software engineering and enterprise integration.

**Steve E Watkins**, Professor  
PHD University Of Texas at Austin  
Fiber optic sensing, optical and electronic materials, electro-optic devices and Fourier optics.

**Cheng Hsiao Wu**, Professor  
PHD University Of Rochester  
Quantum resistor network theory, semiconductor device modeling, DLTS measurement, optical computing.

**Donald C Wunsch II**, Professor  
PHD University Of Washington  
Adaptive critic designs, neural networks, fuzzy systems, surety, nonlinear adaptive control, intelligent agents, applications, financial engineering.

**Chengshan Xiao**, Professor  
PHD University of Sydney,Australia  
Wireless Communications, Information Theory, Signal Processing, and Underwater Acoustic Communications.

**Hai Xiao**, Professor  
PHD Virginia Polytechnic Institute  
Novel photonic device design and fabrication, nanomaterials and nanostructures for chemical and biological sensing, sensors for harsh environments, optical spectroscopy, and machine vision.

**Maciej J Zawodniok**, Assistant Professor  
PHD University of Missouri-Rolla  
Embedded systems for cyber infrastructure, wireless sensor and ad hoc networks, and general wireless communications systems.

**Yahong Rosa Zheng**, Associate Professor  
PHD Carleton University  
Wireless communication systems, wireless ad hoc/sensor networks, array signal processing, and real time digital signal processing.

**Reza Zoughi**, Professor  
PHD University Of Kansas Main Camp  
Electromagnetics, Microwave Engineering, and Microwave and millimeter wave nondestructive evaluation.

## Engineering Management

Engineering management is the art and science of planning, organizing, allocating resources, and directing and controlling activities. The field of Engineering Management has become recognized as a professional discipline with a critical role in the modern society. Graduates develop innovative and integrated solutions to problems that arise at the convergence of engineering and business.

Graduate programs leading to the M.S. and Ph.D. degrees are offered in Engineering Management. The discipline involves designing, operating and continuously improving systems by integrating engineering and management knowledge. This integration starts with an awareness of customer needs and market conditions. It then seeks to optimize the use of people, equipment, money and information to achieve desired objectives. The discipline also seeks to develop students into individuals with leadership potential who can achieve high quality results in an ethical manner and with respect for the environment. The major goal of entering students is to enhance the usefulness of their previously acquired technical background. This is accomplished through coursework and research designed to expand knowledge of the management and operation of organizations in today’s competitive environment. This broader understanding is further enhanced with the opportunity to acquire specialized knowledge in many areas that exist at the interface between the classical engineering and management disciplines.

The Engineering Management Department has produced over 6200 graduates at the B.S., M.S., and Ph.D. level since its inception in 1968. The Engineering Management & Systems Engineering Department is one of only a few institutions in the world that offers B.S., M.S., and Ph.D. degrees in Engineering Management. The B.S. in Engineering Management is fully ABET accredited and the M.S. in Engineering Management has been certified by the American Society of Engineering Management. Graduates have been successful in working at the intersection of technology, engineering, and management to produce outstanding results.

## Criteria for Admission

Admission to the graduate program is limited to applicants with a B.S. degree in engineering or a physical science. Applicants are required to submit the Graduate Record Examination (GRE) scores for admission evaluation. Applicants whose native language is not English are also required to take the Test of English as a Foreign Language (TOEFL) regardless of prior academic experience or place of study. Applicants must have completed undergraduate coursework in engineering economy and engineering statistics; if lacking, these may be satisfied with credit toward the graduate degree through courses at Missouri S&T or
Requirements for Completion

Students following their approved program of study will be assured of graduation upon maintenance of good academic standing. A minimum of 30 units of course work from the areas listed below must be completed with a cumulative grade point average of 3.00 (on a 4.00 scale) and a C grade or better in each course. Accumulation of more than 10 hours of “C” or “F” results in dismissal from the program. A maximum of nine hours of course work for M.S. degrees may be transferred from universities outside the University of Missouri System. Such credits for transfer must have been registered as graduate courses when they were taken. All courses applied to the degree require prior written advisor approval recorded on the study plan in the student’s file. It is the responsibility of each student to apply for graduation with the Missouri S&T Registrar’s Office during his or her last semester. Assistance on this final step can be provided by the Engineering Management & Systems Engineering Department. More details about requirements can be found in the university catalog, and are available from the Engineering Management Graduate Office.

Graduate Certificate Programs

This program is designed to appeal to working professionals. Certificate courses taken for graduate credit will apply to the M.S. degree once accepted into the M.S. degree. If the four-course sequence is completed with a grade of “B” or better in each of the courses taken, they can be admitted to the MS Program in Engineering Management. The certificate program may be followed by six additional 3 credit courses to complete the MS degree. The certificate program is open to all persons holding a B.S., M.S., or Ph.D. degree in engineering or a physical science and who have a minimum of 12 months of professional employment experience or are currently accepted into a graduate degree program at MST.

Once admitted to the program, the student must take the four designated courses as given below. In order to receive a Graduate Certificate, the student must have an average cumulative grade point of 3.0 or better in the certificate courses.

Engineering Management

The Engineering Management Certificate Program aims to provide individuals with a core body of Engineering Management knowledge that includes key technical management concepts, processes, and methods for individuals preparing to transition from individual technical contributors to managers of complex technological projects.

The certificate program coverage includes planning, organizing, allocating resources, and directing and controlling technical projects and people in technical jobs. Students will be responsible for prerequisite knowledge as determined by course instructors.

| ENG MGT 314 Management for Engineers and Scientists |
| ENG MGT 361 Project Management |
| ENG MGT 365 Operations Management Science |
| ENG MGT 452 Advanced Financial Management |

Financial Engineering

The Financial Engineering Certificate Program aims to equip students with a set of tools that will help them meet the standards of the Global Association of Risk Professionals (GARP) and the Professional Risk Managers’ International Association (PRMIA) certifications. While being separate organizations, both GARP and PRMIA have become the standards in financial engineering and financial risk management, due to their similar knowledge of requirements for certification.

Certificate topics will help prepare students to take the GARP Financial Risk Managers (FRM) exam and/or the PRMIA Professional Risk Managers (PRM) exam. Both exams are set around topics in financial theory, financial markets and financial instruments, market risk measures, quantitative analysis, mathematical foundations of risk management, financial derivatives for risk reduction, risk management best practices, operational risk, market risk, credit risk, case studies, ethics, and governance. The certificate courses will provide a strong foundation in these areas.

Students will be responsible for prerequisite knowledge as determined by course instructors and are expected to have taken ENG MGT 308 Economic Decision Analysis, ENG MGT 452 Advanced Financial Management, or an equivalent introduction to finance and/or engineering economics course, as a prerequisite to the certificate program.

| ENG MGT 408 Financial Risk Management |
| ENG MGT 480 Investment |
| ENG MGT 481 Financial Engineering |
| ENG MGT 482 Financial Engineering II |

Human Systems Integration (HSI)

This certificate will prepare students to have a significant impact on complex tasks involving humans. In our increased threat environment, the consequences of HSI failures will become even more critical. We can no longer afford to have a token human factors specialist added to teams addressing complex military issues. A more effective comprehensive approach is to broadly educate military personnel and defense contractors and others in HSI. An increased understanding of human performance will allow for improved performance across the areas of interest which will be gained from this certificate and will result in improved survivability in response to disasters and catastrophes.

The Human Systems Integration Certificate program consists of four of five courses. Students will be responsible for prerequisite knowledge as determined by course instructors. With the prior approval of the department, appropriate courses may be substituted for a certificate course if that course is not available.

| ENG MGT 311 Human Factors |
| ENG MGT 411 Human Systems Integration |
| IS&T 385 Human Computer Interaction |
| Select one of the following: |
| ENG MGT 386 Safety Engineering Management |
| IS&T 387 Human-Computer Interaction Evaluation |

Leadership in Engineering Organizations

The Leadership in Engineering Organizations Certificate Program aims to equip students with a set of tools that will allow them to become effective leaders of groups, programs, and departments engaged in engineering and technology work. Specifically, this certificate program will enable graduates to:

- Understand the technical leadership roles in engineering organizations
- Understand and develop a personal leadership style
• Develop the skill to critically analyze, evaluate, improve, or adapt existing technical and/or managerial systems
• Organize and lead complex projects, groups, and organizations
Students will be responsible for prerequisite knowledge as determined by course instructors.

ENG MGT 313 Managerial Decision Making
ENG MGT 418 Leadership for Engineers
PSYCH 316 Psychology of Leadership in Organizations
PSYCH 374 Organizational Psychology

Lean Six Sigma
This certificate program offers an opportunity for professionals to expand their knowledge in Lean Six Sigma through a flexible graduate education program. The certificate provides a solid foundation of Lean Six Sigma methods and practices that can be immediately applied to process improvement projects in the workplace. The certificate consists of four courses designed to prepare professionals for variation and waste reduction projects and provide a sound statistical background.

The Lean Six Sigma Certificate Program consists of four of the five courses below, which are delivered as part of our regular master's degree programs in Engineering Management. Students will be responsible for prerequisite knowledge determined by course instructors.

ENG MGT 309 Six Sigma
ENG MGT 409 Design for Six Sigma
ENG MGT 472 Lean Systems
Select one of the following:
STAT 343 Probability And Statistics
STAT 353 Statistical Data Analysis

Quality Engineering
This certificate program will prepare students to contribute to the growing need to quickly design and manufacture high quality, low cost products and services. The course of study begins with a review of the fundamental concepts of total quality management with an emphasis on the Deming Way. This is followed by an examination of statistical process control methodology and associated issues. These first two courses prepare the student to study the Taguchi System of Quality Engineering including product parameter design and tolerance design, as covered in the final two courses.

The Quality Engineering Certificate Program consists of four courses listed below, which are delivered as part of our regular master’s degree programs in Engineering Management. Students will be responsible for prerequisite knowledge as determined by course instructors. With the approval of the department, appropriate courses may be substituted for a certificate course if that course is not available.

ENG MGT 375 Total Quality Management
ENG MGT 385 Statistical Process Control
ENG MGT 475 Quality Engineering
ENG MGT 477 Tolerance Design

Project Management
The Project Management Certificate Program aims to equip students with a set of tools that will allow them to achieve Project Management Institute (PMI) standards in the project management area, to successfully manage projects and human resources, and to analyze, evaluate, and improve systems.

The Certificate Program will consist of four required courses:

ENG MGT 308 Economic Decision Analysis
ENG MGT 361 Project Management
ENG MGT 458 Case Studies in Project Management
ENG MGT 461 Global Project Management

Military Construction Management
(Certificate offered in CE and EMGT disciplines only at the Fort Leonard Wood campus restricted to the Captain’s Career Course)

ENG MGT 313 Managerial Decision Making
ENG MGT 314 Management for Engineers and Scientists
CIV ENG 345 Construction Methods
Select one of the following:
CIV ENG 443 Contract Formulation And Project Delivery Systems
CIV ENG 380 Water Resources And Wastewater Engineering

Departmental Laboratories
The department has several "hands on" laboratories that have both a research and teaching focus. Each of our labs is directed by faculty members that work closely with students to enhance their learning experience. The description below gives a brief introduction that will help you understand the purpose of each lab.

Modeling and Integration Lab (M&IL)
The Modeling and Integration Lab in the Engineering Management and Systems Engineering Department provides research space for faculty and student teams in human performance modeling, safety analysis, operations modeling and simulation, alternative energy vehicles.

The 5,000 square foot, high bay facility enables leading edge research in these important areas.

Smart Engineering Systems Lab (SESL)
The department established the Smart Engineering Systems Lab (SESL) to develop approaches in building complex systems that can adapt in the environments in which they operate. The term "smart" in the context indicates physical systems that can interact with their environment and adapt to changes both in space and time by their ability to manipulate the environment through self-awareness and perceived models of the world based on both quantitative and qualitative information. The emerging fields of artificial neural networks, fuzzy logic, evolutionary programming, chaos, wavelets, fractals, complex systems, and virtual reality provide essential tools for designing such systems.

The focus of the SESL is in developing smart engineering architectures that integrate and/or enhance the current and future technologies necessary for developing smart engineering systems while illustrating the real life applications of these architectures. The smart engineering systems design and operations cut across a diversity of disciplines, namely manufacturing, electrical, computer, and mechanical, biomedical, civil and other related fields such as applied mathematics, cognitive sciences, biology and medicine. Current research topics include data mining, artificial life, evolutionary robotics, internet-based pattern recognition, and systems architecture based on DoDAdF framework.
Capabilities of the developed computational intelligence models are demonstrated physically in the lab through mini autonomous research robots. Visit our website at: http://web.mst.edu/~sesl/index.htm.

**Design Engineering Center (DEC)**

The center is one of the outreach arms of the Engineering Management & Systems Engineering Department. The focus is on research and service activities in support of the educational goals of the department through externally funded projects. Current areas of research include total quality management, concurrent engineering, Taguchi Methods®, quality engineering, the product development process, and design optimization. Additional information about the center and its various activities can be found at http://design.mst.edu/.

**Laboratory for Investment and Financial Engineering**

The goal of the Laboratory for Investment and Financial Engineering is to develop techniques and computational tools for increasing investment and capital return while managing and reducing financial risk. This involves research into stocks and financial derivatives (options, futures, forwards, and swaps), financial risk and uncertainty, financial forecasting, market efficiency and behavioral finance, fundamental and technical analysis, equity valuation, real options, and engineering economics. In cooperation with the Smart Engineering Systems Lab, research in the lab may also involve the use of smart and intelligent systems, such as neural networks, fuzzy logic, genetic and evolutionary algorithms, expert systems, intelligent agents, artificial life, chaos and fractals, and dynamic and complex systems. Data mining, principal component analysis and several other forms of applied statistics are also used. Members of the lab have access to financial data and various financial modeling software packages.

**Additional Information**

For additional information you can call our main department phone at (573) 341-4572 or (800) 441-5218 or you can visit our web page at http://emse.mst.edu/.

**Master of Science**

The M.S. degree program is offered on the Rolla campus and several locations including the Missouri S&T Engineering Education Center in St. Louis, Fort Leonard Wood, and by distance education throughout the United States and selected international locations. Distance course lectures are archived upon completion of the lecture and all lectures are available to students through streaming video during the semester for review. These courses can be reached from anywhere at any time. It is feasible to obtain a Missouri S&T non-thesis M.S. degree regardless of your location.

The M.S. non-thesis program requires completion of at least 10 three-hour courses approved by the academic advisor. The M.S. with thesis option requires thirty credit hours including the thesis. All students are required to take the following:

**Core Courses**

- ENG MGT 314 Management for Engineers and Scientists
- ENG MGT 361 Project Management
- ENG MGT 365 Operations Management Science
- ENG MGT 452 Advanced Financial Management

Students are then encouraged to identify an emphasis area depending on their interests and to choose available courses from the selected area. However, courses can be chosen from more than one emphasis area. Students have the option to take up to two out-of-department elective courses.

Students must submit a typed Form I to the EMSE graduate office by advising week of their first semester. Links to forms are available at: http://emgt.mst.edu/currentstudents/formsdeadlines.html. Thesis students cannot register for Graduate Research (ENG MGT 490) until their Form I is on file. If you take courses that vary from your Form I, you must file a Form I-a. Non-thesis students must take three 400-level courses. Thesis students must take two 400-level courses (in addition to ENG MGT 490). Students must meet all requirements for graduation as specified in the Graduate Catalog for Engineering Management. A graduate student already holding or completing a Master's degree may obtain a second M.S. in Engineering Management by completing at least an additional 24 credits of work.

Some recent Master thesis titles include:

- Impacting Co-Worker Trust Toward Persons with Disabilities
- Intelligent Technical Analysis Using Neural Networks and Fuzzy Logic
- Applying the Six Sigma Methodology to Improve the Admissions Process at Missouri S&T
- Strategic Inventory Allocation for Vehicle Rental Agencies
- Design and Development of an Interactive Web-Integrated Flexible Manufacturing Cell Control System
- Investigations in the Design of Products and Factories for End-of-Life Disassembly
- Warranty Cost Prediction Using Mahalanobis Distance
- Automotive Braking System Simulation and Optimization

**M.S. Admission Standards**

- B.S. in engineering or a physical science
- GPA: Regular status: 3.0 cumulative
- Graduate Record Exam (GRE): All students must submit current GRE scores. Students successfully completing one of the department’s graduate certificates with a grade of B or better in all the certificate courses will be admitted without the GRE.
  - Regular status: V+Q#1100, A#4.0 (former scoring) or V#155, Q#148, A#4.0
  - Condition: Student must earn B or better in each of first four graduate courses.
- TOEFL: All international applicants must submit a current TOEFL score, regardless of prior academic experience or place of study.
  - Regular status: 580/237/92
  - Statement of Purpose: All applicants must submit a statement of purpose.
- Financial Support: Students in conditional status are not eligible for financial support from the department.
- Prerequisites: engineering economy and engineering statistics
Doctor of Philosophy

A candidate for the Ph.D. in Engineering Management must complete the equivalent of at least three years of full-time work beyond the bachelor’s degree. The content of all Ph.D. programs is individually structured by the student in consultation with and approved by the student’s advisory committee. All requirements for the degree must normally be completed within an eight-year period. Each candidate must normally spend at least two sequential semesters in full-time residence at Missouri S&T. The department does have special conditions for satisfying residency and meeting research requirements for full-time working engineers that meet all admission standards. At appropriate points in their program, Ph.D. students must pass both a qualifying examination and a comprehensive examination. Ph.D. students must conduct original research under the supervision of a doctoral advisor, and write and successfully defend the dissertation. Some recent Ph.D. dissertation titles include:

- Development and Analysis of Intelligent Computation Based Stock Forecasting and Trading
- An Analysis of Intermodal Transportation Mode Selection Considering Stochastic System Parameters
- Surviving the Change to a Competitive Market Place in the Small Local Carrier Telecommunications Industry
- The Relationship Between R&D Spending and Shareholder Returns in High Technology Industries
- Global Stock Index Forecasting Using Multiple Generalized Regression Neural Networks with a Gating Network
- The Development of Efficient Delivery Routes in Extremely Short Product Life-Cycle Environments
- Quantification of Attribute Driven Cannibalization Induced by New Product Introduction
- Cost Allocation Using Intelligent Agents for New Transmission Investment Under Electricity Deregulation

Residency Requirements

All students are expected to follow the Missouri S&T Graduate Student Residency requirements. Off campus students can meet the 2 year residency requirement with the following requirements: The Qualifying Exam must be taken on campus during the first year of enrollment; the student will have at minimum two video conferences per month with his/her research advisor; The Ph.D. committee will include one person from the student’s professional work location, the appointment committee member must have a Ph.D. and be familiar with the chosen research; the student is expected to meet with the Ph.D. committee on a regular basis with at least two meetings per semester; the student is expected to be on campus a minimum of 16 days per year, visits may be spread over 4 campus visits; the Ph.D. Comprehensive Exam must be taken on campus; the student has the option of conducting research that is beneficial to the student’s professional work; the Defense of Dissertation must take place on campus.

Ph.D. Admission Standards

- B.S. in engineering, or a physical science
- GPA: M.S. GPA = 3.5
- Graduate Record Exam (GRE): All students must submit current GRE scores. V+Q#1100, A#4.0 (former scoring) or V#155, Q#148, A#4.0
- TOEFL: All international applicants must submit a current TOEFL score, regardless of prior academic experience or place of study.
- Regular status: 580/237/92
- Statement of Purpose: All applicants must submit a statement of purpose.
- Prerequisites: engineering economy and engineering statistics

John F Bade, Adjunct Associate Professor
PHD University Of Missouri-Rolla

Andrew S Bodenhamer, Lecturer
MASTER University of Michigan

Elizabeth Anne Fargher Cudney, Assistant Professor
PHD Missouri S&T
Quality, Six Sigma, Robust Engineering, and Lean Enterprise.

Cihan H Dagli, Professor
PHD University of Birmingham,UK

David M Dietrich, Adjunct Assistant Professor
PHD Missouri S&T

Benjamin Lloyd Dow Jr., Associate Teaching Professor
PHD Purdue University

David L Enke, Professor
PHD University of Missouri - Rolla
Investments, Derivatives, Options and Futures, Financial Forecasting, Trading Strategies, Hedge Funds, Endowment Investing, Financial Risk Management, Engineering Economy, Computational Finance, Computational Intelligence, Neural Networks.

Abhijit Gosavi, Assistant Professor
PHD University Of South Florida
Supply chain management, simulation based optimization, and lean enterprise.

Ivan Guardiola, Assistant Professor
PHD Texas Tech University
Simulation and modeling, risk modeling and assessment, systems engineering processes and design, network centric systems, wireless communications networks, stochastic and probability modeling, operations research, birth-death process modeling, speaker recognition and identification systems (pattern recognition), and rare event probability modeling.

Suzanna K. Long, Assistant Professor
PHD University Of Missouri-Rolla
Strategic Management, change management, business logistics, and marketing.

Susan L Murray, Professor
PHD Texas A&M University
Industrial engineering, productivity improvement, human factors and safety.

Ruwen Qin, Assistant Professor
PHD Pennsylvania State University
Financial engineering, real options, and operations research.

Stephen A Raper, Associate Professor
PHD University Of Missouri-Rolla
Associate Chair of Undergraduate Studies in Engineering Management. Packaging engineering, operations, productivity, total quality management, packaging systems design, environmental aspects of packaging, and statistical process control.

Joan Barker Schuman, Assistant Teaching Professor
PHD University Of Southern Mississ
Project Management and Engineering Economics.

David Allyn Shaller, Assistant Professor Emeritus
JD Cleveland State University
Organizational behavior, industrial organization, legal environment of enterprise, labor relations law, collective bargaining, financial management, and marketing management.

Brian Keith Smith, Assistant Professor
PHD University Of Arkansas

David G Spurlock, Lecturer
PHD University Of Illinois Urbana

English

The Department of English and Technical Communication has entered into a cooperative agreement with the Department of English of the University of Missouri–St. Louis to offer the Master of Arts in English. A maximum of 12 graduate semester hours may be taken at MST (with no more than 9 credit hours at the 300 level).

The program provides an avenue for place-bound secondary teachers, traditional and non-traditional Missouri S&T students, and other qualified residents of South Central Missouri to pursue advanced work whether for career advancement or for personal and lifelong learning and enrichment. The program is also designed to help a select group of incoming freshman to complete their bachelor’s and master’s degrees in five years; for more information, contact the Honor Academy (Master Student Fellowship Program).

Candidates for the M.A. in English must meet the admission requirements of both the Graduate Schools and the Departments of English at Missouri S&T and UMSL. Candidates must have a bachelor’s degree, with at least 24 hours in English above the freshman level, 12 in literature courses. Normally only students with a grade point average of at least 3.0 in undergraduate English courses and an overall average of 2.75 will be considered. Applicants must submit scores for the Graduate Record Examination.

In general, students scoring below the 65th percentile on the verbal examination will not be accepted into the program. Students may retake the examination to improve their scores. In addition, the departments require letters of recommendation from two English professors with whom the student has worked. The letters, the undergraduate record, and the Graduate Record Examination scores will be the basis for the admission decision. Three emphasis areas are available: literature, composition, and creative writing. Students must submit fiction or poetry in application for the creative writing track.

Applications should be received by May 1 for fall semester and for the summer session, and 1 December for the spring semester. Late applicants will be considered but cannot be assured of admission. For more information, contact the Missouri S&T Department of English and Technical Communication.

Ed A. Malone, Associate Professor

PHD Southern Illinois Univ Carbond
Kathryn Michele Northcut, Associate Professor
PHD Texas Tech University

Michael David Wright, Assistant Professor
PHD Oklahoma State University Main

Explosives Engineering

The Explosives Engineering program offers a Master of Science degree for students with bachelor's degrees in engineering, science, or technology. Due to the age profile of the explosives industry and attrition of personnel, as well as the rapid change in technology within this field, there is an immediate and growing need for highly trained explosives professionals in the civilian explosive, mining, and civil excavating fields and government and the defense industry. Employers are looking for engineers and scientists with sophisticated skills in the integration of explosives technology into complex systems in a wide range of applications. Employers are also seeking MS graduates because they can move quickly into managerial positions.

Faculty involved in a variety of explosives related research programs teach and direct the program in conjunction with instruction by industry specialists in a wide range of applications. Students will have opportunities to assist the faculty, both in research and teaching, as well as working alongside faculty and graduate students in other engineering and science fields, such as Civil, Architectural, Mechanical, Chemical, Aerospace, Electrical, Geological and Materials Engineering and Geology, Geophysics, Chemistry, and Physics. The explosives engineering faculty and students will be active in the leading professional societies such as the International Society for Explosives Engineers and those in a wide range of associated areas.

The Explosive Engineering program in the department of Mining and Nuclear Engineering offers graduate programs of study which currently lead to the M.S. Degree (thesis and non-thesis options). The program requires a minimum of 30 hours of graduate credit. A core of four courses is required of all students and a module of allied courses in departments outside of explosives engineering in encouraged. A security background check is required.

Degree Requirements

M.S. with Thesis: The MS degree with thesis requires the completion of 24 hours of graduate course work and six hours of research (EXP ENG 490) and the successful completion and defense of a research thesis. Four of the following core courses are required of all MS students in Explosives Engineering:

EXP ENG 307 Principles Of Explosives Engineering
or MIN ENG Principles Of Explosives Engineering 307

EXP ENG 350 Blasting Design And Technology
or MIN ENG Blasting Design And Technology 350

EXP ENG 351 Demolition of Buildings and Structures

MIN ENG 383 Tunneling & Underground Construction Techniques

EXP ENG 402 Environmental Controls For Blasting

Degree Programs
Students select 12 hours of ExpE and other appropriate elective courses. M.S. in Explosives Engineering candidates are advised to group out-of-
department courses into a module that fits their special interest.

M.S. without Thesis (by coursework): The M.S. degree without
thesis requires the completion of 30 hours of graduate coursework
with the same stipulations as above. The six hours of research is
replaced by an explosives related cooperative work experience (Exp
ENG 497) or industry project (EXP ENG 498) with an established
company or government agency commonly using explosives and an
additional explosives course. In addition the candidate is required
to present a formal presentation (oral or poster) with abstract to an
established scientific or industry society and present a formal oral and/or
electronically recorded presentation with abstract to the Mining/Nuclear/
Explosives engineering seminar.

Jason Baird, Associate Professor
PHD University of Missouri - Rolla

Paul Nicholas Worsey, Professor
PHD Univ - Newcastle-upon-Tyne

Geological Engineering

The Department of Geological Sciences and Engineering is home
to three separate programs, Geological Engineering, Geology &
Geophysics, and Petroleum Engineering. Geotechnics is a part of the
Geological Engineering program.

Geological engineering is the application of the knowledge and
principles of geology to the solution of problems in engineering practice. These applications include the evaluation of geological conditions for
environmental protection studies, for groundwater resource and pollution
investigations, for mineral and energy development, for site selection of
civil works facilities and for land use and environmental impact analysis.

The geological engineering laboratories are well equipped for research
relating to physical and hydraulic properties of rock, groundwater
hydrology, remote sensing, and geographic information systems. Computer applications are emphasized, and the department has a
laboratory equipped with a variety of personal computer equipment for
student use. A groundwater hydrology laboratory is equipped to conduct
research in subsurface fluid flow and computer facilities are available for
the modeling of flow through porous media.

Recent research projects in the GE program include:

- Designing excavating tools for geomaterials on earth and in space.
- Studying blasting efficiency for enhancing productivity in the mining
  industry.
- Applying mining methods to potential space mining applications, and
  reducing the size of asteroid on potential collision courses with earth.
- Global sustainability.
- Shale gas and other unconventional energy sources.
- Geologic membrane processes.
- Developing a rock fall hazard rating system for Missouri highways.
- Using LIDAR to research the rock raveling process.
- Multivariate cluster analysis of borehole discontinuity data.
- Developing a virtual geotechnical database for the greater St. Louis
  Metropolitan Area.
- Pilot seismic hazard assessment of the Granite City Monk Mound and
  Columbia Bottom Quadrangles, St. Louis Metropolitan Area.
- Creation of a geologic GIS database for the St. Louis Metropolitan
  Area.
- Bridge deck delamination studies using ground penetrating radar.
- Detection of underground mines and caverns using geophysical
  methods.
- Subsurface imaging in Karst Terrain.
- Bridge pier scour investigations.
- Applying stochastic analysis to groundwater remediation design.
- Developing sustainable point of use drinking water systems in
developing areas.
- Using renewable energy systems to power active groundwater
  pumping and remediation systems.
- Characterizing the reliability of wind and solar energy system
  predication models.

The department maintains a computer learning center and Geographic
Information Systems Laboratory with PCs, and a variety of peripheral
devices such as scanners, digitizers, and printers. ERDAS, IDRISI,
AutoCAD Map and World, Arc View, and other software packages are
available for instruction and research. Applications of GIS and Remote
Sensing Technology which are stressed include site characterization and
selection, geologic hazards mapping and terrain analysis. The
department also offers a graduate certificate in Geotechnics.

Contact information, e-mail gee@umr.edu or visit our website at http://
gse.mst.edu/.

Neil L Anderson, Professor
PHD University of Calgary
Acquisition processing.

Shadab Anwar, Assistant Professor
PHD Florida International Univ
Karst hydrology, carbon sequestration, environmental hydrogeology,
groundwater remediation, numerical modeling.

Kwame Awuah-Offei, Assistant Professor
PHD University Of Missouri-Rolla
Dredging, environmental and reclamation engineering, formation
excavation, mineral processing, systems modeling and optimization.

Jeffrey D Cawlfield, Professor
PHD University Of CA-Berkeley
Director of Freshman Engineering. Probabilistic modeling and geo-
statistics, ground-water and contaminant transport analysis, and
computer applications in geological engineering.

A Curt Elmore, Professor
PHD University Of Arizona
Groundwater remediation, groundwater development, stochastic analysis,
and remedial design.

Ralph E Flori Jr, Associate Professor
PHD University Of Missouri-Rolla
Engineering mechanics, mechanical earth modeling, reservoir
engineering, reservoir simulation, engineering education.

Leslie Sour Gertsch, Associate Professor
PHD Colorado School Of Mines
Rock mechanics, mechanical mining and excavating, mine design and rock fragmentation.

Norbert H Maerz, Associate Professor1,2
PHD University of Waterloo
Program Head. Rock mass classification, rock engineering, slope stability, joint genesis, computer applications and image processing.

Henry J Pernicka, Associate Professor
PHD Purdue University Main Campus
Astrodynamics, orbital mechanics, spacecraft design, spacecraft mission design, satellite attitude dynamics, nonlinear analysis, dynamics and control, optimization.

J David Rogers, Associate Professor1,2
PHD University Of California-Berke
Seismic hazards, geotechnical engineering, dam safety and earth structures.

Geology and Geophysics

Graduate work in Geology and Geophysics is offered at both the master of science (thesis and non-thesis) and doctoral levels. Programs are designed to provide you with an understanding of the fundamentals and principles of geology, geochemistry, and geophysics. Research investigations comprise a significant part of each program, and at the doctoral level an original contribution to the science is required.

Research emphasis of the program is in:

- Low Temperature and Environmental Geochemistry
- Mineralogy/Petroleum/Economic Geology
- Geophysics/Tectonics/Remote Sensing
- Sedimentology/Paleontology/Petroleum Exploration

In Geology and Geochemistry, opportunities for research at both the M.S. and Ph.D. levels are available in Mining Geology, Petroleum Geology, Stratigraphy and Sedimentation, Geochemistry, Clay Mineralogy, Remote Sensing, GIS, Palynology, Structural Geology, Igneous and Metamorphic Petrology, and Volcanology.

In Geophysics, opportunities for research at both the M.S. and Ph.D. levels are available in the areas of Reflection and Refraction Seismology, Theoretical Seismology, Geophysical Data Analysis, Gravity, Magnetics, Seismic Hazards, and Computational Geophysics.

The study of the Earth and other planets includes all areas of scientific inquiry. To work effectively in so broad a discipline requires considerable depth and breadth of understanding of physical principles and advanced proficiency in mathematics, particularly for those students contemplating advanced studies in geophysics. A thorough undergraduate training in an earth or physical science is ordinarily regarded as necessary prerequisite for advanced study in geology or geophysics.

Earth sciences have been an integral part of the university since its founding. The program has a long and proud history of faculty and students who have contributed to the advancement of the science and to mineral and hydrocarbon exploration. The university was formerly the Missouri School of Mines. Because of the school’s tradition and location near the Missouri Lead District the emphasis of the department has been in hard rock exploration. The program has now expanded to include Geochemistry, Geophysics, and Soft Rock Geology. Our graduates find employment in mining, environmental, and petroleum industries. It is our intention to provide the student with a sufficiently diverse and complete education that he or she may seek employment in any area of the earth sciences.

The program has a wide variety of equipment for research and exploration in geology, geochemistry, and geophysics. In addition to its own facilities, the Missouri Department of Natural Resources, and the U.S. Geological Survey’s mid-continent mapping division are also located in Rolla. Cooperative research with other departments within the university or other campuses of the University of Missouri may be undertaken by our faculty and graduate students. Interaction with mining engineering, geological engineering, petroleum engineering, metallurgy, environmental engineering and various other programs/ departments is routine. Cooperative programs are also undertaken with local mining companies, petroleum companies, or other industries using the skills and techniques of the earth scientist. Thus, your research interests need not fall entirely within the interests of our faculty or within the bounds of the equipment directly available within the program.

Although an advanced degree level is not a requirement for professional practice in geology or geophysics, the B.S. should usually be considered a preparatory, the M.S. should be considered the professional degree, and the Ph.D. should be sought by candidates interested in a career in teaching or research. The M.S. degree is typically granted with the thesis option, although a non-thesis option is now available. A qualifying examination is required of all Ph.D. students during the third semester of residency or. For students whose native language is not English, a minimum score of 550 on the standard Test of English as a Foreign Language is generally required for admission.

Neil L Anderson, Professor1,2
PHD University of Calgary
Acquisition processing.

A Curt Elmore, Professor1
PHD University Of Arizona
Groundwater remediation, groundwater development, stochastic analysis, and remedial design.

Ralph E Flori Jr. Associate Professor
PHD University Of Missouri-Rolla
Engineering mechanics, mechanical earth modeling, reservoir engineering, reservoir simulation, engineering education.

Stephen Shangxing Gao, Professor
PHD University of CA - Los Angeles
Seismology, solid earth geophysics, crustal deformation, computational geophysics, plate tectonics.

John Patrick Hogan, Associate Professor
PHD Virginia Polytechnic Institute
Igneous petrology, crust and mantle evolution.

Kelly Hong Liu, Professor
PHD University Of CA - Los Angeles
Exploration geophysics, digital signal processing, seismic hazard, earth structure and dynamics.

Francisca Oboh Ikuenobe, Professor2
PHD Cambridge University
Program Head of Geology and Geophysics. Palynology, biostratigraphy, clastic petrology, diagenesis.

David J Wronkiewicz, Associate Professor
Geotechnics

The Geological Engineering Program at Missouri University of Science and Technology offers an on-line Masters of Engineering degree in Geotechnics. This web-based degree is designed for working professionals, whose upward mobility requires an advanced degree, but who do not wish to take an extended leave of absence to physically attend college. The program is an interdisciplinary master’s degree program without a required research component. Courses in Geological, Civil, and Mining Engineering can be applied to the degree. The program is offered using distance-education methods and therefore there is no formal residency requirement.

Entrance Requirements

This program is open to graduates holding a B.S. degree in engineering or geology or other hard sciences. (For graduates of a non-engineering B.S. some bridging courses may be required). Prerequisite requirements include at least one introductory course in physical geology and one introductory course in rock mechanics or soil mechanics or equivalent. A minimum GRE score of 1100 (verbal plus quantitative) is required as well as a minimum analytical score of 3.5/5.0. (No GRE score is required if students first complete the four course Certificate Program in Geotechnics). For international students, a TOEFL score of at least 550 is required, or an Internet based TOEFL score of at least 80/120.

Contact information e-mail gtech@mst.edu or visit our website at http://gtech.mst.edu/.

Course Requirements

The M.E. degree program will require 30 semester hours of graduate credit in 300 and 400 level courses. The following four core courses (12 hours) are required:

- GEO ENG 381 Intermediate Subsurface Hydrology And Contaminant Transport Mechs
- GEO ENG 371 Rock Engineering
- GEO ENG 341 Engineering Geology And Geotechnics
- CIV ENG 315 Intermediate Soil Mechanics or MIN ENG 432 Advanced Rock Mechanics

An additional 18 hours of coursework are required, included a 3 hour industrial (practice oriented) project (GEO ENG 400). Of the total 30 credit hours required to obtain the degree, a maximum of nine (9) credit hours of graduate-level work with a minimum grade of “B” can be transferred from other another institution, as long as the courses have not been used towards another degree, and have been approved by the student’s advisor. The balance of the credit hours must be taken through Missouri S&T. A minimum of fifteen (15) credit hours must be Geological Engineering courses.

Neil L Anderson, Professor1,2
PHD University of Calgary

Acquisition processing.

Shadab Anwar, Assistant Professor
PHD Florida International Univ
Karst hydrology, carbon sequestration, environmental hydrogeology, groundwater remediation, numerical modeling.

Kwame Awuah-Offei, Assistant Professor
PHD University Of Missouri-Rolla
Dredging, environmental and reclamation engineering, formation excavation, mineral processing, systems modeling and optimization.

Jeffrey D Cawfield, Professor1,2
PHD University Of CA-Berkeley
Director of Freshman Engineering. Probabilistic modeling and geostatistics, ground-water and contaminant transport analysis, and computer applications in geological engineering.

A Curt Elmore, Professor1
PHD University Of Arizona
Groundwater remediation, groundwater development, stochastic analysis, and remedial design.

Ralph E Flori Jr, Associate Professor
PHD University Of Missouri-Rolla
Engineering mechanics, mechanical earth modeling, reservoir engineering, reservoir simulation, engineering education.

Leslie Sour Gertsch, Associate Professor
PHD Colorado School Of Mines
Rock mechanics, mechanical mining and excavating, mine design and rock fragmentation.

Norbert H Maerz, Associate Professor1,2
PHD University of Waterloo
Rock mass classification, rock engineering, slope stability, joint genesis, computer applications and image processing.

Henry J Pernicka, Associate Professor
PHD Purdue University Main Campus
Astrodynamics, orbital mechanics, spacecraft design, spacecraft mission design, satellite attitude dynamics, nonlinear analysis, dynamics and control, optimization.

J David Rogers, Associate Professor1,2
PHD University Of California-Berke
Seismic hazards, geotechnical engineering, dam safety and earth structures.

Information Science and Technology

Information Science and Technology (IST) offers an M.S. degree program. Information technology has transformed every aspect of our economy and society. Rapid spread of technology has generated the need for highly trained professionals to implement and maintain information systems especially in the rapidly growing area of enterprise resource planning. The M.S. in Information Science and Technology is designed to educate students in the design, development, and successful application of information systems in organizations.

Also offered are five graduate certificiates. Human-Computer Interaction, Enterprise Resource Planning, Business Intelligence, Project
Management (jointly offered with the Engineering Management and Systems Engineering Department), and Psychology of Leadership (jointly offered with the Psychological Science Department) are for students who wish to specialize and for working professionals who want to stay ahead of rapidly changing technology. Each Graduate Certificate program consists of a four-course sequence from existing graduate-level courses. Certificate credits earned by students admitted to the M.S. program will count toward their master’s degree. Students admitted just to the Certificate program will have non-matriculated status. However, if they complete the four-course sequence with a grade of “B” or better in each of the courses taken, they will be admitted to the M.S. program if they so choose.

The faculty is active in studying the design and application of the web and has external support for research. Research experiences are integrated into the classroom experience. Specially equipped research laboratories are available to support studies in human-computer interaction and experiments with computer networks, as are general purpose computing laboratories that are available to all students. A large number of computing languages and special-purpose software tools are available on various platforms. While instruction and research are on the leading edge of information systems, the department endeavors to keep class sizes small to facilitate student and faculty interactions.

**IST Graduate Certificates**

The department of Business and Information Technology offers a variety of graduate certificates. Each certificate program is open to persons holding a bachelor’s degree who have the required pre-requisites for the courses in the program. A student must maintain an average cumulative grade of 3.0 or better in the certificate courses in order to receive the graduate certificate.

**Enterprise Resource Planning (ERP)**

ERP is a combination of business management practice and technology, where information technology integrates with a company’s core business processes to enable the achievement of business objectives. The Missouri S&T program prepares undergraduate and graduate students for positions as both technical and business consultants in the ERP field. Students with a Graduate Certificate in ERP will be eligible for a Missouri S&T-SAP Certificate, authorized by the SAP Corporation. A graduate level student may receive an ERP Graduate Certificate from the Department of Business and Information Technology at Missouri S&T by completing four courses, consisting of two required courses:

- ERP 346 Enterprise Resource Planning Systems Design and Implementation
- ERP 446 Enterprise Resource Planning: Systems Config and Integration

and two electives from the 300 and 400 level ERP courses as outlined by their graduate advisor.

**Human-Computer Interaction**

The Human-Computer Interaction (HCI) graduate certificate prepares students for positions as HCI specialists with titles such as interface designer, usability analyst, usability engineer, or similar titles. HCI specialists bridge the gap between those who build technologies and those who use them. A graduate level student may receive an HCI graduate certificate from the Business and Information Technology department at Missouri S&T by completing four courses—three required courses:

- IS&T 385 Human Computer Interaction
- IS&T 386 Human-Computer Interaction Prototyping
- IS&T 387 Human-Computer Interaction Evaluation

and one advanced HCI elective from:

- IS&T 487 Research Methods in Human-Computer Interaction
- IS&T 480 Advanced Web and New Media Studies

**Psychology of Leadership**

The Graduate Certificate in the Psychology of Leadership is designed to provide preparation to meet the challenge of constant change and to interact effectively with individuals up and down the management structure. A graduate student may receive a Psychology of Leadership Graduate Certificate from the Department of Business and Information Technology at Missouri S&T by completing four courses—three from among:

- PSYCH 308 Social Psychology
- PSYCH 316 Psychology of Leadership in Organizations
- PSYCH 374 Organizational Psychology
- ERP 348 Performance Dashboard, Scorecard and Data Visualization
- IS&T 351 Technological Innovation Management and Leadership

and one elective course from:

- PSYCH 350 Psychology of Women
- PSYCH 372 Group Dynamics
- PSYCH 378 Social Influence: Science and Practice
- IS&T 480 Advanced Web and New Media Studies
- IS&T 487 Research Methods in Human-Computer Interaction

**Business Intelligence**

Interest in business intelligence has been a recent strong theme among medium and large-sized business employers of our graduate students. In order to make appropriate decisions, upper-level administration of an organization needs to draw on data from different systems in order to get a crisp picture of the organizational performance and relay the results in effective ways. Examples include the development of organizational scorecards, dashboards, and other tools that provide a picture of how an organization is performing. People capable of creating and maintaining such information are needed, but the in-depth education necessary for these people is available in only a few places.

The Graduate Certificate in Business Intelligence focuses on the technologies that allow an organization to make effective business decisions based on operational data pulled together from many different sources. The target audience consists of any individual who would manage any type of IT professionals, database administrators, business analysts, and any professional who would need to understand the technologies and their capabilities.
A graduate level student may receive a Graduate Certificate in Business Intelligence from the Information Science and Technology program within the Business and Information Technology Department at Missouri S&T by completing four courses. Two of the courses are required:

- **ERP 345** Use of Business Intelligence
- **IS&T 444** Essentials of Data Warehouses

or **ERP 444** Essentials of Data Warehouses

The other two courses may be chosen from the following:

- **ERP 346** Enterprise Resource Planning Systems Design and Implementation
- **ERP 348** Performance Dashboard, Scorecard and Data Visualization
- **ERP 442** Advanced Customer Relationship Management in ERP Environment
- **IS&T 443** Information Retrieval and Analysis
- **IS&T 445** Database Marketing
- **ERP 448** Enterprise Performance Dashboard Prototyping

**Project Management**

This certificate program aims to equip students to successfully manage resources and to analyze, evaluate, and improve complex projects, allowing them to achieve Project Management Institute (PMI) standards in the project management area. A graduate student may receive a Project Management Graduate Certificate from the Department of Business and Information Technology at Missouri S&T by completing four required courses:

- **IS&T 461** Advanced Information Systems Project Management
- **ENG MGT 458** Case Studies in Project Management
- **ENG MGT 461** Global Project Management
- **ENG MGT 361** Project Management

**Financial Assistance**

Financial assistance is available to graduate students in the form of assistantships and fellowships. Research opportunities for advanced students exist. For application forms, contact the department.

**Additional Information**

Contact us at (573) 341-4482, ist@mst.edu or visit http://business.mst.edu.

**Admission Requirements**

In addition to those requirements stated in this catalog, specific requirements for admission to the M.S. in Information Science and Technology (thesis or non-thesis) are as follows:

- Successful completion of an undergraduate degree from a recognized college or university with a GPA (grade point average or international equivalent) of 3.0/4.0 or better.
- Submit scores from the Graduate Record Exam (GRE) or the Graduate Management Admissions Test (GMAT).
- TOEFL or IELTS scores must be submitted if English is not the candidate's natural language.

- Undergraduate coursework in Calculus; Statistics; Programming Languages with Data Structures; Information Systems; Relational Database Management Systems; and Computer Architecture must be shown.

***Please note that meeting the above requirements does not guarantee admission into the M.S. in Information Science and Technology, but, rather, is used by the Admissions committee in the decision-making process***

**Degree Requirements**

M.S. with Thesis: The M.S. degree with thesis requires the completion of 24 hours of graduate course work (a minimum of 12 at the 400 level), 6 hours of research (IS&T 490), and the successful completion and defense of a research thesis.

M.S. without Thesis: The M.S. degree without thesis requires the completion of 30 hours of graduate course work (a minimum of 15 at the 400 level)

The following core courses are required of all M.S. students in Information Science and Technology. These courses are designated to ensure that all IST masters students study the four information systems perspectives of networks and web design, human perception, application implementation, and organizational systems.

- **IS&T 351** Technological Innovation Management and Leadership
- **IS&T 385** Human Computer Interaction
- **IS&T 436** Foundations of Internet Computing
- **IS&T 461** Advanced Information Systems Project Management

**Barry B Flachsbart**, Professor

PHD Stanford University

Expert Systems, Artificial Intelligence, Neural Networks, Fuzzy Logic, large databases, manufacturing information systems, information system project management.

**Richard H Hall**, Professor

PHD Texas Christian University

Cognitive processes in academic learning, in particular cooperative/collaborative learning (especially scripted-cooperative learning); spatial text displays (in particular knowledge maps); and the role of advanced technologies; in particular the world wide web, in education.

**Michael Gene Hilgers**, Professor

PHD Brown University

Learning information systems, virtual reality, participative simulations.

**Bih-Ru Lea**, Associate Professor

PHD Clemson University

Enterprise resource planning, performance dashboards, accounting information systems, data visualization, business process integration, and supply chain management.

**Nicholas Scott Lockwood**, Assistant Professor

PHD Indiana University Bloomington

Communication, collaboration, social media, Web 2.0, virtual worlds, human-computer interaction, psychophysiological research methods.

**Chris J. Merz**, Adjunct Assistant Professor

PHD University Of CA-Irvine
Hong Sheng, Associate Professor  
PHD Univ Of Nebraska Lincoln  
Human-Computer Interaction, information systems management, E-Commerce, mobile commerce and ubiquitous commerce, strategic implications of mobile technology, trust and privacy issues in information systems, RFID in Health Care.

Keng Leng Siau, Professor  
PHD University of British Columbia  
Department of Business & Information Technology. Design science, virtual worlds and 3D web, electronic, mobile, and ubiquitous business, and business intelligence/analytics.

Wen-Bin Yu, Associate Professor  
PHD University Of Louisville  
Agent based systems, supply chain management, demand forecasting, simulation, and business intelligence.

Manufacturing Engineering

Manufacturing uses advanced technologies to transform materials into new products or parts of products. Today’s manufacturing industry includes (but is not limited to) Aerospace, Biotechnology, Electronic Equipment Manufacturing, Engineering in machining and equipment, Food processing and supply, Light metals, Marine industries, etc.

The MST Manufacturing Engineering Education Program offers the interdisciplinary Master of Science (MS) and Master of Engineering (MEng) degrees on campus or through distance learning via the internet. Both degree programs are intended for a student with a BS degree in engineering to learn about modern manufacturing technologies involving computers and automation.

Also offered are two graduate manufacturing engineering certificate programs. Manufacturing Systems and CAD/CAM & Rapid Product Realization are for working professionals who want to stay ahead of rapidly changing technology.

The graduate certificate program consists of a four-course sequence from existing graduate-level courses. While the students admitted to the Certificate Program will have non-matriculated status, if they complete the four-course sequence with a grade of “B” or better in each of the courses taken, they will be admitted to the M.S. program if they so choose. The Certificate credits taken by students admitted to the M.S. program will count toward their master’s degree.

The MS program is a research-oriented degree where the courses supplement the thesis research. The ME program is designed such that the course selection is flexible and the student is allowed to take courses pertaining to his or her area of interest. A practice-orientated project is required by the ME program, which provides an opportunity for the student to participate in a practical project related to a manufacturing process. The ME program is structured so that individuals, such as working engineers, who wish to improve their knowledge and skills can complete their degree in one year.

The basic admission requirements include 1) B.S. degree in an ABET accredited engineering program; and 2) Ranked in upper third of undergraduate class OR a GPA greater than 3.0/4.0. The following test scores are required:

- A minimum GRE quantitative score of 155; minimum verbal plus quantitative score of 302; and a minimum analytical score of 3.5.
- For those not speaking English as their native language, a TOEFL score of 88 internet-based, 230 computer based or 570 paper based.

The MS program requires 30 credit hours and a thesis:

- 12 credit hours from the Manufacturing Core Areas
- 6 credit hours of 400 level courses in Manufacturing
- 3 credit hours of approved Mathematics/Computer Science or any suggested Manufacturing courses
- 6 credit hours for thesis research
- 3 credit hours of graduate courses in Manufacturing

The ME Program requires 30 credit hours and a practice-oriented project. The course requirements include 12 credit hours from the Manufacturing Core Areas, 6 credit hours of 400 level courses in Manufacturing; 3 credit hours of approved Mathematics/Computer Science or any suggested Manufacturing courses, 3 credit hours for work related to the practice-oriented project, and 6 credit hours of graduate courses in Manufacturing. The practice-orientated project is defined by the student and academic advisor. At the end of the project experience, the student should demonstrate not only the proficiency of operating certain manufacturing processes, but also the capability to improve the process. At the end of the ME program, a presentation and a report documenting the practice oriented projects are required. For both programs, at most 6 credit hours of two hundred level classes can be completed in the degree.

For both programs, each student must take at least one course from each of the core areas in Manufacturing Engineering during his or her first two semesters of graduate work. The core requirements may be deemed satisfied if a student has already taken a core course as a technical elective in his or her undergraduate program, thus allowing more freedom in the selection of other courses. The related courses in Manufacturing Core Areas are selected and offered from various departments.

The Manufacturing Core Areas include:

- Materials and Manufacturing Processes
- Process, Assembly and Product Engineering
- Manufacturing Competitiveness
- Manufacturing System Design

The graduate committee for each student in the interdisciplinary Master of Science degree program will consist of three faculty of which at least two must be from the Manufacturing Education Committee (MEC). The major advisor should also be a member of the Manufacturing Education Committee. The Master of Engineering student does not need a committee, but the advisor should be from MEC. MEC is formed by over 40 faculty members from various departments, such as Ceramic Engineering, Chemical Engineering, Computer Science, Electrical and Computer Engineering, Engineering Management, Mechanical and Aerospace Engineering, Metallurgical Engineering, Mining Engineering, and Business Administration. For details regarding the application, curriculum, courses in Manufacturing Core Areas, and MEC faculty, you may also wish to explore the program’s web page at: http://mfge.mst.edu. Some examples of research areas in which you can specialize include:

- Design for Manufacturing/Assembly
- CAD/CAM/CIM
- Product/Process Development
- Manufacturing Management
- Manufacturing Processes
- Manufacturing Materials
- Lean Manufacturing
Graduate Certificates

CAD/CAM & Rapid Product Realization Certificate

One each from the four core areas in the Manufacturing Engineering program as outlined below:

Course I

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH ENG</td>
<td>363</td>
<td>Principles And Practice Of Computer Aided Design</td>
</tr>
</tbody>
</table>

Course II

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH ENG</td>
<td>308</td>
<td>Rapid Product Design And Optimization</td>
</tr>
<tr>
<td>ENG MGT 354</td>
<td>354</td>
<td>Integrated Product And Process Design</td>
</tr>
<tr>
<td>or MECH ENG</td>
<td>357</td>
<td>Integrated Product And Process Design</td>
</tr>
</tbody>
</table>

Course III

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH ENG</td>
<td>459</td>
<td>Advanced Topics In Design And Manufacturing</td>
</tr>
</tbody>
</table>

Course IV

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AERO ENG</td>
<td>360</td>
<td>Probabilistic Engineering Design</td>
</tr>
<tr>
<td>or ENG MGT</td>
<td>360</td>
<td>Probabilistic Engineering Design</td>
</tr>
<tr>
<td>or MECH ENG</td>
<td>360</td>
<td>Probabilistic Engineering Design</td>
</tr>
<tr>
<td>MECH ENG</td>
<td>356</td>
<td>Design For Manufacture</td>
</tr>
</tbody>
</table>

Manufacturing Systems Certificate

For the Manufacturing Systems Graduate Certificate Program the students will need to take four course sequences, one each from the four course areas in the Manufacturing Engineering program as outlined below:

Course I-Materials and Manufacturing Processes

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH ENG</td>
<td>320</td>
<td>Advanced Mechanics of Materials</td>
</tr>
<tr>
<td>MECH ENG</td>
<td>336</td>
<td>Fracture Mechanics</td>
</tr>
<tr>
<td>MECH ENG</td>
<td>382</td>
<td>Introduction To Composite Materials &amp; Structures</td>
</tr>
<tr>
<td>MECH ENG</td>
<td>459</td>
<td>Advanced Topics In Design And Manufacturing</td>
</tr>
</tbody>
</table>

Course II-Process, Assembly and Product Engineering

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG MGT 354</td>
<td>354</td>
<td>Integrated Product And Process Design</td>
</tr>
<tr>
<td>or MECH ENG</td>
<td>357</td>
<td>Integrated Product And Process Design</td>
</tr>
<tr>
<td>MECH ENG</td>
<td>308</td>
<td>Rapid Product Design And Optimization</td>
</tr>
<tr>
<td>MECH ENG</td>
<td>363</td>
<td>Principles And Practice Of Computer Aided Design</td>
</tr>
</tbody>
</table>

Course III-Manufacturing Competitiveness

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG MGT 309</td>
<td>309</td>
<td>Six Sigma</td>
</tr>
<tr>
<td>AERO ENG</td>
<td>360</td>
<td>Probabilistic Engineering Design</td>
</tr>
<tr>
<td>or MECH ENG</td>
<td>360</td>
<td>Probabilistic Engineering Design</td>
</tr>
<tr>
<td>ENG MGT 364</td>
<td>364</td>
<td>Value Analysis</td>
</tr>
<tr>
<td>ENG MGT 385</td>
<td>385</td>
<td>Statistical Process Control</td>
</tr>
<tr>
<td>ENG MGT 472</td>
<td>472</td>
<td>Lean Systems</td>
</tr>
<tr>
<td>ERP 346</td>
<td>346</td>
<td>Enterprise Resource Planning Systems Design and Implementation</td>
</tr>
</tbody>
</table>

Course IV-Manufacturing Systems Design

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH ENG</td>
<td>355</td>
<td>Manufacturing Equipment Automation</td>
</tr>
<tr>
<td>MECH ENG</td>
<td>356</td>
<td>Design For Manufacture</td>
</tr>
<tr>
<td>MECH ENG</td>
<td>378</td>
<td>Mechatronics</td>
</tr>
</tbody>
</table>

Materials Science and Engineering

The Materials Science and Engineering Department offers a variety of educational and research opportunities for graduate study including degree programs in materials science and engineering, ceramic engineering, and metallurgical engineering. The department offers the following degrees: M.S. and Ph.D. in Materials Science and Engineering, M.S. and Ph.D. in Ceramic Engineering, and M.S. and Ph.D. in Metallurgical Engineering. Further information regarding these degree programs may be found below and under the individual degree programs within this catalog.
The requirement for entry into one of these programs includes a baccalaureate degree in Materials Science or Engineering, Ceramic Engineering or Science, Glass Science or Technology, or Metallurgical Science or Engineering. A baccalaureate degree in Physics, Chemistry, Chemical Engineering, or related discipline may also be acceptable.

In the areas of glass, ceramic, and biomaterials, the department carries out research in electronic ceramics, high temperature materials, structural ceramics, composites, ceramic processing, laser glasses, and nuclear waste encapsulation glasses. Fundamental and applied interests include structure and its relation to the properties of ceramics and glasses; defect chemistry, thermochemistry and phase equilibria; electrical, dielectric, optical, thermal and mechanical properties of ceramics; ceramic-ceramic, ceramic-metal, and ceramic-polymer composites; compositional effects on the optical properties and chemical corrosion of glass; solid oxide fuel cells; high temperature superconducting ceramics; ferroelectric ceramics; glasses and ceramics for biomedical applications such as drug delivery and medical implants; and processing, forming, and microstructure control of structural and functional ceramics. The department has extensive facilities for the synthesis, forming, and fabrication of ceramics and glasses, as well as for the detailed characterization of the properties of ceramics. A mechanical testing laboratory is available for characterizing mechanical properties under controlled temperature and atmospheric conditions.

In the areas of Metallurgical Science and Engineering, the department carries out research in physical and mechanical metallurgy, extractive metallurgy, metals casting, joining and forming, and manufacturing metallurgy. Additional research activities include friction stir welding and adaptations known as friction stir processing. Interdisciplinary research opportunities are also available in other areas of specialization through collaborations with faculty members in other engineering and science departments on campus. The department foundry has research facilities for green sand casting, centrifugal casting, lost foam casting, and permanent mold casting, together with a variety of metal joining processes. Principal research interests include metal deposition, high temperature and intermetallic compounds, powder metallurgy, plasma spray deposition, and electro-metallurgical processes, environmental aspects of metal manufacturing, and treatment of metals industry wastes. Capabilities for research in these areas include an apparatus for studying mixing in reactors, a vacuum induction furnace, a plasma smelting furnace, and a metal atomizing pilot plant.

In the area of biomaterials the department carries out research in the synthesis and characterization of novel biomaterials, the design and fabrication of scaffolds for tissue engineering of biological tissues, interactions of biomaterials with living systems, and tissue-engineered restoration of biological tissues.

The department also has a strong affiliation with the Graduate Center for Materials Research at Missouri S&T, which houses major instrumentation for materials characterization. Faculty members within the MSE Department are either Senior Research Investigators or Research Investigators in this nationally recognized center. Facilities available within the MRC to support graduate research include electron microscopy, thermal analysis, Auger Electron Spectroscopy, FIB (Focused Ion Beam) x-ray diffraction, together with grazing incidence for film analysis, among others. Extensive capabilities for materials coatings, preparation and analysis are also available.

The department is a participating institution in an NSF-sponsored Center for Dielectric Studies at the Pennsylvania State University. Dielectric ceramics for high energy density applications form a major focus of the department's research activities in this center.

**Degree Requirements**

M.S. and Ph.D. degrees are offered in Materials Science and Engineering. Students may apply for either degree and may be admitted directly to the Ph.D. program upon approval (i.e., there is no M.S. requirement). Depending upon their intended career path, students may be encouraged to pursue one of the MSE graduate degrees or other degree programs noted above.

The total number of hours required for the M.S. in Materials Science and Engineering is 30. The M.S. with thesis is oriented toward the completion of a research project and the degree requirements are 18 hours of course work and 12 hours of research. It is recommended that the student complete the core courses offered by the department including MS&E 421, MS&E 422 and MS&E 423, which are graduate level crystallography, thermodynamics and kinetics. At least 6 hours of course work must be 400 level courses. It is recommended that six additional hours be completed outside of the department. The other courses are chosen with the approval of the advisor.

For the non-thesis M.S. degree in Materials Science and Engineering, 30 hours of course work must be completed with a minimum of 12 hours at the 400 level.

The total number of hours required for the Ph.D. degree in Materials Science and Engineering is 72. Ph.D. students are required to complete the three core courses, MS&E 421, MS&E 422, and MS&E 423. To advance to Ph.D. candidacy, the student must take and pass a qualifying exam. This must be completed prior to the beginning of the fifth semester after entering the graduate program. Students must also take and pass the comprehensive exam in accordance with Missouri S&T rules.

Mohsen Asle Zaeem, Assistant Professor  
PHD Washington State University

Richard K Brow, Curators Professor  
PHD Pennsylvania State University  
Senior Investigator, Graduate Center for Materials Research. Physics and chemistry of inorganic glasses; spectroscopic characterization of glass structure; biomaterials; optical materials.

Fatih Dogan, Professor  
PHD Technical University of Berlin  
High temperature superconductors, solid oxide fuel cells, dielectrics, nanostructured electronic ceramics.

William G Fahrenholtz, Curators Professor  
PHD University Of New Mexico Main  
Thermodynamics, phase equilibria, reactive processing, ultra-high temperature ceramics.

Gregory E Hilmas, Curators Professor  
PHD Univ. of Michigan - Ann Arbor  
Senior Investigator, Graduate Center for Materials Research. Microstructure-processing-mechanical property relationships in structural ceramics; novel processing techniques for the fabrication of ceramics and ceramic composites; biomaterials.

Wayne Huebner, Professor  
PHD University Of Missouri-Rolla
Department Chair. Structure-property relationships in ferroelectric, piezoelectric, and ionically-conducting materials.

**F Scott Miller.** Associate Teaching Professor  
PHD University of Missouri-Rolla  
Electron microscopy, materials characterization.

**Michael Scott Moats.** Associate Professor  
PHD University of Arizona

**Joseph W Newkirk.** Associate Professor  
PHD University Of Virginia Main Ca  
Intermetallic alloys, alloys for corrosion and high temperature, powder metallurgy.

**Matthew J Okeefe.** Professor  
PHD University Of Illinois Urbana  
Thin film and coating materials deposition, process development and characterization.

**Kent Dean Peaslee.** Curator Teaching Professor¹  
PHD University Of Missouri-Rolla  
F. Kenneth Iverson Chair of Steelmaking Technology. Manufacturing and process metallurgy, environmental concerns and recycling in metals industry.

**Mohamed N Rahaman.** Professor  
PHD University of Sheffield (UK)  
Processing of ceramics; sintering and microstructure control; biomaterials.

**Van L Richards.** Professor  
PHD University Of Michigan Ann Arb  
Metal casting, mold materials, property enhancement of cast alloys.

**Jeffrey D Smith.** Associate Professor  
PHD University of Missouri - Rolla  
Thermochemistry and high temperature phase equilibria of condensed and non-condensed ceramic systems; chemical, mineralogical and microstructural analysis of refractory materials.

**David C Van Aken.** Curator Teaching Professor¹  
PHD University Of Illinois Urbana  
Thermal spraying, fatigue and fracture, rapid solidification, advanced alloy design, electron microscopy.

**Jeremy Lee Watts.** Research Assistant Professor  
PHD Missouri S&T

**Mathematics and Statistics**

The Department of Mathematics and Statistics offers programs leading to the M.S. in applied mathematics, either with or without a thesis, the Master of Science for Teachers degree, and the Ph.D. in Mathematics. The M.S. in applied mathematics and the Ph.D. in mathematics can be pursued with either a mathematics or a statistics emphasis. The M.S. is recommended, but not required, as a prerequisite for the Ph.D. If you intend to pursue the doctorate without obtaining a master's degree, 32 hours of graduate credit are required before you may register as a doctoral candidate. These hours should be selected so that you will have obtained an introduction to modern and linear algebra, analysis, statistics and topology if selecting the mathematics emphasis, and to linear algebra, probability and mathematical statistics, and statistical inference if choosing the statistics emphasis, by the end of your first year of graduate study.

The program for the M.S. degree without a thesis must include at least 33 hours of graduate credit, nine hours of which must be lecture courses at the 400-level. For the M.S. degree with thesis, the program must include at least 30 hours of graduate credit, at least six hours of which must be lecture courses at the 400-level and six or more hours of which must be Graduate Research, MATH 490 or STAT 490. Candidates in a non-thesis program must pass a final comprehensive examination while candidates in a thesis program must pass an oral thesis defense. All M.S. candidates are encouraged to include in their program courses in engineering and science which are closely related to their research in Mathematics or Statistics. For those intending to terminate study at the M.S. level, specializations supporting specific career goals are possible.

The Master of Science for Teachers program is primarily designed for secondary school teachers in the Physical Sciences and Mathematics. The program of study must include at least 32 hours of courses numbered above 200 in Science and Mathematics, three hours of which must be at the 400-level. Candidates must pass a final comprehensive examination.

The Mathematics and Statistics Department also offers graduate certificates in Financial Mathematics, Psychometrics, and Statistics (See Academic Programs for graduate certificate details.)

A program for the Ph.D. degree includes about 30 hours of breadth in graduate level Mathematics and Statistics, about 30 hours of courses in or outside of the department representing a field of specialization, and about 30 hours devoted to the dissertation. The specific program for a candidate is designed jointly by the candidate and the candidate’s advisory committee. A qualifying examination, usually taken soon after completion of the M.S. degree or equivalent course work, is required. For those obtaining a doctoral degree with emphasis in Mathematics a reading knowledge of one modern foreign language, typically either French, German, or Russian, is required. Those whose doctoral emphasis is statistics, knowledge in a programming language such as C, C++, or Fortran and programming expertise demonstrated through an approved project is required. At times approved by the advisory committee, candidates must pass both written and oral comprehensive examinations. These examinations may cover courses outside the department. The dissertation is expected to represent original research and to meet the standard ordinarily required for publication in one of the journals devoted to reporting research in the selected field.

 Fellowships and graduate assistantships are available to qualified applicants. Detailed information about these opportunities may be obtained from the department chair or the director of graduate studies. Additional information is available electronically at: http://math.mst.edu/

The department faculty and graduate students, along with graduate instruction and research activities, are housed in the Rolla Building. The Rolla Building, erected 1871, was the original home of the University of Missouri School of Mines and Metallurgy.

**Akim Mouhamadou Adekpedjou.** Assistant Professor  
PHD Univ Of South Carolina Columbi  
Recurrent event data analysis, stochastic processes, survival analysis, actuarial science.

**Elvan Akin.** Associate Professor  
PHD Univ Of Nebraska Lincoln
Ordinary differential equations, difference equations, boundary value problems, oscillation, dynamic equations on time scales.

**Wlodzimierz Jan Charatonik**, Professor  
PHD Warsaw University  
Topology, continuum theory, hyperspaces, inverse limits.

**Stephen L Clark**, Professor  
PHD Univ. of Tennessee-Knoxville  
Operator theory, direct and inverse spectral theory, boundary value problems.

**Roman Dwilewicz**, Professor  
PHD University of Warsaw, Poland  
Geometric analysis, complex analysis, algebraic geometry, number theory.

**Gregory Gelles**, Professor  
PHD West Virginia University  
Department Chair. Finance, risk and uncertainty, mathematical analysis.

**David E Grow**, Associate Professor  
PHD Univ Of Nebraska Lincoln  
Fourier analysis, mathematical physics, functional analysis.

**Barbara N Hale**, Professor  
PHD Purdue University Main Campus  
Theoretical atmospheric physics involving studies of nucleation and growth of ice.

**Leon M Hall**, Professor  
PHD University Of Missouri-Rolla  
Department Chair. Ordinary differential equations, mathematical analysis, geometry.

**Xiaoming He**, Assistant Professor  
PHD Virginia Polytechnic Institute  
Computational partial differential equation, computational fluid dynamics, computational electromagnetic, interface problems, stochastic partial differential equations, extrapolation, boundary integral equations.

**Eugene M Insall Jr**, Associate Professor  
PHD University Of Houston  
Algebra, nonstandard methods, logic, applications.

**Vy Khoi Le**, Professor  
PHD University Of Utah  
Nonlinear differential equations, bifurcation, calculus of variations.

**Gayla Renee Olbricht**, Assistant Professor  
PHD Purdue University  
Statistical genomics and epigenomics, hidden Marker models, mixed models, and modeling dependent data.

**Robert L. Paige**, Associate Professor  
PHD Colorado State University  
Saddlepoint approximations, non-parametric methods, biostatistics.

**Robert Paul Roe**, Associate Professor  
PHD University Of Wyoming  
Chaotic dynamical systems, topological dynamics, geometric topology, geometric analysis.

**V A Samaranayake**, Professor  
PHD Kansas State Univ Of Agricultu  
Reliability, time series analysis, statistical applications in biology, economics, and engineering.

**Yanzhi Zhang**, Assistant Professor  
PHD National Univ of Singapore  
Computational and applied mathematics, multiscale material modeling and simulation, optimal control problems, Bose-Einstein condensation and superconductivity.

# Mechanical Engineering

The Mechanical Engineering Program in the Department of Mechanical and Aerospace Engineering offers comprehensive graduate education in a number of areas. The principal areas include: dynamics and controls; manufacturing; materials and structures; mechanical design; and thermal and fluid systems. A wide variety of interdisciplinary programs meeting specific objectives are available. The Mechanical Engineering Program offers the master of science, doctor of philosophy, and doctor of engineering degrees.

The department offers several graduate certificate programs in both Aerospace Engineering and Mechanical Engineering. Details of certificate programs can be found at the end of the Mechanical Engineering program listing.

The master of science thesis program consists of a minimum of 30 semester hours, including 21 hours of course work with nine hours from the mechanical engineering core curriculum and at least six hours in mathematics and/or computer science. At least six credit hours of 400-level course work must be from the major field of study. In addition, a thesis from research that is equivalent to at least six credit hours in a major area must be prepared. A master of science non-thesis program consists of a minimum of 30 semester hours, including at least 21 hours of course work within the department, of which six hours must be from two mechanical engineering areas in the mechanical engineering core curriculum, and at least six hours from outside the department. At least nine credit hours of 400-level course work must be from the major field of study.

The Mechanical Engineering core curriculum consists of six areas: fluid mechanics; manufacturing; materials and structures; mathematics and computer science; mechanics and system design; and thermal science.

A candidate for the degree of doctor of engineering must complete the equivalent of three years (six semesters) of full-time work beyond the bachelor's degree for a total of at least 90 semester hours. The six semesters must include a minimum of two semesters in residence at Rolla with a graduate registration of at least 12 hours per semester. At least two semesters above the M.S. must be in residence at Missouri S&T with a registration of at least six hours per semester. The course work must be directed toward two major engineering areas plus one area from the physical sciences, mathematics, or another field of engineering. In addition, a non-technical group of courses of 9 to 12 hours is required. The formal course work is expected to consist of at least 65 hours (the average is 72 hours). In addition to the formal course work, the candidate is expected to complete an internship with an industrial organization. This internship will consist of a minimum of one year of planned and approved high-level engineering experience. At the end of the internship period, the candidate will prepare a dissertation which will earn from 18 to 25 hours credit and will be included in the total of 90 hours for the degree of doctor of engineering.
A student pursuing the doctor of philosophy degree normally follows a program of 90 semester hours beyond the B.S. degree or 60 semester hours beyond the M.S. degree. For those with M.S. degree, the 60 hours will consist of 24 hours of course work and 36 hours of thesis research. The Ph.D. course work must satisfy the departmental core course requirements for the M.S. degree. For the 24 hours of course work, a minimum of 12 hours must be completed within the department and at least three credit hours of mathematics/statistics. At least nine credit hours of course work must be at the 400-level in the major field of study. In addition to these course requirements, a candidate must prepare a dissertation based on analytical and/or experimental research in a major area. This research must be equivalent to a minimum of 36 hours beyond the M.S. degree. There are no foreign language requirements for the master of science, doctor of engineering and doctor of philosophy degrees in mechanical engineering. However, a reading knowledge of one foreign language, German, French or Russian, may be required for the doctor of philosophy degree if the candidate’s advisory committee feels that it is necessary.

A candidate for the degree of doctor of philosophy must pass a qualifying examination. The qualifying examination consists of taking a minimum of nine credit hours of approved graduate course work at the 300- and 400-level, including six hours in the major field, of which three hours must be at the 400-level, and three hours of mathematics/statistics. To pass the qualifying examination, a student must have obtained a grade of B or better for all the courses with a GPA of at least 3.25.

The comprehensive examination and the final examination, consisting of the dissertation defense, are conducted according to the rules of the Graduate Faculty and the department. The Graduate Faculty has residency requirements which must be satisfied by all doctoral students.

Some examples of research areas a candidate could specialize in are: acoustics; biomechanics; combustion and I. C. engines; computational fluid dynamics; computer-aided design; design methodology; dynamics and controls; heating, ventilation and air-conditioning (environmental control); heat transfer; laser-aided manufacturing; manufacturing and machining processes; materials and structures; mechanisms and robotics; mechatronics; micro-electromechanical systems (MEMS); thermal-fluid and energy systems; tribology; virtual reality and rapid prototyping.

The Department of Mechanical and Aerospace Engineering has many well-equipped laboratories that are located on the main campus, and a subsonic-flow laboratory in an off-campus facility. Some of the specially equipped laboratories on campus include: aerospace flow laboratory; advanced machining laboratory, augmented reality laboratory, composite materials manufacturing and characterization laboratory, computational radiative transfer laboratory, convection heat transfer laboratory, electromechanical transducer development laboratory, environmental control group laboratory, fluid dynamics and combustion laboratories, internal combustion engine and spray laboratories, laboratory for industrial automation and flexible manufacturing, laser-based manufacturing laboratory, rapid prototyping laboratory, radiative heat transfer laboratory, robotics laboratory, structural health monitoring laboratory and welding laboratory.

Graduate Certificate Programs (MAE)

The Department of Mechanical and Aerospace Engineering offers six Graduate Certificate programs. The certificate program consists of a four-course sequence from existing graduate-level courses. The Graduate Certificate program is available to all individuals holding a BS degree in an appropriate engineering discipline who have a minimum of two years of professional experience or are currently accepted into a graduate degree program in the Department of Mechanical and Aerospace Engineering. While the students admitted to the Certificate Program will have non-matriculated status, if they complete the four-course sequence with a grade of B or better in each of the courses taken, they will be admitted to the M.S. program if they so choose. The Certificate credits taken by students admitted to the M.S. program will count toward their master’s degrees. Currently, most classes offered in the Graduate Certificate are offered over the internet.

**CAD/CAM and Rapid Product Realization**

Graduate Certificate Curriculum

<table>
<thead>
<tr>
<th>Area I.</th>
<th>MECH ENG</th>
<th>Principles And Practice Of Computer Aided Design 363</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area II.</td>
<td>MECH ENG</td>
<td>Rapid Product Design And Optimization 308</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>ENG MGT 354 Integrated Product And Process Design or MECH ENG Integrated Product And Process Design 357</td>
<td></td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>MECH ENG</td>
<td>Advanced Topics In Design And Manufacturing 459</td>
</tr>
<tr>
<td>Area III.</td>
<td>MECH ENG</td>
<td>Design For Manufacture 356</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>AERO ENG 301 Special Topics or ENG MGT 301 Special Topics or MECH ENG Special Topics 301</td>
<td></td>
</tr>
</tbody>
</table>

**Composite Materials and Structures**

Graduate Certificate Curriculum

Students enrolled in this graduate certificate program will take the four courses from the following. Alternative courses can be substituted with the departmental approval dependent on the availability of the courses listed below:

<table>
<thead>
<tr>
<th>MECH ENG 336</th>
<th>Fracture Mechanics</th>
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</thead>
<tbody>
<tr>
<td>or AERO ENG 336</td>
<td>Fracture Mechanics</td>
</tr>
<tr>
<td>MECH ENG 382</td>
<td>Introduction To Composite Materials &amp; Structures</td>
</tr>
<tr>
<td>or AERO ENG 311</td>
<td>Introduction To Composite Materials &amp; Structures</td>
</tr>
<tr>
<td>MECH ENG 484</td>
<td>Analysis Of Laminated Composite Structures</td>
</tr>
<tr>
<td>or AERO ENG 484</td>
<td>Analysis Of Laminated Composite Structures</td>
</tr>
</tbody>
</table>
Degree Programs

MECH ENG 485 Mechanics Of Composite Materials
or AERO ENG 485 Mechanics Of Composite Materials

This certificate program allows working professionals to keep current with the rapid pace of technological changes in the area of engineering mechanics and to earn a graduate certificate in their field of interest. Furthermore, this program provides students with the opportunity to improve their academic record for possible admission to the MS degree program in Mechanical or Aerospace Engineering. All courses are available over the Internet.

The certificate program consists of four courses delivered as part of the MS degree program in Engineering Mechanics. Choose classes covering topics like continuum mechanics, solid mechanics, stability, fracture mechanics, composites, fatigue analysis, plates, shells, and laminated composites.

Engineering Mechanics
Graduate Certificate Curriculum

Students enrolled in this Graduate Certificate program will have a choice from the following list of courses offered to graduate students in Mechanical or Aerospace Engineering:

MECH ENG 311 Introduction To Continuum Mechanics
MECH ENG 320 Advanced Mechanics of Materials
or AERO ENG 320 Advanced Mechanics of Materials
MECH ENG 334 Stability Of Engineering Structures
or AERO ENG 334 Stability Of Engineering Structures
MECH ENG 336 Fracture Mechanics
or AERO ENG 336 Fracture Mechanics
MECH ENG 338 Fatigue Analysis
or MECH ENG 338 Interdisciplinary Problems In Manufacturing Automation
MECH ENG 382 Introduction To Composite Materials & Structures
or AERO ENG 311 Introduction To Composite Materials & Structures
MECH ENG 422 Applied Linear Elasticity
or AERO ENG 422 Applied Linear Elasticity
MECH ENG 430 Theory Of Plates
MECH ENG 484 Analysis Of Laminated Composite Structures
or AERO ENG 484 Analysis Of Laminated Composite Structures

Manufacturing Systems
Graduate Certificate Curriculum

For the Manufacturing Systems Graduate Certificate Program the students will need to take a four course sequence, one each from the four core areas in the Manufacturing Engineering program as outlined below:

Course I - Materials and Manufacturing Processes
Select one of the following:
MECH ENG Introduction To Composite Materials & Structures 382
MET ENG 305 Nondestructive Testing
MET ENG 307 Metals Casting
MS&E 325 Materials Selection in Mechanical Design

Course II - Process, Assembly and Product Engineering
Select one of the following:
ENG MGT 354 Integrated Product And Process Design
or MECH ENG Integrated Product And Process Design 357
MECH ENG Rapid Product Design And Optimization 308
MECH ENG Principles And Practice Of Computer Aided Design 363

Course III - Manufacturing Competitiveness
Select one of the following:
ENG MGT 309 Six Sigma
AERO ENG Probabilistic Engineering Design 360
or MECH ENG Probabilistic Engineering Design 360
ENG MGT 364 Value Analysis
ENG MGT 372 Production Planning And Scheduling
ENG MGT 385 Statistical Process Control
ENG MGT 472 Lean Systems

Course IV – Manufacturing Systems Design
Select one of the following:
MECH ENG Design For Manufacture 356
ENG MGT 334
MECH ENG Manufacturing Equipment Automation 355
MECH ENG Advanced Topics In Design And Manufacturing 459

Manufacturing Automation
Graduate Certificate Curriculum

Students pursuing a graduate certificate in Manufacturing Automation through the Mechanical Engineering or Engineering Management programs will select two courses from Group I and two courses from Group II.

Group I
Select two of the following:
AERO ENG Special Topics 301
Mechanical and Aerospace Control Systems

Graduate Certificate Curriculum

Students pursuing a graduate certificate in Control Systems will select two courses from Group I and two courses from Group II.

**Group I**

Select two of the following:

- **MECH ENG** Mechanical And Aerospace Control Systems 381
- or **AERO ENG** Mechanical And Aerospace Control Systems 381
- **MECH ENG** Special Topics 401
- or **AERO ENG** Special Topics 401
- **MECH ENG** Analysis And Synthesis Of Mechanical And Aerospace Systems 479
- or **AERO ENG** Analysis And Synthesis Of Mechanical And Aerospace Systems 479

**Group II**

Select two of the following:

- **AERO ENG** Flight Dynamics-Stability And Control 361
- **ELEC ENG** Digital Control 331
- **ELEC ENG** Linear Control Systems 431
- **ELEC ENG** Optimal Control And Estimation 432
- **MECH ENG** Mechanical And Aerospace Control Systems 381
- or **AERO ENG** Mechanical And Aerospace Control Systems 381
- **MECH ENG** Special Topics 401
- or **AERO ENG** Special Topics 401
- **MECH ENG** Analysis And Synthesis Of Mechanical And Aerospace Systems 479
- or **AERO ENG** Analysis And Synthesis Of Mechanical And Aerospace Systems 479

**Howard R. Appelman**, Adjunct Associate Professor

MBA Washington University

**Bassem F Armaly**, Curators Professor Emeritus

PHD University Of California-Berke

Heat transfer and fluid mechanics, thermophysical properties, heat pipes, combined conduction-convection and radiation heat transfer problems, solar energy, cryogenics, and thermal effects in manufacturing processes.
S N Balakrishnan, Curators Professor
PHD University Of Texas Austin
Control of aerospace and mechanical systems, flight and orbital mechanics, optimization identification and estimation, numerical methods and stochastic processes, neural networks, wavelets.

Arindam Banerjee, Adjunct Assistant Professor
PHD Texas A&M Univ College Station

Victor Birman, Professor
PHD Technion, Haifa, Israel
Director Engineering Education Center in St. Louis. Composite material structures, smart structures and materials, structural dynamics and vibration, buckling and dynamic stability.

Douglas A. Bristow, Assistant Professor
PHD University Of Illinois Urbana

K Chandrashekhara, Curators Professor
PHD Virginia Polytechnic Institute
Composite materials, smart structures, structural dynamics, finite element analysis, composite manufacturing and experimental characterization.

Alfred Linden Crosbie, Curators Professor
PHD Purdue University Main Campus
Multidimensional radiative heat transfer, laser processing of materials, radiative heat transfer in combustion processes, microscale heat transfer, biomedical optics, interaction of radiation with conduction and convection, multiple scattering and polarization of laser beams, solutions of integral equations, and numerical heat transfer.

Lokeswarappa R Darhali, Curators Professor
PHD Clemson University
Senior Investigator in Graduate Center for Materials Research. Micromechanics of bi-material interfaces, composite materials, fracture mechanics, fatigue and failure analysis of welded structures, wear and friction in composites, fracture and failure of laminated glass.

James A Drallmeier, Curator Teaching Professor
PHD University Of Illinois Urbana
Department Chair. Combustion, laser based diagnostics for sprays and combustion, optical measurement systems, fuel injection, and internal combustion engines.

Walter Eversman, Curators Professor
PHD Stanford University Main Campus
Noise control, acoustics, vibrations, aircraft structural dynamics and aeroelasticity, systems and control.

Jie Gao, Assistant Professor
PHD Columbia University
Nanophotonics devices based on silicon photonics, plasmonics and metamaterials; light-matter interactions in photonic nanostructures; optical sensing; quantum dots; quantum optics and quantum information processing; solar energy harvesting; light emitting devices.

Abhijit Gosavi, Assistant Professor
PHD University Of South Florida
Supply chain management, simulation based optimization, and lean enterprise.

Kelly O Homan, Associate Professor
PHD University Of Illinois (UIUC)

Fluid dynamics, heat transfer and thermodynamics of energy systems, heat and mass transfer in buoyant flows, second-law and energy analysis, numerical simulation of transport phenomena and experimental methods.

Serhat Hosder, Assistant Professor
PHD Virginia Tech
Computational fluid dynamics, aerodynamics, multidisciplinary design and optimization, uncertainty and error quantification in computational simulations, robust design, micro/nano flows, hypersonic flows, numerical methods.

Kakkattukuzhi M Isaac, Professor
PHD Virginia Polytechnic Institute
Associate Chair for Aerospace Engineering. Fluid dynamics and combustion, aero-structure interaction and control, intelligent aircraft, active flow control, wave-riders, microfluidics, MEMS, flow and combustion in porous media, multiphase flow, emissions from combustion and evaporative systems, lean premixed combustion, combustion instability, active combustion control, atomization and sprays, particle image velocimetry (PIV) and CFD applications in fluid dynamics and combustion problems.

Edward C Kinzel, Assistant Professor
PHD Purdue University
Infrared metamaterials for radiation heat-transfer, optical antennas, near-field optics, and nanophotonics for laser based manufacturing, particularly at the micro/nanoscale and direct energy conversion.

Ronald Allen Kohser, Professor
PHD Lehigh University
Metal forming, surface and wear behavior.

Umit O Koylu, Professor
PHD University of Michigan Ann Arbor
Combustion, environmental technology, soot formation, turbulent flames, laser diagnostics, flame radiation, formation and emission of pollutants, synthesis of nanoparticles, micro-energy systems.

K Krishnamurthy, Professor
PHD Washington State University
Vice Provost for Research. Advanced manufacturing systems, intelligent control, micro-electromechanical systems, nanotechnology, robotics.

Robert G Landers, Professor
PHD University Of Michigan Ann Arbor
Manufacturing, systems, and control; modeling, analysis, monitoring, and control of manufacturing processes; metal cutting processes; laser metal deposition; friction stir welding; freeze extrusion fabrication; integrated design and control; control of alternative energy systems; digital control applications.

Ming C Leu, Professor
PHD University Of California-Berke
Rapid prototyping, intelligent manufacturing, virtual reality, CAD/CAM, robotics, mechatronics, automatic control.

FueWen Frank Liou, Professor
PHD Univ Of Minnesota Twin Cities
Michael and joyce Bytnar Product Innovation and Creativity Professor of Mechanical Engineering; Director of Manufacturing Engineering. Computer-aided design and manufacturing, rapid prototyping, rapid manufacturing, virtual manufacturing, and micro-machining.
Metallurgical Engineering

The metallurgical engineering program in the Department of Materials Science & Engineering offers comprehensive graduate education in a number of areas including physical and mechanical metallurgy, extractive metallurgy, metals casting, joining and forming, and manufacturing metallurgy. Additional research opportunities include friction stir welding and friction stir processing. Further information on these opportunities and facilities available to carry out research in metallurgical engineering may be found under Materials Science & Engineering.

Degree Requirements

M.S. and Ph.D. degrees are offered in Metallurgical Engineering. Recognizing the educational value of research, most metallurgical engineering M.S. degree candidates complete a thesis program. Non-thesis exceptions may be granted in special circumstances.

The total number of hours required for the M.S. in Metallurgical Engineering is 30. A minimum of 6 hours 400 level lectures and a minimum of 11 hours graduate research on the Missouri S&T campus are required. A maximum of 6 hours 200 level lectures may be accepted.

The minimum number of hours (beyond the bachelor's degree) required for the Ph.D. in Metallurgical Engineering is 72. At least 12 hours of course work outside metallurgy is recommended, a minimum of 24 hours will be dissertation research, and a minimum of 24 hours must be course work. Students will also be required to take and pass qualifying and comprehensive exams in accordance with Missouri S&T rules.

Lana Zarkia Alaga, Assistant Professor
PHD University of Texas at Dallas

Mohsen Asle Zaeem, Assistant Professor
PHD Washington State University

A Curt Elmore, Professor
PHD University Of Arizona
Groundwater remediation, groundwater development, stochastic analysis, and remedial design.

Gregory E Hilmas, Curators Professor
PHD Univ. of Michigan - Ann Arbor
Senior Investigator, Graduate Center for Materials Research. Microstructure-processing-mechanical property relationships in structural ceramics; novel processing techniques for the fabrication of ceramics and ceramic composites; biomaterials.

Wayne Huebner, Professor
PHD University Of Missouri-Rolla
Department Chair. Structure-property relationships in ferroelectric, piezoelectric, and ionically-conducting materials.

Ronald Allen Kohser, Professor
PHD Lehigh University
Metal forming, surface and wear behavior.

Arvind Srivastava Kumar, Professor
PHD University Of California-Berke
Program Chair. Nuclear materials, radiation damage, and mechanical properties.

F Scott Miller, Associate Teaching Professor
PHD University of Missouri-Rolla

Ashok Midha, Professor
PHD Univ Of Minnesota Twin Cities
Director of the Product Innovation Creativity Center. Mechanical design, rigid-body and compliant mechanism design, high-performance machinery analysis and design, machine vibration and stability.

J Keith Nisbett, Associate Professor
PHD University Of Texas Arlington
Associate Chair for Mechanical Engineering. Kinematics, mechanical design, and synthesis of mechanisms.

Anthony Chukwujekwu Okafor, Professor
PHD Michigan Technological University
Manufacturing including intelligent machining, metal forming, machine tool dynamics, acoustic emission, sensors, multi-sensor fusion and signal processing, CNC, CAD/CAM, virtual manufacturing, machine tool metrology, neural network and expert system applications; smart structures including intelligent health monitoring, damage assessment of composite structures; non-destructive evaluation.

David W Riggins, Professor
PHD Virginia Tech
Fluid dynamics, computational fluid dynamics, hyper/sonic propulsion systems, computational analysis of jet mixing, flow losses and mixing enhancement in combustors, aircraft gas turbine scramjet propulsion systems, and scramjet performance.

Joshua Lucas Rovey, Assistant Professor
PHD University Of Michigan Ann Arbor
Plasma aerospace applications, advanced plasma space propulsion, Hall thrusters, ion thrusters, plasma aerodynamics and flow control, plasma-enhanced combustion, plasma-based energy systems, hypersonics/ re-entry body plasma interactions, plasma physics and rarefied gas dynamics.

Daniel S Stutts, Associate Professor
PHD Purdue University Main Campus
Dynamics, vibrations, modeling and development of piezo-actuators and transducers-mechatronics, mechanics of bone, design of orthopedic implants, structural dynamics, optimal design, acoustics.

Hailung Tsai, Professor
PHD University Of California-Berkeley
Solidification processes, heat transfer and fluid mechanics in materials processing and manufacturing (alloy casting, welding, crystal growth, metal matrix composites, injection molding), laser-based manufacturing (laser welding, cladding, micro-machining, rapid prototyping).

Donald C Wunsch II, Professor
PHD University Of Washington
Adaptive critic designs, neural networks, fuzzy systems, surety, nonlinear adaptive control, intelligent agents, applications.

Xiaodong Yang, Assistant Professor
PHD Columbia University
Optical materials and devices in nanophotonics and plasmonics; physics and applications of optical metamaterials; nanoscale optomechanics, optical nanoelectromechanical systems (NEMS); integrated optofluidic devices and optical sensors; photon management for solar/thermal energy harvesting; optical device micro-/nano-fabrication.
Electron microscopy, materials characterization.

Michael Scott Moats, Associate Professor
PHD University of Arizona

Joseph W Newkirk, Associate Professor
PHD University Of Virginia Main Ca

Intermetallic alloys, alloys for corrosion and high temperature, powder metallurgy.

Matthew J Okeefe, Professor
PHD University Of Illinois Urbana

Director of Materials Research Center. Thin film and coating materials deposition, process development and characterization.

Kent Dean Peaslee, Curator Teaching Professor¹
PHD University Of Missouri-Rolla

F. Kenneth Iverson Chair of Steelmaking Technology. Manufacturing and process metallurgy, environmental concerns and recycling in metals industry.

Von L Richards, Professor
PHD University Of Michigan Ann Arb

Metal casting, mold materials, property enhancement of cast alloys.

David C Van Aken, Curator Teaching Professor¹
PHD University Of Illinois Urbana

Thermal spraying, fatigue and fracture, rapid solidification, advanced alloy design, electron microscopy.

Jeremy Lee Watts, Research Assistant Professor
PHD Missouri S&T

Mining Engineering

The Mining Engineering Program in the Department of Mining and Nuclear Engineering offers the Master of Engineering (M.E.), Master of Science (M.S.), Doctor of Philosophy (Ph.D.), and Doctor of Engineering (D.Eng.) degrees in Mining Engineering. The M.S. and Ph.D. degrees require research components for program completion. The core research strength include surface and underground mining methods and machinery, mine planning and design, rock mechanics and ground control, explosives sciences and engineering, systems engineering and operations research, waterjet and novel excavation engineering, mine plant design and maintenance, mine health and safety, mine ventilation and atmospheric control, coal mining, mining economics, and environmental aspects of mining.

The M.S. degree requires a minimum of 30 credit hours, including the required research for the thesis. Minimum requirements include 6 credit hours for 400-level courses, 6 credit hours for courses outside the major and 6 credit hours toward thesis research. M.S. candidates must pass a final oral examination of the thesis. The Ph.D. degree in Mining Engineering requires a minimum of 3 years of full-time study beyond the bachelor’s degree, including research work for the dissertation. Ph.D. candidates must complete at least 15 credit hours of course work at Missouri S&T and are required to pass the qualifying, comprehensive and final oral examinations of the Ph.D. research. The M.E. degree is distance education-based and requires a problem report or design project for program completion. This graduate catalog must be consulted for all the detailed regulations and requirements for completing any graduate degree in Mining Engineering at Missouri S&T.

Graduate studies and research are greatly enhanced by laboratories in McNutt Hall (on Missouri S&T campus) and major research facilities (on university property a short distance southwest of the campus). A mine ventilation laboratory provides facilities for detailed studies of airflow and air distribution. The rock mechanics laboratory offers modern facilities for the mechanical testing of rocks by universal testing machines, direct shear apparatus, and various nondestructive techniques. A state-of-the-art Computer Learning Center supports graduate studies, and a broad suite of mining-related software applications is available. Industry sites also provide appropriate experimental research facilities and equipment to aid faculty research.

Major facilities include the Rock Mechanics and Explosive Research Center (RMERC), Virtual Surface Mining Facility (VSMF), and the Experimental Mine. RMERC, founded in 1964, provides research leadership in a broad range of scientific and engineering fields. RMERC houses research facilities and equipment for conducting rock mechanics, high-pressure waterjet and explosives and propellant science and engineering. VSMF consists of a virtual surface mine simulator for research and operator training.

Missouri S&T’s Experimental Mine is one of only a few such facilities found on a university campus for mineral engineering education purposes. The facility is used primarily for instruction and research in mining and other engineering disciplines. The experimental mine has more than 1,500 linear feet of horizontal underground passages with two adits, four vertical shafts and two adjacent quarries. The mine plant has electrical power, compressed air, water supply, track haulage, and other mining equipment for major research investigations. A high-capacity fan provides air for the mine during its operation and actual underground mine conditions for airflow studies. A portion of the ventilation laboratory, located on the surface, contains modern equipment for mine gas detection, dust analysis, air conditioning, and fan performance studies. This facility is also used for hands-on research and various engineering studies.

Lana Zakaria Alagha, Assistant Professor
PHD University of Texas at Dallas

Nassib Samir Aouad, Assistant Teaching Professor
PHD Missouri University of Science

Kwame Awuah-Offei, Assistant Professor
PHD University Of Missouri-Rolla

Dredging, environmental and reclamation engineering, formation excavation, mineral processing, systems modeling and optimization.

Jason Baird, Associate Professor
PHD University of Missouri - Rolla

Defense against blast, energetic materials, advanced composite materials, explosive taggants, structural integrity of materials, explosive-driven pulsed power.

Samuel Frimpong, Professor¹
PHD University of Alberta, Canada

Chair of Mining and Nuclear Engineering and Robert H. Quenon Endowed Chair Professor. Surface mining, oil sands extraction, machine-information interactions, mine machinery health and longevity, bulk material transport, risk and safety engineering, operations research.

Grzegorz Galecki, Associate Professor
PHD Wroclaw Tech Univ - Poland
High-pressure waterjet technology, designing special equipment and processes supported by waterjets, design for manufacturing, computer integrated manufacturing.

**Mao Chen Ge**, Associate Professor  
PHD Penn State University  
Rock mechanics, ground support, ground movement, mathematical modeling.

**Gregory Gelles**, Professor  
PHD West Virginia University  
Finance, risk and uncertainty, mathematical analysis.

**Leslie Sour Gertsch**, Associate Professor  
PHD Colorado School Of Mines  
Rock mechanics, mechanical mining and excavating, mine design and rock fragmentation.

**Argyle Douglas Stewart Gillies**, Professor  
PHD University of New South Wales  
Explosives, blasting and excavation engineering, commercial pyrotechnics.

**Nuclear Engineering**

The Nuclear Engineering Graduate Program offers the Master of Science, the Doctor of Engineering, and the Doctor of Philosophy degrees. B.S. in a field of engineering or any physical science is a prerequisite for admission into the nuclear engineering graduate program. The master’s degree program is designed to provide training and expertise in the design of nuclear energy systems, use of nuclear technology for medical as well as industrial applications. Both thesis and without thesis options are available for M.S. degree program with a minimum of 30 credit hours required for successful completion. Research areas of specialization include:

- Reactor design and safety
- Thermal hydraulics
- Radiation effects
- Radiation dosimetry, protection and health physics
- Radiation transport and shielding
- Space nuclear power
- Materials for nuclear applications
- Nuclear fuel cycle
- Radioactive waste management
- Radiation imaging
- Radiation measurements and spectroscopy

For the Ph.D. program, a research project with a written dissertation of high caliber demonstrating candidate’s capacity to conduct independent and original research, to critically analyze results and to infer sound conclusions is necessary. The dissertation must produce original research results acceptable for publication in a refereed journal. To facilitate high quality research, the nuclear engineering program has the following laboratory facilities:

**Nuclear Reactor**

The Missouri University of Science and Technology Nuclear Reactor (MSTR) is a Nuclear Regulatory Commission (NRC) licensed 200 kilowatt pool-type reactor that is used to support the engineering and science activities on campus. Using the facility, the reactor staff provides hands-on laboratory, research & development and project opportunities. The reactor itself uses uranium fuel and is cooled by natural convection in a pool containing approximately 30,000 gallons of water.

The open pool design allows access to the reactor core where experiments and samples to be irradiated can be positioned. The facility is equipped with a pneumatics sample irradiation system, a neutron beam port that provides a collimated neutron beam, and a thermal column.

**Internet-Accessible Hot Cell Facility**

A dual-chambered internet-accessible heavily shielded facility with pneumatic access to the University of Missouri Science and Technology (Missouri S&T) 200 kW Research Nuclear Reactor (MSTR) allows authorized distance users to remotely manipulate and analyze neutron irradiated samples. The system consists of two shielded compartments, one for multiple sample storage, and the other dedicated exclusively for radiation measurements and spectroscopy. The second chamber has multiple detector ports, with graded shielding, and has the capability to support gamma spectroscopy using radiation detectors such as an HPGe detector. Both these chambers are connected through a rapid pneumatic system with access to the MSTR nuclear reactor core. The total transportation time between the core and the hot cell is less than 3.0 seconds.

**Radiation Measurements Laboratory**

The radiation measurements laboratory is equipped with NIM standard electronic units, neutron and gamma scintillation detectors, solid-state detectors, coincidence electronics, and multi-channel analyzers connected to PCs for automated data analysis. The laboratory also includes two portable EG&G HPGe detector, a Canberra Thermoluminescent dosimeter with state-of-the-art electronics and software, and a Lynx digital data analysis system for remote web-based experimental capacity.

**Nuclear Materials Laboratory**

The facilities of the Materials Research Center, Metallurgical Engineering, and Nuclear Engineering programs are also available for nuclear materials-related research. These facilities include state of the art SEM/EDX, TEM, STEM, FIB/FESEM, and XRD.

**Computer Laboratory**

You will have the opportunity to use large computer codes commonly used in the nuclear industry for reactor core design, radiation transport, and thermal hydraulics analysis. The nuclear engineering program maintains an excellent laboratory with personal computers with access to a campus cluster of numerically intensive computing (NIC) systems.
Two-phase Flow and Thermal-Hydraulics Laboratory (TFTL)

The Nuclear Engineering TFTL is designed to perform both fundamental and advanced two-phase flow experiments simulating prototypic nuclear reactor conditions. The TFTL is equipped with state-of-the-art instrumentation such as a micro multi-sensor conductivity probe, a high-speed digital motion-corder, various flow measurement devices, and a data acquisition system and software. Topics of research studied in the TFTL include advanced two-phase flow modeling, two-phase flow characterization in various flow channel geometries, air-water two-phase bubble jet experiment, secondary flow analysis in liquid film flow, and development of two-phase flow instrumentation.

Advanced Radiography and Tomography Lab

The laboratory is designed to perform radiation imaging for medical or industrial purpose. You will have opportunities of running Monte Carlo simulation codes for radiation imaging systems and experimenting with digital x-ray radiography, x-ray computed tomography, etc. The technologies developed in the lab can be applied to either medical imaging or non-destructive inspection of various materials or objects.

Neutron Generator Laboratory

The neutron generator laboratory has a D-D neutron generator that produces approximately 109 neutrons/sec. The neutron generator is available for both graduate and undergraduate research and education at Missouri S&T. Examples of research using the neutron generator are reactor kinetics research, the study of two-phase flow, research in nuclear forensics and radiochemistry, particle tracking in complex flows, and the photon-neutron tomography for mechanical testing of structural materials.

Muthanna Hikmat Al Dahhan, Professor
PHD Washington University
Department Chair. Multiphase reaction and reactor engineering flow systems; transport-kinetic integration; advanced measurement and computational techniques; applications to green technology and sustainable development in energy, products, and environment.

Ayodeji Babatunde Alajo, Assistant Professor
PHD Texas A & M University
High fidelity nuclear systems design and modeling, advanced fuel cycles, radioactive waste management, and nuclear systems safety.

Carlos Henry Castano, Assistant Professor
PHD University Of Illinois Urbana
Plasma material interactions and vacuum breakdown, nuclear materials, and radiochemistry.

Arvind Srivastava Kumar, Professor
PHD University Of California-Berke
Nuclear materials, radiation damage, and mechanical properties.

Hyoung Koo Lee, Associate Professor
PHD University Of California-Berke
Radiation imaging systems (x-ray, gamma, and neutron), digital image processing and CT reconstruction, medical and industrial applications of radiation imaging.

Xin Liu, Assistant Professor
PHD University of WI - Madison
Radiation detection and measurement, medical imaging system, Monte Carlo simulation, advanced nuclear energy system design.

Gary Edward Mueller, Associate Professor
PHD University of Missouri-Rolla
Nuclear power safety analysis, heat transfer and fluid flow, packed bed characteristics.

Joshua Lucas Rovey, Assistant Professor
PHD University Of Michigan Ann Arb
Plasma aerospace applications, advanced plasma space propulsion, Hall thrusters, ion thrusters, plasma aerodynamics and flow control, plasma-enhanced combustion, plasma-based energy systems, hypersonics/re-entry body plasma interactions, plasma physics and rarefied gas dynamics.

Joseph D Smith, Professor
PHD Brigham Young University
Laufer Chair of Energy. Hybrid energy generation, gas flare design, process modeling, and control.

Shoaib Usman, Associate Professor
PHD University Of Cincinnati
Turbulence and dispersion, environmental radon measurement, radiation measurement and effects on materials, and radiation interaction with fluids.

Petroleum Engineering

The Petroleum Engineering program offers courses of study leading to the Masters of Science, Doctor of Philosophy, or Doctor of Engineering degrees. The master’s degree can be earned with either a thesis option or a non-thesis option.

While the program encourages students with an undergraduate degree in petroleum engineering to pursue graduate study, many graduate students are accepted with backgrounds in other areas of engineering, such as Chemical Engineering, Mechanical Engineering, or Geological Engineering. The program accepts such students with the expectation that any remedial Petroleum Engineering coursework will be met by the student while in residence for the master’s degree. Students with backgrounds in Geology or Geophysics will also need to complete all fundamental engineering courses required for a degree in Engineering.

Graduate students studying for a Masters degree with a thesis option typically find support for their study depending on current research projects and the availability of funding. Students preferring the non-thesis option are typically self-funding for their Masters degree.

Each student’s graduate degree program is designed around a set of core Petroleum Engineering courses and other courses selected to support the thesis topic of interest. Students identify their thesis topic by the end of their first semester.

Research specialties of the Petroleum Engineering program include reservoir enhancement, hydraulic fracturing, CO2 sequestration, gel treatments, drilling, well completion performance studies, and geomechanics of petroleum recovery.

The Program emphasizes mechanical earth modeling as a specialty. The MEM group owns part of the University numerical intensive computing cluster. Students with a strong background in geological engineering and geomechanics will likely find excellent opportunities for advanced studies.
The Petroleum Engineering laboratories contain modern equipment designed to study the many problems encountered in oil and gas production, as well as support research. The department laboratories include gas porosimeter and permeameter, liquid permeameter, viscometers, tensiometers, and a HPTP core flooding cell. The program also utilizes departmental facilities that include core cutting and preparation, laser ablation, XRD, SEM, and a triaxial and fracture cell and a direct shear apparatus for determining rock and fracture properties.

Students externally supported by international oil and gas operating companies may also suggest research topics related to their professional experience or special topics of interest to their companies.

For additional information regarding graduate study opportunity contact rooks@mst.edu. Additional information may also be found at the web pages at: http://gse.mst.edu/ or http://petroleum.mst.edu/.

The department’s research emphasis includes both fundamental and applied studies in three areas of physics: condensed matter, solid state, and materials physics; cloud, aerosol and environmental physics; and atomic, molecular, and optical physics. Experimental and theoretical research opportunities are available for study in each of these areas. Following their core coursework, graduate students in the department are able to work with faculty on a wide range of problems, including the characterization of magnetic materials, predicting the properties of quantum and classical phase transitions, establishing the structure and properties of atmospheric aerosols, investigating electron transport in polymers, determining electron-atom scattering events, characterizing the particulate in rocket engine exhaust, exploring the structural properties of thin magnetic films, computing the electronic structure of new materials, measuring and imaging ion-atom collisions, investigating water and sulfuric acids cluster interactions, analyzing and characterizing nanostructures on surfaces, ascertaining the properties of charged particles and atoms, studying the nucleation of vapors into droplets, growing and characterizing exotic materials, studying wave propagation in complex media, and exploring quantum electrodynamics’ descriptions of few-electron atoms and ions.

The research and computing laboratories of the Physics Department are recently renovated and are continuously being updated. Most of these facilities are in the main Physics Building, but several research studies are being carried out in cloud and aerosol laboratories housed in Norwood Hall. Several faculty working on condensed matter projects make use of extensive instrumentation and materials characterization facilities available in the Materials Research Center. Special facilities include a unique ion-atom accelerator and energy-loss spectrometer, custom UHV systems for preparing and characterizing in situ spin properties of magnetic films, state-of-the-art cloud simulation chambers developed to study nucleation of vapors and droplets, Auger and XPS surface characterization spectrometers, specially developed instrumentation for use in aircraft to study rocket and aircraft exhaust characteristics, positron-ion scattering facilities, Mossbauer and x-ray spectrometers, high performance computer systems for computational physics studies, facilities for the growth of exotic materials, and low temperature transport measurement instruments.

Ronald James Bieniek, Professor
PHD Harvard University
Theoretical atomic and molecular collision processes; Physics education.

Robert D Dubois, Professor
PHD Univ Of Nebraska Lincoln
Experimental atomic and molecular collisions.

**Donald Edward Hagen**, Professor  
PHD Purdue University Main Campus  
Experimental and theoretical studies of condensation, nucleation, and aerosol physics.

**Barbara N Hale**, Professor  
PHD Purdue University Main Campus  
Theoretical atmospheric physics involving studies of nucleation and growth of ice.

**Yew San Hor**, Assistant Professor  
PHD Rutgers University  
Growth and characterization of exotic materials.

**Don H Madison**, Curators Professor  
PHD Florida State University  
Theoretical studies of electron-atom collisions.

**Ioulia Y. Medvedeva**, Associate Professor  
PHD Russian Academy of Science  
Theoretical condensed matter physics. First principles computational methods.

**Paul E Parris**, Professor  
PHD University Of Rochester  

**Jerry Lee Peacher**, Professor  
PHD Indiana University Bloomington  
Theoretical atomic and molecular collisions.

**Oran Allan Pringle**, Curator Teaching Professor  
PHD University Of MO-Columbia  
Experimental solid state physics. Magnetism, neutron scattering and Mossbauer spectroscopy.

**Joshua Lucas Rovey**, Assistant Professor  
PHD University Of Michigan Ann Arb  
Plasma aerospace applications, advanced plasma space propulsion, Hall thrusters, ion thrusters, plasma aerodynamics and flow control, plasma-enhanced combustion, plasma-based energy systems, hypersonics/re-entry body plasma interactions, plasma physics and rarefied gas dynamics.

**Michael Schulz**, Curators Professor  
PHD University Of Heidelberg  
Experimental atomic and molecular collisions.

**John G Story**, Associate Professor  
PHD University Of Southern Califor  
Experimental atomic and molecular physics. Laser excitation of atoms.

**Steffen Thomas Vojta**, Professor  
PHD Chemnitz Univ. Techn., Germany  
Theoretical condensed matter and statistical physics. quantum and classical phase transitions, transport, and disorder.

**George D Waddill**, Professor  
PHD Indiana University Bloomington  
Experimental solid state physics. Surface physics and nano-scale magnetism.

**Alexey Georgiyevich Yamilov**, Assistant Professor  
PHD The City University of NY  
Theoretical optical Physics. Wave propagation in complex media.

**Psychology**

**Graduate Certificate Programs**

**Psychology of Leadership**

This certificate program is designed to provide formalized education in the area of the Psychology of Leadership and is open to all persons holding a Bachelors, Masters, or Ph.D. degree who have the required pre-requisites for the courses offered. After being admitted to the program, a student must take three courses from a group of five and an additional fourth course from a second group of five.

Choose three courses from the following:

- PSYCH 308 Social Psychology
- PSYCH 316 Psychology of Leadership in Organizations
- PSYCH 374 Organizational Psychology
- ERP 348 Performance Dashboard, Scorecard and Data Visualization
- IS&T 351 Technological Innovation Management and Leadership

And a fourth course from one of the following five:

- PSYCH 350 Psychology of Women
- PSYCH 372 Group Dynamics
- PSYCH 378 Social Influence: Science and Practice
- IS&T 480 Advanced Web and New Media Studies
- IS&T 487 Research Methods in Human-Computer Interaction

Other courses approved by the program advisor may be substituted for any of the above listed courses on a case-by-case basis.

In order to receive a Graduate Certificate, the student must have an average cumulative grade of 3.0 or better in the certificate courses. Students admitted to the Certificate program will have a non-matriculated status as a graduate student. If they complete the four course sequence with a grade of B or better, they will be admitted to the Master’s degree program in Information Science and Technology or if they apply. Students who do not have all of the prerequisite courses necessary to take a course in the certificate program will be allowed to take “bridge” courses at either the graduate or undergraduate level to prepare for the formal certificate courses.

**Psychometrics**

This certificate program is designed to provide formalized education in the area of Psychometrics. Psychometrics is the field of study concerned with the theory and technique of psychological measurement and includes the measurement of knowledge, abilities, attitudes, and personality traits. The field is primarily concerned with the study of differences between individuals and involves two major research tasks: (1) the construction of instruments and procedures for measurement; and (2) the development and refinement of theoretical approaches to measurement. After being admitted to the program, a student must take two courses from a group of three and an additional two courses from a second group of three.
Choose two courses from the following three:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYCH 307</td>
<td>Industrial Psychology</td>
</tr>
<tr>
<td>PSYCH 364</td>
<td>Tests and Measurements</td>
</tr>
<tr>
<td>PSYCH 403</td>
<td>Psychometrics</td>
</tr>
</tbody>
</table>

And an additional two from these three:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 346</td>
<td>Regression Analysis</td>
</tr>
<tr>
<td>STAT 353</td>
<td>Statistical Data Analysis</td>
</tr>
<tr>
<td>STAT 444</td>
<td>Design And Analysis Of Experiments</td>
</tr>
</tbody>
</table>

The Psychometrics Certificate Program is open to all persons holding a Bachelors, Masters, or Ph.D. degree and who have the required prerequisite courses for the courses offered. In order to receive a Graduate Certificate, the student must have an average cumulative grade of 3.0 or better in the certificate courses.

Students admitted to the certificate program will have a non-matriculated status as a graduate student. If they complete the four course sequence with a grade of B or better, they will be admitted to the Missouri S&T Master’s degree program in Mathematics and Statistics if they apply. Students who do not have all of the prerequisite courses necessary to take a course in the certificate program will be allowed to take “bridge” courses at either the graduate or undergraduate level to prepare for the formal certificate courses.

Leadership in Engineering Organizations

The Departments of Psychological Science and Engineering Management and Systems Engineering offer an interdisciplinary certificate program entitled “Leadership in Engineering Organizations.” This certificate program aims to equip students with a set of tools that will allow them to become effective leaders of groups, programs, and departments engaged in engineering and technology work. Specifically, this certificate program will enable graduates to:

- understand the technical leadership roles in engineering organizations
- understand and develop a personal leadership style and develop the skill to critically analyze, evaluate, improve, and adapt existing technical and/or managerial systems
- organize and lead complex projects, groups, and organizations

The Leadership in Engineering Organizations Certificate Program consists of the following four courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENG MGT 313</td>
<td>Managerial Decision Making</td>
</tr>
<tr>
<td>PSYCH 316</td>
<td>Psychology of Leadership in Organizations</td>
</tr>
<tr>
<td>PSYCH 374</td>
<td>Organizational Psychology</td>
</tr>
<tr>
<td>ENG MGT 418</td>
<td>Leadership for Engineers</td>
</tr>
</tbody>
</table>

In order to receive a Graduate Certificate, the student must have an average cumulative grade point of 3.0 or better in the certificate courses. A student will be given three years to complete the program so long as he/she maintains a B average in the courses taken.

Students admitted to the certificate program will have non-degree graduate status but will earn graduate credit for the courses they complete. If the four-course sequence is completed with a grade of B or better in each of the courses taken, they will be admitted to the Engineering Management M.S. program if they apply. The certificate courses taken by students admitted to the M.S. program will count towards their master’s degrees. Students who do not have all of the prerequisite courses necessary to take the courses in the certificate program will be allowed to take “bridge” courses at either the graduate or undergraduate level to prepare for the formal certification courses.

Susan L Murray, Professor

PHD Texas A&M University

Industrial engineering, productivity improvement, human factors and safety.

Systems Engineering

Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems by defining customer needs and required functionality early in the development cycle. Systems engineers are responsible for the design and management of complex systems guided by systems requirements. There is a growing need for engineers who are concerned with the whole system and can take an interdisciplinary and top down approach. Systems engineers need to be problem definers, not just problem solvers, and be involved with a system through its life cycle, from development through production, deployment, training support, operation, and disposal.

Systems Engineering Graduate Certificate

Required CORE courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYS ENG 368</td>
<td>System Engineering and Analysis I</td>
</tr>
<tr>
<td>SYS ENG 413</td>
<td>Economic Analysis for Systems Engineering</td>
</tr>
<tr>
<td>SYS ENG 468</td>
<td>Systems Engineering Analysis II</td>
</tr>
<tr>
<td>SYS ENG 469</td>
<td>Systems Architecting</td>
</tr>
</tbody>
</table>

Upon successful completion of the four courses as described above, students will be awarded certification. The student must complete the four courses with a minimum of a 3.0 or higher in all classes. Students may apply to the M.S. program with the completion of the certificate.

Network Centric Systems Graduate Certificate

(Offered in Computer Engineering discipline also)

Two core courses required:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYS ENG 419</td>
<td>Network Centric Systems</td>
</tr>
<tr>
<td>or COMP ENG</td>
<td>Network Centric Systems</td>
</tr>
<tr>
<td>419</td>
<td></td>
</tr>
</tbody>
</table>

COMP ENG Network-Centric Systems Reliability and Security 449
Select two elective courses

**Computational Intelligence**

This graduate certificate program provides practicing engineers the opportunity to develop the necessary skills in the use and development of computational intelligence algorithms based on evolutionary computation, neural networks, fuzzy logic, and complex systems theory. Engineers can also learn how to integrate common sense reasoning with computational intelligence elective courses such as data mining and knowledge discovery.

The certificate program consists of four courses, two core courses and two elective courses. In order to receive a graduate certificate, the student must have an average cumulative grade point of 3.0 or better in the courses taken.

**Core Courses**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP ENG 358</td>
<td>Computational Intelligence</td>
</tr>
<tr>
<td>or ELEC ENG 367</td>
<td>Computational Intelligence</td>
</tr>
<tr>
<td>or SYS ENG 367</td>
<td>Computational Intelligence</td>
</tr>
</tbody>
</table>

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP SCI 347</td>
<td>Introduction To Artificial Intelligence</td>
</tr>
<tr>
<td>COMP SCI 348</td>
<td>Evolutionary Computing</td>
</tr>
<tr>
<td>SYS ENG 378</td>
<td>Introduction To Neural Networks &amp; Applications</td>
</tr>
<tr>
<td>or COMP SCI 378</td>
<td></td>
</tr>
<tr>
<td>or ELEC ENG 368</td>
<td>Introduction To Neural Networks &amp; Applications</td>
</tr>
</tbody>
</table>

Select two of the following not taken as a core course:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMP SCI 347</td>
<td>Introduction To Artificial Intelligence</td>
</tr>
<tr>
<td>COMP SCI 348</td>
<td>Evolutionary Computing</td>
</tr>
<tr>
<td>COMP SCI 447</td>
<td>Advanced Topics In Artificial Intelligence</td>
</tr>
<tr>
<td>COMP SCI 448</td>
<td>Advanced Evolutionary Computing</td>
</tr>
<tr>
<td>SYS ENG 458</td>
<td>Adaptive Critic Designs</td>
</tr>
<tr>
<td>or COMP ENG 458</td>
<td>Adaptive Critic Designs</td>
</tr>
<tr>
<td>or ELEC ENG 458</td>
<td>Adaptive Critic Designs</td>
</tr>
<tr>
<td>COMP SCI 434</td>
<td></td>
</tr>
<tr>
<td>or SYS ENG 434</td>
<td></td>
</tr>
<tr>
<td>or COMP ENG 434</td>
<td></td>
</tr>
<tr>
<td>ELEC ENG 337</td>
<td>Neural Networks For Control</td>
</tr>
</tbody>
</table>

**Engineering Management & Systems Engineering Laboratories**

The department established the Smart Engineering Systems Lab (SESL) to develop approaches in building complex systems that can adapt in the environments in which they operate. The term “smart” in the context indicates physical systems that can interact with their environment and adapt to changes both in space and time by their ability to manipulate the environment through self-awareness and perceived models of the world based on both quantitative and qualitative information. The emerging fields of artificial neural networks, fuzzy logic, evolutionary programming, chaos, wavelets, fractals, complex systems, and virtual reality provide essential tools for designing such systems.

The focus of the SESL is in developing smart engineering architectures that integrate and/or enhance the current and future technologies necessary for developing smart engineering systems while illustrating the real life applications of these architectures. The smart engineering systems design and operations cut across a diversity of disciplines, namely manufacturing, electrical, computer, and mechanical, biomedical, civil and other related fields such as applied mathematics, cognitive sciences, biology and medicine. Current research topics include data mining, artificial life, evolutionary robotics, internet-based pattern recognition, and systems architecture based on DoDAF framework. Capabilities of the developed computational intelligence models are demonstrated physically in the lab through mini autonomous research robots. Visit our website at http://web.mst.edu/~sesl/index.htm.

**M.S. Degree Program**

**Requirements for Admission**

A bachelor's degree in an engineering or scientific discipline with a cumulative GPA of at least 3.0 on a 4.0 scale, and a GRE score of V+Q # 1100, A # 4.0 (former scoring) or V # 155, Q # 148, A # 4.0. Three years of work experience is recommended.
CORE Courses

- SYS ENG 368 System Engineering and Analysis I
- SYS ENG 411 Systems Engineering Capstone
- SYS ENG 412 Complex Engineering Systems Project Management
- SYS ENG 413 Economic Analysis for Systems Engineering
- SYS ENG 468 Systems Engineering Analysis II
- SYS ENG 469 Systems Architecting

Specialization Tracks
Choose 4 courses in an area or combination of areas. (Please refer to the Engineering Management & Systems Engineering Department for course information in each area.)

- Computational Intelligence
- Data Mining and Knowledge Discovery
- Structural Engineering
- Geotechnical Engineering
- Communication and Signal Processing
- Computer and Security Reliability
- Control Systems
- Economic Decision Analysis
- Financial Engineering
- Finance and Accounting
- Integrated Enterprise
- Technology Management
- Integrated Flight and Control Systems Structures
- Human-Computer Interaction
- Network and Telecommunications Management
- Enterprise Resource Planning
- Information Technology Foundations
- Computer Systems
- Information Systems
- Software Engineering
- Manufacturing Systems
- Multimedia
- Network Centric Systems
- Quality Engineering
- Reliability
- Computational Software Systems
- Modeling and Simulation

With the permission and approval of an advisor, a student may propose a different field other than those shown, or a combination of shown fields if it meets the program and university criteria.

M.S. in Systems Engineering, Non-Thesis

M.S. in Systems Engineering Students following their approved program of study will be assured of graduation upon maintenance of good academic standing. A minimum of 30 units of course work must be completed with a cumulative grade point average of 3.0.

M.S. in Systems Engineering with Thesis

36 credit hours are recommended. All students are encouraged to complete 30 credit hours of course work and 6 credit hours of research.

Second M.S. in Systems Engineering

A student may complete a second master's degree with a minimum of 24 units of course work. The student must complete the six core courses and two specialization track courses with a minimum grade point average of 3.0.

Ph.D. Requirements

Admissions Requirements

Applicants need a B.S. in engineering, physical science or math; M.S. in Systems Engineering or related field with a minimum GPA of 3.5; a minimum of three years of post-graduate work; GRE scores of V+Q # 1100, A # 4.0 (former scoring) or V # 155, Q # 148, A # 4.0. A Statement of Purpose is required for all students. A Qualifying Exam is required during the first year of courses. All requirements should be completed within an eight year period. A comprehensive exam is required near the completion of classes.

Residency Requirements

All students are expected to follow the Missouri S&T Graduate Student Residency requirements. Off campus students can meet the 2 year residency requirement with the following requirements: the Qualifying Exam must be taken on campus during the first year of enrollment; the student will have at least two video conferences per month with his/her research advisor; the Ph.D. committee will include one person from the student's professional work location, the appointment committee member must have a Ph.D. and be familiar with the chosen research; the student is expected to meet with the Ph.D. committee on a regular basis with at least two meetings per semester; the student is expected to be on campus a minimum of 16 days per year, visits may be spread over 4 campus visits; the Ph.D. Comprehensive Exam must be taken on campus; the student has the option of conducting research that is beneficial to the student's professional work; the Defense of Dissertation must take place on campus.

Major Requirements

May be taken during M.S. degree

Core Curriculum

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<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>SYS ENG 368 System Engineering and Analysis I</td>
<td>24</td>
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<tr>
<td>SYS ENG 411 Systems Engineering Capstone</td>
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<tr>
<td>SYS ENG 412 Complex Engineering Systems Project Management</td>
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<tr>
<td>SYS ENG 413 Economic Analysis for Systems Engineering</td>
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<tr>
<td>SYS ENG 419 Network Centric Systems or COMP ENG Network Centric Systems 419</td>
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<td>SYS ENG 468 Systems Engineering Analysis II</td>
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<td>SYS ENG 469 Systems Architecting</td>
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<td>SYS ENG 479 Smart Engineering System Design</td>
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<td>SYS ENG 490 Research</td>
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Electives

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<th>Course</th>
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<td>36</td>
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The minimum total credit requirements for graduation are 60 credit hours after successful completion of a M.S. degree in Systems Engineering or 90 credit hours after a B.S. degree in engineering, math or physical science. The student’s dissertation committee establishes specific requirements for each student’s Ph.D. by approving the student’s plan of study.

**Research Areas**

**Network Centric Systems**

**Systems Architecting**

**Systems Engineering Process and Design**
Design for Flexibility, Smart Systems Engineering, and Lean Systems Engineering.

**Network Centric Manufacturing and Control**

**Modeling and Simulation**

**Computational Intelligence**
Neural and Fuzzy Logic and Evolutionary Computation, Artificial Life, Swarm Optimization, Intelligent Systems Design, Interoperability between Database Systems, and Integration of Ontologies into Systems Engineering organizational design. Prerequisite: PSYCH 50.

**Infrastructure Systems**
Health Mentoring of Infrastructure Systems; Interoperability; Infrastructure models to ensure the coordination and interaction among multiple stakeholders with life line systems consisting of utility systems and transportation systems; Geomechanical and Geotechnical Systems; Environmental Systems; Behavior of Infrastructure systems under extreme conditions.

**Technical Communication**
The Technical Communication program offers an M.S. degree (either online or traditional) for any student with a bachelor’s degree in any discipline and a strong background in writing and technology. Because of the rapid changes in technology, particularly due to the effects of information systems, there is an immediate and growing need for highly trained professional communicators to design information. Employers are looking for communicators with sophisticated skills in the integration of visual communication tools with written and spoken communication.

Faculty involved in a variety of technical communication research programs teach and direct the program. Students will have opportunities to assist these faculty, both in research and teaching, as well as to work alongside faculty and graduate students in engineering and science. The technical communication faculty and students are active in the leading professional societies.

The program requires a minimum of 30 hours of graduate credit and includes both a thesis and non-thesis option.
Technical Communication Graduate Minor

The technical communication program offers a graduate-level minor that is open to any graduate student. The minor is designed to strengthen the written, oral, and visual communication skills of students majoring in the sciences, engineering, management, information systems, or other fields. The minor will be particularly useful for those students who will pursue the “paper option” thesis or dissertation. The minor will also be beneficial for those students who will make oral or poster presentations at technical conferences, write journal articles, prepare research proposals, design technical web pages, or prepare technical marketing information.

The program requires a minimum of 12 hours of credit (excluding all courses taken for undergraduate credit). A minimum of 6 hours of 300- or 400-level courses with the TCH COM designation is required. At least 6 additional hours of technical communication intensive courses are required. The additional courses may come from courses with the TCH COM designation, the list of approved technical communication intensive courses, and/or technical communication intensive courses from any academic discipline with the approval of the minor advisor and the English and Technical Communication Department.

Students can elect to pursue this minor at any point during their graduate studies by submitting the Application for a Designated Graduate Minor form (available at http://registrar.mst.edu/documents/gradminorapp.pdf) to the English and Technical Communication Department. Upon application, each student will be assigned a minor advisor who will work with the student to develop a proposed list of courses to fulfill the program requirements.

Approved Technical Communication Intensive Courses

All Tch Com 300 & 400 level courses
BIO SCI 451 Environmental Microbiology
BUS 311 Business Negotiations
ENGLISH 281 Theory Of Written Communication
ENGLISH 329
GEO ENG 352 International Engineering and Design
IS&T 487 Research Methods in Human-Computer Interaction
MATH 209 Foundations Of Mathematics
MATH 303 Methods of Applied Mathematics
MATH 308 Linear Algebra II
MATH 354 Mathematical Logic I
MS&E 422 Thermodynamics and Phase Equilibria

The Technical Communication Graduate Minor Advisory Committee will evaluate other courses, upon the request of students or faculty, for inclusion on the approved list or on a case-by-case basis for individual programs.

Graduate Certificate Programs

The Graduate Certificate in Technical Communication serves current Missouri S&T graduate students in any discipline; individuals who already have undergraduate or graduate degrees and are seeking to add value to their degrees; and current industry employees who need to hone their communication skills to remain competitive in the market and better serve their employers.

The certificate may be pursued either online or on campus.

The following 4 courses* (totaling 12 credit hours) will be required for the certificate:

- TCH COM 331 Technical Editing
- TCH COM 334 Usability Studies
- TCH COM 409 Web-Based Communication
- TCH COM 433 Advanced Proposal Writing

These four courses are also required for the M.S. in Technical Communication and could be counted toward that degree if the certificate student later decided to go on for the M.S.

- Course Substitutions may be permitted by the department in some circumstances.

Degree Requirements

The following 10 courses (totaling 30 credit hours) are required for the M.S. and may be taken online:

- TCH COM 302 Research Methods in Technical Communication
- TCH COM 325 Help Authoring
- TCH COM 331 Technical Editing
- TCH COM 334 Usability Studies
- TCH COM 361 History of Technical Communication
- TCH COM 402 Foundations of Technical Communication
- TCH COM 409 Web-Based Communication
- TCH COM 411 Advanced International Technical Communication
- TCH COM 420 Advanced Theories of Visual Technical Communication
- TCH COM 433 Advanced Proposal Writing

A student completing the master’s degree will also take a comprehensive exam during his/her final semester and prepare a portfolio of projects. If the student chooses to do a thesis instead of the exam, and the technical communication faculty gives their approval to this plan, the student will have to take 6 hours of TCH COM 490 in addition to the above 10-course sequence.

Ed A. Malone, Associate Professor
PHD Southern Illinois Univ Carbond

Kathryn Michele Northcut, Associate Professor
PHD Texas Tech University

Michael David Wright, Assistant Professor
PHD Oklahoma State University Main
Research Centers and Institutes

Center for Bone and Tissue Repair and Regeneration (CBTRR)

McNutt Hall
Mohamed N. Rahaman (Director)

Faculty

Research Investigators
R.K. Brow (Materials Science & Engineering); R.F. Brown (Biological Sciences); D.E. Day (Materials Science & Engineering); Y.W. Huang (Biological Sciences); C-S. Kim (Electrical & Computer Engineering); H.K. Lee (Mining & Nuclear Engineering); M.C. Leu (Mechanical & Aerospace Engineering); Y. Liu (Materials Science & Engineering); H. Shi (Chemistry); S. Usman (Mining & Nuclear Engineering); J.C. Wang (Chemical & Biological Engineering); Y. Ma (Chemistry); H. Xiao (Electrical & Computer Engineering)

The Center for Bone and Tissue Repair and Regeneration (CBTRR) is a multidisciplinary research center with a mission to research and develop advanced biomaterials and biomedical devices for the repair and regeneration of bone and soft tissues.

The objectives of the Center are to:

- Promote interdisciplinary collaboration that enhances the rate of scientific discovery and technological advances to develop the next generation of biomaterials and biomedical devices
- Enhance facilities and equipment for research in biomaterials and biomedical devices
- Develop research and education programs to train the next generation of biomedical/biomaterials engineers, providing a future workforce for the vital biotechnology industry in Missouri and the US
- Promote technology transfer and entrepreneurship to commercialize new knowledge, which should improve patient outcomes and expand economic development in Missouri and the US

Key research and development areas include:

- Bioactive glass science and engineering
- Bioactive glass and bioactive ceramic scaffolds for regenerating bone
- Nanofibrous bioactive glass for healing soft tissue wounds
- Nanostructured biocompatible phosphate devices for drug and growth factor delivery
- Biomedical devices to monitor healing of bone and soft tissues

To contact us, please visit our web page at http://cbtrr.mst.edu or e-mail: cbtrr@mst.edu or call (573) 341-4711.

Center for Environmental Science and Technology (CEST)

Bureau of Mines Building #1
Virgil J. Flanigan, Ph.D.; P.E. (Director)

Senior Investigators
K. Chandrashekhara (Mechanical Engineering), D. Forciniti (Chemical Engineering), S. Kapila (Chemistry), Y. Ma (Chemistry), Gerald Wilemski (Physics)

Research Investigators
J. Drallmeier, P. Nam (Chemistry), R. Richter, R. Seemamahannop (Chemistry), D.J. Westenberg (Biological Sciences).

The Center for Environmental Science and Technology (CEST) is an expression of commitment by the University to be a positive force in helping society deal with environmental problems and concerns. Its mission is to involve students in the resolution of real-world environmental problems by enlisting them in research programs at Missouri S&T. To this end, CEST fosters academic (students and faculty), industrial, and government laboratory participation in interdisciplinary environmental research. This multi-faceted program brings to bear new and existing technologies to the solution of environmental problems.

CEST may, therefore, be considered a catalyst for environmental research and teaching. It brings together under a common umbrella more than 15 faculty as senior investigators, research investigators, and adjunct investigators. Represented are nine engineering, physical science, biological science, mining, and metallurgical disciplines. CEST also brings together a wide array of extraordinary laboratories and institutes. These have an impressive array of capabilities and unique expertise in cloud and aerosol sciences, materials research and recycling, environmental trace analysis, material characterization, toxicology, coatings technology, environmental monitoring, and many other areas. To contact us e-mail CEST@mst.edu.

Center for Infrastructure Engineering Studies (CIES)

223 Engineering Research Lab
Kamal H. Khayat (Director)

Staff
Jason Cox (Senior Research Specialist); Abigail Sherman (Program/Project Support Specialist); Gayle Spitzmiller (Administrative Assistant); John Bullock (Research/Laboratory Technician); Cheryl Geisler (Secretary).

Researchers
Kamal Khayat (CArE); Neil Anderson (Geological Sciences & Engineering); Bate Bate (CArE); Chandrashekhara, K. (Mechanical and Aerospace Engineering); Genda Chen (CArE); Joon-Ho Choi (CArE); Suzanna Long (EMSE); Ronaldo Luna (CArE); Norbert Maerz (Geological Sciences & Engineering).
The Center for Infrastructure Engineering Studies (CIES) was created through the University of Missouri's Mission Enhancement Program at the Rolla campus. The center provides research expertise in the area of buildings and civil infrastructure and infrastructure management.

The mission of CIES is to provide leadership in research and education for solving the problems affecting the nation's infrastructure systems. CIES is the primary conduit for communication among those on the Missouri S&T campus interested in infrastructure studies. The center provides coordination for collaborative, interdisciplinary efforts with emphasis on:

- Interdisciplinary research and development with projects tailored to address needs of federal agencies, state agencies, and private industry;
- Technology transfer and continuing distance education to the engineering community and industry.

CIES is the home of the National University Transportation Center (UTC) which was established by the US Department of Transportation to advance technology and expertise in many transportation-related disciplines through the mechanisms of education, research, and technology transfer at university-based centers of excellence. The Missouri S&T UTC funds research proposals in the areas of advanced materials, non-destructive testing technologies, and alternative fuels with the objective of advancing the state-of-the-art of transportation structures. Three examples of such areas are: improvement of existing civil engineering construction materials, FRP composites, and non-destructive testing.

CIES is also the home of the Mid-America Transportation Center (MATC)-Missouri S&T Partner. MATC is a consortium partnership among the Region VII State Universities. The theme of the Center is to improve safety and minimize risk associated with increasing multi-model freight movements.

The Natural Hazards Mitigation Institute (NHMI), also housed within CIES, is a multi-disciplinary program of research focused on evaluation of naturally-occurring phenomena and developing effective mitigation techniques utilizing new technologies and materials. NHMI draws on faculty expertise in civil and environmental engineering, geology, seismology, geophysics, and geological engineering. Email cies@mst.edu, visit our website at: http://cies.mst.edu or phone: (573)341-4497.

**Cloud and Aerosol Sciences Laboratory (CASL)**

**Norwood Hall**  
**Donald E. Hagen (Director)**

**Faculty**

R. W. Alexander (Emeritus Prof. Phys.); D.J. Alofs (Emeritus Prof. M&AE and EM); J.C. Carstens (Emeritus Prof. Phys.); N. Ercal (Chem); B.N. Hale (Phys.); S. Kapila (Chem.); U.O. Koylu (M&AE); P. Nam (Chem); J.L. Schmitt (Phys.); D.R. White, (Assoc. Prof. Emeritus, B.E.); P.D. Whitefield (Chem.); G. Wilemski (Phys.).

Global, regional, and local environmental concerns have propelled the atmospheric sciences to international prominence. Well known issues such as the local air quality, ozone, acid rain, photo-chemical smog, and global warming attest to the urgency of atmospherically related problems now facing society.

CASL is a multidisciplinary effort drawing on the solid base of engineering and sciences provided by Missouri S&T. Students from various academic departments perform their thesis research within the laboratory in partial fulfillment of the M.S. or Ph.D. degree requirements of their "home" department.

The program is directed toward a fundamental understanding of the role of aerosols, including clouds and fogs, in our atmospheric environment. Current studies focus on the generation and environmental impact of anthropogenic combustion aerosols, basic nucleation processes of water and ice, cluster structure both in the gaseous phase and on substrates, homogenous binary nucleation, neutron scattering measurements on nanodropet aerosols, particle formation in supersonic expansions, the heterogeneous chemistry and chemical composition of air borne aerosols and their impact on the atmosphere, and the behavior of aerosol particles in the human respiratory system.

Interdisciplinary research and development with projects tailored to address needs of federal agencies, state agencies, and private industry; technology transfer and continuing distance education to the engineering community and industry.

CASL provides leadership in international and national research programs. It is the home for the Missouri S&T lead federal Center of Excellence for Aerospace Particulate Emissions Reduction Research, is a member of the FAA-NASA-Transport Canada Center of Excellence for Aviation Noise and Aircraft Emissions Mitigation, and leads the air related mission for the Missouri S&T Center for Emerging Contaminants. Its brief extends to particulate mitigation strategies for new combustor development.

The Laboratory houses a variety of instrumentation, much of it unique. This includes a finely tuned expansion chamber used to study nucleation phenomena, instrumentation designed to directly determine the chemical composition of particles on which droplets form, and an extensive mobile facility for both the on-ground and in-flight collection and analysis of combustion (e.g. jet exhaust) aerosols.

In addition to acquiring knowledge of cloud, aerosol, and atmospheric science, the laboratory imparts to students a familiarity with a wide variety of data acquisition, signal conditioning, and system engineering problems. Visit our website at http://coe.mst.edu.

**Energy Research and Development Center (ERDC)**

**305 McNutt Hall**  
**Mariesa L. Crow (Director)**

The Energy Research and Development Center (ERDC) provides an environment for researchers from various Missouri S&T disciplines to collaborate on sponsored projects involving energy and its impact on society and the environment. The mission of the ERDC is to educate students in energy topics to solve problems of society to deliver solutions for energy-related issues by forming collaborative relationships with industry and government, for the benefit of the university, the state of Missouri, and the nation. Topics of interest include the development of biofuels, alternative energy sources including wind and solar, plug-in hybrid vehicles, the bulk power system, hydrogen technologies, cybersecurity of energy management systems, synthetic fuel development, advancing nuclear energy, and petroleum exploration and extraction.
methods. More than 41 faculty researchers are affiliated with the Center. Researchers affiliated with the Energy R&D Center also closely collaborate with other research centers including Materials Research Center, Intelligent Systems Center, Center for Infrastructure Engineering Studies, and the Environmental Research Center. For more information visit the web site at http://energy.mst.edu or contact erdc@mst.edu.

Environmental Research Center for Emerging Contaminants (ERCEC)

201 Butler Carlton Hall
Dan Oerther (Director)

The mission of the Environmental Research Center (ERC) is to provide the infrastructure and coordinated faculty base to conduct wide range of large-scale federally-funded research initiatives designed to protect public health from emerging contaminants. ERC investigators conduct research sponsored by a wide range of entities including the NSF, USEPA, USDA, USGS, Missouri Department of Natural Resources, American Water Works Association Research Foundation, as well as industry in Missouri and elsewhere.

Examples of current research areas in the ERC include: occurrence and control of antibiotics and antibiotic resistant bacteria at concentrated animal feed operations (CAFOs) and in drinking water; occurrence, fate and removal of estrogenic, endocrine disrupting chemicals, disinfection byproducts, pharmaceuticals, and cyanobacterial toxins in drinking water and wastewater treatment plants; reactions of indoor air pollutants in home and business environments; phytoremediation technology for treatment of organic contaminants in soil and groundwater; nutrient control using struvite precipitation; control of heavy metals with constructed wetlands; control of odor emissions from CAFOs; fate of mercury in incinerator flyash; treatment of MTBE and alternative fuel oxygenates; and transport of lead and zinc in Missouri rivers in the Old and New Lead Belts.

Labsitories associated with the Environmental Research Center maintain state-of-the-art instrumentation including: a wide variety of gas chromatographs with mass spectrometer and other detectors; high pressure liquid chromatographs with mass spectrometer and UV detectors; ion chromatograph; total organic carbon analyzer; atomic absorption spectrometers with graphite furnace and flame combustion; inductively couple plasma mass spectrometer with laser ablation; a wide variety of ultraviolet and visible spectrophotometers; stopped flow spectrophotometer; molecular biology tools including polymerase chain reaction (PCR) instrumentation and denaturing gradient gel electrophoresis (DGGE) and clone libraries; microscopes; respirometers; and wide variety of other instruments. Specialized research equipment and facilities include temperature control rooms; a trailer-mounted experimental water treatment system; a trailer-mounted mobile air pollution analysis laboratory; a rooftop greenhouse; pilot-scale air stripping system; pilot-scale advanced oxidation and ozonation systems; laminar flow hoods; anaerobic microbiology facilities; and a variety of other research equipment. The original Environmental Research Center (ERC) was established in 1965. Phone: 573-341-6908. E-mail address is erc@mst.edu or visit the website at: http://erc.mst.edu/.

Intelligent Systems Center (ISC)

320 Engineering Research Lab
Ming C. Leu (Director)

Senior Research Investigators
Frank Liou, Bruce McMillin, Jag Sarangapani, Don Wunsch.

Research Investigators

Affiliated Members
Levent Acar, Venkat Allada, Douglas Bristow, Sriram Chellappan, Maggie Cheng, Joon-Ho Choi, Mariessa Crow, Abhijit Gosavi, Zhen Liu, Ruwen Qin, Xiaodong Yang, Maciej Zawodniok, Zhaozheng Yin, Jie Gao.

The Intelligent Systems Center (ISC) mission is to provide an interdisciplinary research environment in which faculty from various departments can cooperate and conduct research on sponsored projects involving real physical systems with special emphasis on an intelligent (smart) system approach. ISC has integrated its primary research mission with Missouri S&T's commitment to develop internationally recognized graduate research programs focused on key technologies.

The approaches for accomplishing ISC’s objectives consist of:

- developing interdisciplinary research programs to match the emphasis areas of sponsoring agencies with the expertise of Missouri S&T faculty
- obtaining long-term federal research grants and industrial contracts
- developing multidisciplinary research facilities

ISC considers the education of graduate students as one of its major activities and provides graduate research assistantships through the Center’s investigators. The students supported by research grants choose their thesis topics to be closely related to the grant. The interdisciplinary nature of research provides an excellent opportunity for the students to interact with students from other disciplines. The students also gain valuable experience in working as a team and acquire communication and project organization skills. The interaction between graduate students and program managers from industries and federal agencies is very helpful in the application of their research to real-world problems.

Multidisciplinary research teams consisting of faculty members and graduate students from the departments of computer science, electrical and computer engineering, engineering management and systems engineering, mechanical and aerospace engineering, and material sciences and engineering have been established to conduct research in emerging technologies. The ISC has also developed state-of-the-art laboratories to conduct research on virtual reality, smart structures, neural networks, energy systems, agile manufacturing and automatic inspection, MEMS, robotics, and structural health monitoring. The Center provides computing facilities to its research investigators and graduate students working on research projects. Active research is in progress in the following interdisciplinary research areas:
1. Intelligent Manufacturing Processes and Systems
   - 1.1 Virtual and Rapid Prototyping & Manufacturing
   - 1.2 Laser Based Deposition & Prototyping
   - 1.3 Laser Micromachining
   - 1.4 Friction Stir Processing
   - 1.5 Composite Manufacturing
   - 1.6 Liquid Metal Processing
   - 1.7 Machining, Structural Health Monitoring & NDE
   - 1.8 Integrated & Collaborative Design & Manufacturing
2. Cyber Physical Systems
   - 2.1 Advanced Critical Infrastructure Systems
   - 2.2 Advanced Simulation of Cyber-Physical Systems
   - 2.3 Hardware/Software Co-Design
3. Advanced Simulation, Sensing, Control, and Communication
   - 3.1 MEMS and Nanosensors
   - 3.2 Wireless Sensor Networks
   - 3.3 Intelligent and Adaptive Control
   - 3.4 Virtual Reality and Advanced Simulation
4. Computational Intelligence and Embedded Systems
   - 4.1 Data Processing, Fusion and Management
   - 4.2 System Design and System Support
   - 4.3 Trustworthy and Embedded Hybrid Systems


Materials Research Center (MRC)

Straumanis-James Hall
Matthew J. O’Keefe (Director)

Senior Investigators
R. Brow (MSE), L. Dharani (MAE), J. Drewniak (ECE), W. Fahrenholtz (MSE), G. Hilmas (MSE), J. Switzer (Chem), D. Van Aken (MSE), H. Xiao (ECE).

Research Investigators
B. Bai (GE), B. Bate (Civil), D. Bristow (Mech), C. Castano (Nuc), A. Choudhury (Chem), H. Collier (Chem), D. Day (Chem), F. Dogan (MSS), C.S. Kim (ECE), M. Koledintseva (ECE), X. Liang (Chem), F. Lou (Mech), R. Luna (Civil), M. Nath (Chem), J. Newkirk (MSE), K. Peaslee (MSE), C. Ray (MSE), V. Richards (MSE), J. Rovey (Mech), J. Volz (Civil), J. Winiarz (Chem), D. Wronkiewicz (GE), X. Yang (Mech), L. Zhang (MSE).

The Graduate Center for Materials Research was established for the purpose of multidisciplinary research on materials and to provide improved centralized laboratories and specialized equipment for faculty and students involved in materials research. The Center provides graduate students in many academic departments (e.g. Materials Science and Engineering, Chemical and Biological Engineering, Mechanical and Aerospace Engineering, Chemistry, Biological Sciences and Physics) with advanced training in materials related engineering and science research.

The research conducted in the Center ranges from fundamental science to applied engineering and includes the development, evaluation, application, and understanding of metals, polymers, biomaterials, electronic materials and composites.

Accomplishments from the Center include: glass microspheres for treatment of liver cancer, transparent composites for windows/armor, environmentally friendly corrosion coatings, laser glasses, epitaxial chiral surfaces, biomineralization, fuel cell electrolytes and sealing materials, electrochemical biosensors, multi-layer nano-capacitors, enhanced magnetic materials, and thin film electromagnetic probes.

The Center is located in Straumanis-James Hall, a four-story building with 30,000 square feet of laboratory and office space. The Center contains the modern equipment needed for research on materials development, characterization and evaluation, and for measuring common mechanical, thermal, electrical, and optical properties. It contains specialized and adaptable experimental facilities for:

- Electrochemical deposition and corrosion
- Electronic materials
- Glass melting and processing
- Nanomaterials
- Plasma deposition of materials
- Biomaterials
- Composites
- Microfabrication including sputter deposition, evaporation, reactive ion etching and photolithography equipment
- Characterization of materials by x-ray diffraction, focused ion beam (FIB) microscopy, scanning and transmission electron microscopy, scanning tunneling and atomic force microscopy, thermal analysis, optical techniques, x-ray photoelectron and Auger electron spectroscopy.

The Center has an active interest in industrial research and economic development suitable for graduate and undergraduate student education that falls within the technical expertise of the staff.

E-mail mrc@mst.edu or visit our website at http://mrc.mst.edu.

Rock Mechanics and Explosives Research Center (RMERC)

Stewart Gillies (Interim Director)

Research Investigators
Kwame Awuah-Ofefi (MinEng), Jason Baird (MinEng), Jeffrey Cawfield (GeoEng), Sriram Chellappan (CompSci), Andreas Eckert (PetroEng), Grzegorz Galecki (MinEng), Mao Chen Ge (MinEng), Leslie Gertsch (GeoEng), Hyoung Lee (NucEng), Norbert Maerz (GeoEng), Runar Nygaard (PetroEng), David Summers (MinEng), Jerry Tien (MinEng), Jeffery Volz (ArchEng), Wan Yang (GeoEng).

Staff
Mike Bassett (Research Technician), Diane Henke (Secretary), Leanne Nuckolls (Administrative Assistant), John Tyler (Research Engineer).

The Rock Mechanics and Explosives Research Center brings together leading investigators from different disciplines to research static and dynamic rock mechanics, rock fragmentation and excavation, and explosives technology. The High Pressure Waterjet Laboratory of the Center has developed a world-renowned team of waterjet technology specialists. The Linear Rock Cutting Machine is one of only two such full-scale facilities operating in the U.S.; with an accompanying suite of full-
scale Rotary Rock Cutting Machines, it provides world-class research capability in mechanical rock excavation.

Areas of current research capability are: mine design, strata control, rock stress measurement, centrifugal testing – simulation of stress in complex geological structures, properties of rock under confining pressures, similitude studies, rock mechanics and applied geology, dynamic rock mechanics, dynamic strain measurement, high-pressure waterjet rock cutting, constitutive properties of rocks, high-pressure waterjet long-wall mining of coal, deep mine problems, ultrasonic wave measurements in rock, dynamic creep in rock, wall breaking, cratering with explosives, fracture propagation in rock, explosives and blasting, explosive labeling and detection, rock penetration and disintegration for rapid excavation, coal mine roof stability, concrete cutting and scarifying with water, and waterjet cleaning. Center faculty work in the development of new methods and machines for excavation, and concurrently the means to protect structures from blast and other methods of attack. E-mail rockmech@mst.edu or visit our website at http://rockmech.mst.edu.
Special Facilities and Programs

Advanced Materials Characterization Laboratory

McNutt Hall and Straumanis Hall
F. Scott Miller (Director)
smill@mst.edu
http://amcl.mst.edu

The Advanced Materials Characterization Laboratory was established in 2001 to provide advanced materials characterization instrumentation and expertise to Missouri S&T researchers as well as technological industries in Rolla and the state of Missouri. The laboratory combines advanced analytical resources from several departments on campus, as well as the Materials Research Center to provide a centralized point of contact for researchers.

The characterization equipment available in the AMCL includes: a dual-beam Focused Ion Beam/Scanning Electron microscope instrument, two scanning electron microscopes (SEM), and a transmission electron microscope (TEM), all of which are combined with energy dispersive X-ray Spectroscopy (EDS) systems, two x-ray diffractometers, scanning tunneling and atomic force microscopes, x-ray photoelectron spectrometers, and instruments for thermal analysis, including thermogravimetric analysis and differential scanning calorimetry.

Training in these methods and assistance in the use of the equipment are provided to faculty researchers, graduate and undergraduate students by the director and staff of the AMCL.

Center for Aerospace Manufacturing Technologies

320 Engineering Research Lab
Ming C. Leu (Director)
http://campus.mst.edu/camt

Investigators

The mission of the Center for Aerospace Manufacturing Technologies (CAMT) is to serve as a center of excellence to research, develop, evaluate and demonstrate new and optimal methodologies and tools for the rapid and cost-effective manufacture of aerospace components and products and to promote new education and training programs for the evolving aerospace manufacturing workforce, resulting in significant technological advancement and national economic impact.

CAMT was established in May 2004 at Missouri S&T in partnership with Boeing through major funding from the Air Force Research Laboratory in Dayton, Ohio, with the following objectives:

- Research, develop, evaluate and demonstrate transfer advanced technologies of critical importance to the Air Force and the aerospace supply chain in the United States.
- Create knowledge, methodologies and tools to improve affordability, rapidity, quality, productivity, reliability, and safety in aerospace manufacturing.
- Disseminate the generated results to the aerospace supply chain through direct technology transfer as well as education, training and outreach activities.
- Serve as a role model of university-industry-government collaborative relationship.

CAMT has involved over forty faculty members and over one hundred and fifty research staff and students from academic disciplines including mechanical and aerospace engineering, electrical and computer engineering, materials science and engineering, chemical and biological engineering, mining engineering, engineering management, and computer science.

CAMT has an array of technologies devoted to advancing manufacturing fabrication and assembly. The interdisciplinary teams, along with advanced equipment and facilities, have created a substantial technology force at Missouri S&T. Realizing the value and importance of CAMT to the entire U.S. aerospace industry, the CAMT Industrial Consortium was established in 2007. Through this, CAMT benefits all consortium members, and its R&D activities are directed by the consortium members. For more information, visit campus.mst.edu/camt.

Center of Excellence for Aerospace Particulate Emissions Reduction Research

Norwood Hall G-11
Philip D. Whitefield, (Director)
pwhite@mst.edu
http://coe.mst.edu

The Missouri S&T COE is a university/industry consortium coordinated by Missouri University of Science and Technology conducting critical research that is providing the tools to characterize, measure, and predict propulsion particulate emissions in current and future aircraft. These tools will be validated both in the field and in realistic laboratory test environments that integrate propulsion altitude cells with state-of-the-art diagnostic systems and numerical modeling, and will be used as much needed consistent standards for current and future engine design by the U.S. and for characterizing the aircraft component of combustion emission in the assessment of local air quality in and around our airports.

The Missouri S&T COE is a founding member and the lead entity for emissions characterization in the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) a leading aviation cooperative research organization and an FAA/NASA/Transport Canada/USDoD/UP EPA-sponsored Center for Excellence. Our objectives are to characterize the emissions (both small particles and condensable gaseous species) from aircraft and airports through measurements, understanding and model the microphysical processes associated with particle formation, and determine the health effects of emissions. The characterization of emissions from aircraft and airports requires comprehensive measurement of small particles and condensable gaseous species. In fact, it requires measurement of both the emissions...
of individual airplanes as they contribute to the total aircraft segment of
the emissions budget of an airport, and the emissions at the fence line of
the airport due to all airport operations.

The major tasks of the COE are:

- Analyze and Correlate Particle Concentration Data
- Study quantifying emission indexes
- Develop Field Testing Data

Visit our website at: http://coe.mst.edu or e-mail pwhite@mst.edu

Design Engineering Center

109 Engineering Management Building
Kenneth M. Ragsdell (Director)

The Design Engineering Center is a unique industry, government,
university research partnership. The purpose of the Center is two-fold:
to address the universal need for effective design and manufacturing
methodology in support of efficient product development, and to provide
quality educational opportunities to properly prepare and motivate
students (undergraduate, graduate, and practicing engineers). The
Center is a research activity in the Engineering Management and
Systems Engineering Department. The current organization consists
of a director, a number of graduate and undergraduate students, and
participating faculty. Current areas of research include total quality
management, concurrent engineering, Taguchi Methods®, quality
engineering, six sigma and design for six sigma, the product development
process, and design optimization. E-mail ragsdell@mst.edu or visit our
website at http://dec.mst.edu/.

Engineering Education Center at
St. Louis (EEC)

University of Missouri-St. Louis Campus
Victor Birman (Director)

The Missouri S&T Engineering Education Center, located on the UM-
St. Louis campus, offers Missouri S&T courses and degrees to working
engineers and scientists in the St. Louis area. The courses, offered in
the evenings, are graduate credit courses applicable to M.S. or Ph.D.
degrees. In addition, the Center offers graduate certificate programs.
Most of the courses can also be taken by non-degree candidates for
personal enhancement.

The M.S. may be earned in aerospace, civil, computer, electrical,
environmental, manufacturing and mechanical engineering, computer
science, information science and technology, and engineering
management. Offerings may be expanded if warranted by interests and
requirements of area students.

Requirements for the M.S. degree at the Missouri S&T Engineering
Education Center are identical to those on the Rolla campus. Courses
are taught by Missouri S&T faculty and by Missouri S&T-approved
adjunct faculty (industrial research engineers and scientists).

The center was established in 1964, as a part of the continuing education
programs at Missouri S&T. Over 2,700 engineers obtained M.S. degrees
at the Center.

Further information can be obtained from the director, at:

E-mail mining@mst.edu or visit our web site at: http://mining.mst.edu/research/depexpmine.html.

Experimental Computation Laboratory

308 Computer Science Building
Bruce McMillin (Director)

The Experimental Computation Laboratory (ECL) is an organization
dedicated to research in advanced methods of distributed and parallel
computation. The current focus is on the use of rigorous mathematics
through formal methods to create fault-tolerant and secure real-time
distributed computing systems applied to critical infrastructure protection.
This area is known as Cyber-Physical Systems. The laboratory supports
undergraduate, graduate, and faculty researchers.

E-mail us at ff@mst.edu or visit our current project website at http://
filpower.mst.edu.

Experimental Mine

Bridge School Road
J.C. Tien (faculty member responsible)

The Experimental Mine, situated on Bridge School Road 1.5 miles from
the main campus, consists of 25 acres of surface and underground
facilities which provide excellent opportunities for mineral engineering
teaching and research. The surface land includes several dolomite
quarries. The underground workings consist of four shafts and 1,500 feet
of single-level drifts.

This excellent teaching facility is equipped with a variety of mine-related
equipment which offers practical hands-on experience in critical topics.
This includes air compressors, rock drills, mucking machine, slusher and
motor, diamond core drill, blasting seismography, extensometers, and
surveying instruments. A complete ventilating fan system is connected
to the underground area, appropriately installed for experimental data
collection. The mine classroom has internet access and is equipped with
an overhead projector, surround sound, and other teaching facilities.

Recent faculty and students research has been conducted in the areas of
rock blasting, mine ventilation and atmospheric control, rock mechanics,
and pipeline transportation. The quality of facilities is indicated by the
frequency of requests for government and industrial use of the premises.
Student projects, however, retain priority on this equipment and the
working areas.

E-mail mining@mst.edu or visit our web site at: http://mining.mst.edu/
research/depexpmine.html.
High Pressure Waterjet Laboratory

Rock Mechanics Facility
Grzegorz Galecki (Director)

The High Pressure Waterjet Laboratory is one of the research groups within the Rock Mechanics and Explosives Research Center that has been in existence the longest, started in 1984 by Dr. David Summers. Since then, this unique laboratory has built an international reputation in the area of high-pressure waterjet applications that recognizes Missouri S&T leadership in waterjet research.

State-of-the-art equipment provides support for studying special needs of manufacturing, mineral processing, nano-size materials, military, and environmental industries. These include, but are not limited to, high-precision waterjet cutting, depth-cut control, surface preparation of many kinds and materials, accelerated excavation, comminution, multi-axis milling in mining and manufacturing, erosion prevention, as well as fundamental studies of two- and three-phase flow, the mechanics of fluid jet generation, high speed phenomena, and the physics of fluid impact.

For more information please visit our website http://rockmech.mst.edu/facilities/hpwaterjet/, call (573) 341-4365, or email ggalecki@mst.edu.

Institute for Applied Chemistry and Nuclear Magnetic Resonance

Schrenk Hall
Klaus Woelk (Director)

The Institute for Applied Chemistry and Nuclear Magnetic Resonance was established by the Chemistry Department in 1990.

The purpose of this Institute is to provide a research group that can focus on problems relating to applied chemistry. In addition, the funding partially supports the operation of the Nuclear Magnetic Resonance (NMR) Laboratory, supervised by Dr. Rex Gerald. The NMR instrumentation is multi-disciplinary and is used by many researchers on campus.

Members of the Institute include: Dr. R. G. Brow, Dr. H. Collier, Dr. R. Gerald, Dr. N. Leventis, Dr. P. Reddy, Dr. T. Schuman, Dr. C. Sotiriou-Leventis, Dr. P. Stavropoulos, Dr. J. Switzer, Dr. M. Van De Mark, and Dr. K. Woelk.

The Institute promotes the study of chemical solutions to practical problems in the areas of polymers, coatings, solvents, surfactants, thin films, and environmental science. The specific interest is the behavior of polymers and biopolymers, coatings, composites, and conducting materials, as well as the discovery of new types of materials by use of chemical synthesis and novel techniques. The transport of molecules in colloidal and polymer systems is being studied by several researchers. The structure and dynamics of surfactant-based systems, including micelles, microemulsions, liquid crystals, and colloidal dispersions, are being studied as well. The development of chemical processing methods and the production of nano-scale and ceramic materials are also of interest.

Institute for Chemical and Metallurgical Process Development

Straumanis-James Hall
Matthew J. O’Keefe (Director)

The Institute for Chemical and Metallurgical Process Development (ICMPD) was established by the Chemistry Department in 1990.

The purpose of the ICMPD is to provide a research group that can focus on problems relating to applied chemistry. In addition, the funding partially supports the operation of the High Pressure Waterjet Laboratory. The Institute for Chemical and Metallurgical Process Development investigates a wide range of materials that are of technological importance. Emphasis areas include, but are not limited to, electrochemical processing, corrosion, environmentally benign materials and processes, thin films and coatings, and surface modification technologies. Characterization and analysis of materials and processes using advanced experimental and computational techniques and state of the art equipment are emphasized.

E-mail address is mjokeefe@mst.edu.

Laboratory for Atomic, Molecular and Optical Research

Physics
Michael Schulz (Director)

The Laboratory for Atomic, Molecular and Optical Research is composed of Missouri S&T faculty members performing research in atomic molecular and optical physics. This scientific area is concerned with the few body problems, the structure of atoms and molecules and their interaction with each other, with electromagnetic fields, and with surfaces.

The laboratory provides an environment which enhances this research activity, and which fosters cooperation and collaboration. The laboratory also provides a structure for formal cooperative programs, group funding, and other collective scientific activities.

Basic studies in the atomic, molecular and optical sciences have made major contributions to many of the new technologies that exist today. Laboratory faculty and staff members continue to contribute to the development of advanced concepts in such wide-ranging areas as femtosecond laser physics, atomic interaction dynamics for electron, positron, and ion impact, and atomic processes important in controlled nuclear fusion.

Visit http://physics.mst.edu or email schulz@mst.edu.

Laboratory for Information Technology Evaluation

Bureau of Mines #1
Richard Hall (Director)

The Laboratory for Information Technology Evaluation (LITE) and affiliated Center for Technology Enhanced Learning support the prototyping and evaluation of advanced information technologies and new media systems, with a particular focus on interactive learning
Many of these natural hazard events have common attributes:

- The onset of these disruptive natural forces occur within a short time frame, often with little immediate warning, threatening both lives and property.
- The widespread impact of the event extends over an area and its contents, whether people, domestic dwellings, transportation or civil infrastructure.
- The multiplicative influence of weaknesses in geology and soil stratigraphy can compound structural damage.
- The impact of man’s activities can contribute to the problem or can impede access to the area, slowing the needed mitigation and remediation of damage.

The complex and multifaceted nature of these natural hazards, which nevertheless have a common central theme, requires a coordinated and multi-disciplinary approach to develop a strategy to provide protection to people and vulnerable structures before an event, to minimize injury and damage during the event and to ease the requirements for remediation after it is over. This requires a deep understanding and awareness of the areas at risk, if mitigation, response and remediation procedures are to be effectively developed.

The Missouri S&T Natural Hazards Mitigation Institute (NHMI) is charged with mitigating and remediating the detrimental effects of natural hazards both within the State of Missouri and nationally, through research, public service and education. More specifically, the Missouri S&T NHMI is charged with the following responsibilities:

- Conduct, lead, coordinate and otherwise facilitate interdisciplinary research in the broad area of natural hazards including likelihood of occurrence, cause, effects, mitigation and remediation.
- Provide and disseminate public service information regarding probability of natural hazard occurrences, their potential outcomes, and precautionary measures which can minimize detrimental effects of natural hazards.
- Prepare, sponsor, coordinate and otherwise facilitate the development and offering of educational courses (academic and training) in the broad area of natural hazards.

Office of Technology Commercialization and Economic Development

Centennial Hall
Keith Strassner (Director)

The Office of Technology Transfer and Economic Development (OTTED) serves as the focal point for entrepreneurship, economic development, technology transfer and technology commercialization within the Missouri S&T, and as such functions as a resource for the development, dissemination, and implementation of enabling discoveries to commercial partners. The OTTED provides the means for applying these practices by offering business development and technology commercialization assistance to University and business ventures. The office actively brings together the organizations, resources, and processes that will efficiently develop the university’s discoveries for the betterment of society and the University.

The OTTED offers university faculty and students what they need to transfer technologies and create a start-up business by bringing new technologies to the widest possible audience through the commercialization of these discoveries. Through its programs, services, and efforts, OTTED is laying the ground work for the creation of new products, new jobs, and new opportunities for America. To efficiently meet the needs of Missouri S&T for technology transfer and commercialization support, OTTED consists of a Technology Transfer Office (TTO) and the Small Business Technology Development Center (SBTDC). Both groups work closely together and with the University of Missouri’s Office of Research and Economic Development to provide responsive, professional service to our faculty, students and industry.
partners to facilitate the creation of wealth, jobs and opportunities for faculty, staff, students and business within the state of Missouri and the world.

The TTO provides technology transfer expertise for identifying high-value innovative research, assessment of the licensability of Missouri S&T research, and securing intellectual property protection (when appropriate) for those inventions. The professional staff works with the researcher and faculty to provide advice about technology transfer issues during the research activity and to assist in the invention disclosure process. The TTO also provides guidance on an effective patent and copyright strategy and handles all the implementation details. To effectively bring Missouri S&T's technology into commercial use, the TTO assists in the technical and market assessments and actively markets Missouri S&T's technologies to industry partners. As part of these activities the TTO will expand and improve the technology transfer process on campus to ensure responsiveness to faculty, open and transparent decision making, and industry friendly interaction with potential licensees to ensure access to the public and support the University's strong commitment to economic development initiatives.

The SBTDC integrates the activities of faculty, students and inventors by linking with technology-based small businesses to create commercialization opportunities, offer short courses and seminars on entrepreneurship, showcase technologies to government and industry partners, and identify business issues that require public policy attention. Business assistance programs offered by SBTDC include the SBIR/STTR, LWI, MO PTAC, and University of Missouri Extension.

A start-up business has the potential to produce significant opportunities for the inventors, the University, and the community. Given the right circumstances a start-up company can bring a technology to market more quickly, increase the value of a technology to outside partner companies, and aid University research activities. SBTDC’s professional staff provides proactive assistance in analyzing potential opportunities to form a start-up business with Missouri S&T’s technology and encourage this interaction early in the disclosure process. In all cases, a new start-up business must make a compelling case to investors, inventors, business partners, and the University that it can attract funding and resources to achieve sustainable success. SBTDC’s staff provides hands on business assistance and links to funding and people resources.

The Small Business Innovation Research and Small Business Technology Transfer Program (SBIR/STTR) is a unique partnership among the Missouri University of Science & Technology, University of Missouri Extension and its partners, to bring government research and development awards to the small business and faculty. The staff can help you seek out, apply for and win government SBIR awards. The SBIR program is designed to:

- Stimulate technological innovation
- Partner with small businesses to meet federal research and development needs
- Encourage the participation of disadvantaged businesses and minority-owned firms in technological innovation; and
- Increase private sector commercialization derived from federal research and development funding.

The program offers small technology-based companies the opportunity to obtain seed capital for research and development early in the innovation process.

Dealing with regulations and red tape can be frustrating. In fact, those obstacles often keep highly qualified suppliers from selling to the government. The Missouri Procurement Technical Assistance Centers assist businesses—including small, disadvantaged and women owned firms—in obtaining federal, state and local government contracts. Procurement specialists will help you in identifying opportunities and understanding the government contracting process so you can take advantage of government sales dollars.

University Missouri Extension provides research-based knowledge and problem-solving resources from the University of Missouri to citizens, communities and businesses at the local level. Specialists in each county center can assist you directly or put you in touch with statewide experts and resources to serve your needs. The Business Development Program seeks to provide a seamless network of business support services that are proactive in anticipating needs, responsive to Missourians, effective in assistance and efficient in delivery to Missouri entrepreneurs and businesses, with outcomes that result in maximizing Missouri’s economic viability, individual capacity, families, communities and environment.

The OTTED also operates a student business incubator. The objective of the student business incubator is to encourage student entrepreneurship at Missouri S&T. The student business incubator provides resources and services to new business ventures started and operated by students at Missouri S&T. This includes work space, a business mailing address, ongoing business counseling, and access to shared resources such as a conference room, copier, printer, scanner, and fax machine. Only student businesses are eligible to participate in the student business incubator.

For more information about technology and business development efforts at Missouri S&T, contact us at otced@mst.edu or visit our website at http://ecodevo.mst.edu.

South Central Regional Professional Development Center

800 University Drive

John Lewis (Director)

The South Central Regional Professional Development Center (SCRPD) is a part of the statewide system of support for K-12 public school districts. The center officially serves 63 school districts in the counties of Crawford, Dent, Franklin, Howell, Iron, Maries, Oregon, Phelps, Pulaski, Reynolds, Shannon, Texas, and Washington. The Center also provides services to educators for some of the surrounding counties. The Center’s programs and services are available free of charge to students and faculty in the Missouri S&T teacher education program, and are available at cost recovery only to all Missouri S&T faculty and staff.

The mission of SCRPDC is “Building the Capacity of Educators to Ensure Student Success.” The center delivers the following services to educators and leaders throughout the region: Establishing collaborative cultures focused on learning; collecting, analyzing, and using data for decision-making; implementing common core standards aligned to curriculum; developing effective social / behavioral systems; selecting and implementing research-based highly effective instructional strategies; developing and implementing quality formative and summative assessments; and developing and supporting effective leaders committed to these priority areas. The center strives to increase the performance of schools throughout the region by providing high quality professional learning with a sustained focus on increasing student learning. This work is delivered both regionally and on-site in schools, is research based, and if implemented with fidelity is designed to positively impact student
Special Facilities and Programs

achievement. In order to accomplish our mission, SCRPDC organizes and implements workshops, role- alike network groups, study groups, on-going school improvement initiatives, and consultation and technical support. The center serves in a leadership capacity for the professional learning throughout the region. Contact us at rpdc@mst.edu, or visit our website at http://rpdc.mst.edu.

Student Design and Experiential Learning Center

116 Kummer Design Center
Roger LaBoube (Director)

The Student Design and Experiential Learning Center (SDELC) was established in 2000 to better support S&T's multi-disciplinary student design teams. The center's mission includes offering experiential learning opportunities that enhances classroom learning while exposing students to real open ended challenges that builds confidence in skills and knowledge. Students learn and practice critical problem solving techniques necessary for success in the real world including product/ process development, project management, and team-based leadership. Experiences range from service learning opportunities to student competitions.

Located in the Kummer Student Design Center, the SDELC offers collaborative design space, fabrication centers (machining, electrical, welding, and composites), and administrative support. The center provides unique training opportunities ranging from safety (including 10-30 hr. OSHA training) to leadership programs (course credit available). The SDELC supports the Residential College, offering programming that promotes “hands-on” learning.

The SDELC continues the S&T legacy of educating industry leaders who enter the workforce ready to produce with confidence. Experiences provided through the center are cornerstones to successful industry careers.

Visit our website at: design.mst.edu; call: (573) 341-7546; e-mail: sdelc@mst.edu for more information or to learn how to join a team.

Wei-Wen Yu Center for Cold-Formed Steel Structures

Butler-Carlton Civil Engineering Hall
Roger A. LaBoube (Director)
Wei-Wen Yu (Founding Director)

To meet an ever-increasing demand for technical assistance from steel and construction industries and to create more economic designs and applications, the Missouri S&T Wei-Wen Yu Center for Cold-Formed Steel Structures (CCFSS) was established to provide an integrated approach for handling research, teaching, and technical services on cold-formed steel structures at Missouri S&T. The Center brings together technical resources from universities, trade associations, research laboratories, steel producers, manufacturing companies, consulting engineers, building officials, governmental agencies, and others.

The Center is currently co-sponsored by the American Iron and Steel Institute, Cold-Formed Steel Engineering Institute of the Steel Framing Alliance, Metal Building Manufacturers Association, Metal Construction Association, Rack Manufacturers Institute, Steel Deck Institute, Simpson Strong-Tie, Steel Stud Manufacturers Association, Steel Framing Industry Association, and the Missouri University of Science & Technology.

Since 1968 Missouri S&T has conducted numerous research projects on cold-formed steel structures. These projects have been supported by the American Iron and Steel Institute, National Science Foundation, the American Society of Civil Engineers, Metal Building Manufacturers Association, Metal Lath/Steel Framing Association, the Steel Deck Institute, the Chromium Centre in South Africa, The Nickel Development Institute in Canada, the Specialty Steel Industry of the United States, and individual companies.

With regard to teaching, Missouri S&T is one of few universities to offer a graduate course on cold-formed steel structures. In addition to the regular course, Missouri S&T has regularly conducted short courses and international specialty conferences to provide continuing education programs for the engineering profession. Visit our website at http://ccfssonline.org.
Course Information

Course Numbers

This section has been prepared to give you a listing and description of the approved graduate level courses at the Missouri University of Science and Technology. Courses listed are those approved at the time this publication went to press. Changes are made at regular intervals. Electronic catalog descriptions, which are updated during the academic year, are available on the Web at: http://registrar.mst.edu/cataloginfo/cataloginfo.html or on JoeSS. This will enable you to keep abreast of new course additions. For current information on when courses are available, consult the campus schedule of classes available from the Registrar’s Office, 103 Parker Hall.

0-99 Courses normally taken by freshman and sophomores. May not be used as any part of a graduate degree program.

100-199 Courses normally taken by upper-class undergraduate students. May not be used as any part of a graduate degree program.

200-299 Upper-class undergraduates and restricted graduate courses. Courses so numbered do not give graduate credit for an advanced degree in the field of the department offering the course.

300-399 Upper-class undergraduates and graduate students. Commonly approved for graduate programs only when the student is regularly enrolled in a graduate school and then only if the course fits the purpose of the degree program.

400-499 Graduate courses and research. Undergraduate and postbaccalaureate students are not normally eligible to enroll in 400-level courses.

Course Information

The number in parentheses following the name of the course indicates the number of credit hours given for successfully completing the course. It also reflects the section type; for example, (LEC 3.0) designates a lecture course of three hours credit; (LAB 1.0) designates a laboratory course of one-hour credit and (IND 0.0-15.0) designates independent study or research with variable hours. A lecture credit hour is usually the credit granted for satisfactorily passing a course of approximately 15 classroom hours. A laboratory course of one-hour credit would normally meet three classroom hours per week for 15 weeks.

Three credit hour courses normally meet 50 minutes three times per week, or 75 minutes twice a week, for 15 weeks. The time in class is the same in each case. If you have two classes in succession, there should be at least 10 minutes between classes. Classes meeting Monday-Wednesday-Friday will normally begin on the hour. Classes meeting Tuesday-Thursday will normally alternate between the hour and half hour, beginning at 8:00 a.m. In addition, there is an Academic Free hour 12:00-1:00 on Monday, Wednesday, and Friday.

Students must have completed the stated prerequisite(s) for the course for admission to the course or obtain the ‘Consent of the Instructor’ of the course.

Aerospace Engineering (AERO ENG)

AERO ENG 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

AERO ENG 301 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

AERO ENG 307 Vibrations I (LEC 3.0)
Equations of motion, free and forced vibration of single degree of freedom systems. Natural frequencies, resonance, modes of vibration and energy dissipation are studied. The vibration of continuous systems is introduced. Prerequisites: Mech Eng 211 and 213, or Aero Eng 213 and Math 204. (Co-listed with Mech Eng 307).

AERO ENG 309 Engineering Acoustics I (LEC 3.0)
Introduction to acoustical theory and measurement with emphasis on mechanical and aerospace engineering applications. Plane and spherical wave propagation, resonators and filters, absorption, room acoustics, human response to noise, noise legislation, noise control. Use of common instrumentation in several projects. Prerequisites: Mech Eng 211 & 213, or Aero Eng 213 & Math 204. (Co-listed with Mech Eng 309).

AERO ENG 311 Introduction To Composite Materials & Structures (LEC 3.0)
Introduction to fiber-reinforced composite materials and structures with emphasis on analysis and design. Composite micromechanics, laminating theory and failure criteria. Design procedures for structures made of composite materials. An overview of fabrication and experimental characterization. Prerequisite: Civ Eng 110. (Co-listed with Mech Eng 382).

AERO ENG 313 Intermediate Dynamics Of Mechanical And Aerospace Systems (LEC 3.0)
Principles of dynamics are applied to problems in the design of mechanical and aerospace systems; basic concepts in kinematics and dynamics; dynamics of systems of particles; dynamics of rigid bodies, three-dimensional effects in machine elements; dynamic stability, theory and applications; methods of analytical dynamics. Prerequisite: Mech Eng 213 or Aero Eng 213. (Co-listed with Mech Eng 313).

AERO ENG 314 Spaceflight Mechanics (LEC 3.0)
Further topics in orbital mechanics. Time equations, Lambert’s problem, patched-conic method, orbital maneuvers, orbit determination, orbit design, re-entry problem. Prerequisite: Aero Eng 213.

AERO ENG 315 Concurrent Engineering I (LEC 3.0)
Students will be introduced to the concurrent engineering approach to product development. They will learn to set up quantitative requirements and then use a quantitative rating process to identify the critical requirements relating to the desired product. The interaction between design, manufacturing, assembly, cost, and supportability will be covered. The students will form teams and practice the concurrent engineering process for simple products. Prerequisites: Mech Eng 213 or Aero Eng 231, and Civ Eng 110. (Co-listed with Mech Eng 315).
AERO ENG 316 Concurrent Engineering II (LAB 3.0)
Students will form groups and then using the electronic data based approach apply the concurrent engineering process to develop products. Areas to be covered are the customer, design, manufacturing, assembly, cost and supportability. Prerequisite: Aero Eng 315 or Mech Eng 315. (Co-listed with Mech Eng 316).

AERO ENG 319 Advanced Thermodynamics (LEC 3.0)
After a short review of classical thermodynamics, the elements of chemical reactions, chemical equilibrium, statistical thermodynamics, and the basic concepts of kinetic theory are presented. Prerequisite: Mech Eng 219. (Co-listed with Mech Eng 319).

AERO ENG 320 Advanced Mechanics of Materials (LEC 3.0)
Comprehensive insight into mechanics of materials. Topics to include: theories of failure, torsion of noncircular sections, shear flow and shear center, unsymmetric bending, bending of curved members, beams on elastic foundation and pressurization of thick walled cylinders. Prerequisites: Civ Eng 110, Math 204. (Co-listed with Mech Eng 320).

AERO ENG 322 Introduction To Solid Mechanics (LEC 3.0)
Review of basic concepts in continuum mechanics. Finite elasticity: some universal solutions for isotropic materials, application of special mechanical models. Linear elasticity: compatibility, stress functions, superposition, special examples such as extension, torsion, bending, and plane problems. Elements of plasticity. Prerequisite: Eng Mech 311. (Co-listed with Mech Eng 322).

AERO ENG 325 Intermediate Heat Transfer (LEC 3.0)
Analytical study of conduction; theory of thermal radiation and applications; energy and momentum equations in convective heat transfer and review of empirical relations. Current topics are included. Prerequisite: Mech Eng 225. (Co-listed with Mech Eng 325).

AERO ENG 327 Combustion Processes (LEC 3.0)
Application of chemical, thermodynamic, and gas dynamic principles to the combustion of solid, liquid, and gaseous fuels. Includes stoichiometry, thermochemistry, reaction mechanism, reaction velocity, temperature levels, and combustion waves. Prerequisite: Mech Eng 221. (Co-listed with Mech Eng 327).

AERO ENG 329 Smart Materials And Sensors (LEC 2.0 and LAB 1.0)
Smart structures with fiber reinforced polymer (FRP) composites and advanced sensors. Multi-disciplinary topics include characterization, performance, and fabrication of composite structures; fiber optic, resistance, and piezoelectric systems for strain sensing; and applications of smart composite structures. Laboratory and team activities involve manufacturing, measurement systems, instrumented structures, and performance tests on a large-scale smart composite bridge. Prerequisites: Senior standing and Math 204. (Co-listed with Mech Eng 329, Elec Eng 329 and Civ Eng 318).

AERO ENG 330 Applied Computational Methods (LEC 3.0)
Detailed study of computational methods for efficient solution of selected fluids, structures, thermodynamics, and controls problems in aerospace and mechanical engineering. Besides basic numerical techniques, topics covered include gradient-based optimization and uncertainty quantification. Prerequisite: Comp Sci 53 or 73 or 78; Math 204. (Co-listed with Mech Eng 330).

AERO ENG 331 Intermediate Thermofluid Mechanics (LEC 3.0)
Derivation of Navier-Stokes equations, analytical solutions of viscous flows; flow in pipes, flow networks; intermediate treatment of boundary layer theory; micro-fluidics and MEMS; introduction to numerical methods for solving fluid flows; and, preliminary treatise on turbulence. Prerequisite: Mech Eng 231 or Aero Eng 231. (Co-listed with Mech Eng 331).

AERO ENG 334 Stability Of Engineering Structures (LEC 3.0)
Solution of stability problems with applications to columns, plates and shell structures. Torsional and lateral buckling of columns. Buckling under high temperatures. Effect of imperfections introduced by a technological process on stability. Design issues related to stability requirements. Prerequisites: Civ Eng 110; Math 204; and IDE 150 or Mech Eng 160 or Aero Eng 160. (Co-listed with Mech Eng 334).

AERO ENG 335 Aerospace Propulsion Systems (LEC 3.0)
Study of atmospheric and space propulsion systems with emphasis on topics of particular current interest. Mission analysis in space as it affects the propulsion system. Power generation in space including direct and indirect energy conversion schemes. Prerequisite: Aero Eng 235.

AERO ENG 336 Fracture Mechanics (LEC 3.0)
Linear elastic and plastic mathematical models for stresses around cracks; concept of stress intensity; strain energy release rates; correlation of models with experiment; determination of plane stress and plane strain parameters; application to design. Prerequisite: Civ Eng 110. (Co-listed with Mech Eng 336).

AERO ENG 339 Computational Fluid Dynamics (LEC 3.0)
Introduction to the numerical solution of the Navier-Stokes equations, by finite difference methods, in both stream function-vorticity and primitive variable formulations. Course format emphasizes student development of complete computer programs utilizing a variety of solution methods. Prerequisites: Comp Sci 53 or 73 or 74; one course in fluid mechanics. (Co-listed with Mech Eng 339).

AERO ENG 342 Experimental Stress Analysis II (LAB 1.0 and LEC 2.0)
Acquaints the student with some techniques of experimental stress analysis. Topics include principal stresses, strain to stress conversion, transmission and reflection photoelastic methods, Moire fringe methods, and analogies. Prerequisites: Civ Eng 110, Eng Mech 321. (Co-listed with Mech Eng 342, Eng Mech 342).

AERO ENG 344 Fatigue Analysis (LEC 3.0)
The mechanism of fatigue, fatigue strength of metals, fracture mechanics, influence of stress conditions on fatigue strength, stress concentrations, surface treatment effects, corrosion fatigue and fretting corrosion, fatigue of joints components and structures, design to prevent fatigue. Prerequisite: Civ Eng 110. (Co-listed with Mech Eng 338).

AERO ENG 349 Robotic Manipulators & Mechanisms (LEC 2.0 and LAB 1.0)
Overview of industrial applications, manipulator systems and geometry. Manipulator kinematics; hand location, velocity and acceleration. Basic formulation of manipulator dynamics and control. Introduction to machine vision. Projects include robot programming, vision-aided inspection and guidance, and system integration. Prerequisites: Comp Sci 73, Aero Eng 213. (Co-listed with Mech Eng 349).
AERO ENG 350 Integrated Product Development (LEC 2.0 and LAB 1.0)
Students in design teams will simulate the industrial concurrent engineering development process. Areas covered will be design, manufacturing, assembly, cost, and product support. Using a 3-D solid modeling program, students will design, analyze, and send the data base to the automated machine shop where the parts will be manufactured. The parts will then be assembled, tested and analyzed for their performance. Prerequisites: Aero Eng 251 or Mech Eng 208 for Design; Mech Eng 213 for Assembly; Accompanied or preceded by Mech Eng 353 for Manufacturing; Eng Mgt 375 or 385 for Cost/Product Support.

AERO ENG 352 Introduction to Finite Element Analysis (LEC 3.0)
Variational formulation of the governing equations. Finite element model, interpolation functions, numerical integration, assembly of elements and solution procedures. Applications to solid mechanics, fluid mechanics and heat transfer problems. Two-dimensional problems. Computer implementation and use of commercial finite element codes. Prerequisite: Mech Eng 208 or Aero Eng 253 or consent of instructor for majors that do not require either of these courses. (Co-listed with Mech Eng 312).

AERO ENG 353 Aeroelasticity (LEC 3.0)
Study of phenomena involving interactions among inertial, aerodynamic, and elastic forces and the influence of these interactions on aircraft and space vehicle design. Some aeroelastic phenomena are: divergence, control effectiveness, control reversal, flutter, buffetting, dynamic response to rapidly applied loads, aeroelastic effects on load distribution, and static and dynamic stability. Prerequisites: Aero Eng 251 and 271.

AERO ENG 360 Probabilistic Engineering Design (LEC 3.0)
The course deals with uncertainties in engineering analysis and design at three levels - uncertainty modeling, uncertainty analysis, and design under uncertainty. It covers physics-based reliability analysis and reliability-based design, robustness assessment and robust design, their integration with design simulations, and their engineering applications. Prerequisite: Mech Eng 208 or Aero Eng 261. (Co-listed with Mech Eng 360).

AERO ENG 361 Flight Dynamics-Stability And Control (LEC 3.0)
Review of static stability, dynamic equations of motion, linearized solutions, classical control design and analysis techniques, introduction to modern control. Prerequisite: Aero Eng 261.

AERO ENG 369 Introduction To Hypersonic Flow (LEC 3.0)

AERO ENG 370 Plasma Physics I (LEC 3.0)
Single particle orbits in electric and magnetic fields, moments of Boltzmann equation and introduction to fluid theory. Diffusion of plasma in electric and magnetic fields. Analysis of laboratory plasmas and magnetic confinement devices. Introduction to plasma kinetic theory. Prerequisite: Aero Eng 231 or Mech Eng 231 or Physics 221 or Nuc Eng 221 or Elec Eng 271. (Co-listed with Mech Eng 370, Nuc Eng 370, Physics 370).

AERO ENG 371 V/STOL Aerodynamics (LEC 3.0)

AERO ENG 377 Principles Of Engineering Materials (LEC 3.0)
Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Chem Eng 347, Physics 377, Met Eng 377, Cer Eng 377).

AERO ENG 378 Mechatronics (LEC 2.0 and LAB 1.0)
This course will introduce students to the basics of mechatronics (i.e., the integration of mechanical, electrical, computer, and control systems). Students will learn the fundamentals of sensors and actuators for mechanical systems, computer interfacing, microcontrollers, real-time software, and control. Prerequisite: Mech Eng 279 or equivalent. (Co-listed with Mech Eng 378, Elec Eng 378 and Comp Eng 378).

AERO ENG 380 Spacecraft Design I (LEC 3.0)
Fundamentals of spacecraft design. Systems engineering, subsystem analysis and design. Gantt charts, organizational charts. Oral presentations and technical documentation. Term project to involve design and development of actual flight hardware, continuing into Spacecraft Design II. Prerequisites: Aero Eng 251, 261, and 271 for Aero Eng majors; consent of instructor for non-Aero Eng majors.

AERO ENG 381 Mechanical And Aerospace Control Systems (LEC 3.0)
Synthesis of mechanical and aerospace systems to perform specific control functions. Response and stability are studied. Singular value analysis for stability margins is introduced. Prerequisite: Mech Eng 279 or Aero Eng 361. (Co-listed with Mech Eng 381).

AERO ENG 382 Spacecraft Design II (LAB 3.0)
As a continuation of Aero Eng 380, detailed spacecraft design is performed, leading to procurement of components. As schedules permit, spacecraft fabrication and test commence. Development of labs to facilitate spacecraft test, operation, and data analysis continues. Prerequisites: Aero Eng 380 for Aero Eng majors; consent of instructor for non-Aero Eng majors.

AERO ENG 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

AERO ENG 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

AERO ENG 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title. (Co-listed with Mech Eng 401).

AERO ENG 407 Advanced Vibrations (LEC 3.0)
Advanced treatment of discrete and continuous vibratory systems. Extensive use is made of matrix methods and operator notation. Special topics include: transmission matrices, relative coordinates, time dependent boundary conditions, approximate techniques for linear systems, nonlinear systems and random excitations. Prerequisite: Mech Eng or Aero Eng 307. (Co-listed with Mech Eng 407).
AERO ENG 408 Advanced Finite Element Analysis (LEC 3.0)
Higher order, isoparametric and mixed finite elements. Eigenvalue and
time-dependent problems. Solution procedures for dynamic analysis.
Implicit and explicit methods. Applications to viscous incompressible fluid
and plate bending problems. Three-dimensional problems. Nonlinear
finite element analysis. Practical applications using commercial software.
Prerequisite: Mech Eng 312 or Aero Eng 352. (Co-listed with Mech Eng
408).

AERO ENG 410 Seminar (LEC 0.0-1.0)
Discussion of current topics. (Co-listed with Mech Eng 410).

AERO ENG 413 Advanced Aerospace Mechanics (LEC 3.0)
Current problems in aerospace dynamics are treated using methods of
analytical mechanics; gyroscopic phenomena; the calculus of variations,
stability of systems, to include approximate techniques. Prerequisite:
Mech Eng or Aero Eng 313. (Co-listed with Mech Eng 413).

AERO ENG 414 Advanced Astrodynamics (LEC 3.0)
Analysis of spacecraft motion using different dynamic models and
perturbations. Using the state transition matrix and differential corrections
 technique for trajectory computation. Introduction to the three-body
problem. Use of computational and numerical methods to solve
astrodynamics problems. Prerequisite: Aero Eng 314.

AERO ENG 422 Applied Linear Elasticity (LEC 3.0)
Formulation and study of boundary-value problems in 2-D linear
elastostatics: Equilibrium and compatibility. Stress function formulations
in Cartesian and polar coordinates. Curved beam, wedge and
plane contact problems. Dislocations and cracks. Thermoelectricity.
Prerequisites: IDE 110, Math 325 (Co-listed with Mech Eng 422).

AERO ENG 423 Viscous Fluid Flow (LEC 3.0)
Fundamentals of viscous fluids for incompressible and compressible
flows governed by Navier-Stokes equations; exact, approximate, and
numerical solutions for steady and unsteady laminar flows; boundary
layer theory for incompressible and compressible flows; stability and
transition. Prerequisite: Mech Eng 331 or Aero Eng 331 or Mech Eng 339
or Aero Eng 339 or equivalent. (Co-listed with Mech Eng 423).

AERO ENG 425 Heat Transfer By Conduction (LEC 3.0)
A study of conduction of heat transfer in solids by analytical and other
methods. Prerequisite: Mech Eng or Aero Eng 325. (Co-listed with Mech
Eng 425).

AERO ENG 427 Heat Transfer By Convection (LEC 3.0)
An analytical study of convective heat transfer in laminar and turbulent
flows; forced convection, natural convection, and mixed convection;
combined heat and mass transfer; heat transfer with change of phase;
instability of laminar flow; current topics in convection. Prerequisite: Mech
Eng or Aero Eng 325. (Co-listed with Mech Eng 427).

AERO ENG 429 Heat Transfer By Radiation (LEC 3.0)
A study of the nature of thermal radiation; implications from
electromagnetic theory; radiative characteristics of surfaces; enclosures;
configuration factors; radiosity; specular and diffuse reflection; transfer in
absorbing, emitting and scattering media; combined radiation conduction
and convection; experimental methods. Prerequisite: Mech Eng or Aero
Eng 325. (Co-listed with Mech Eng 429).

AERO ENG 431 Gas Dynamics I (LEC 3.0)
A critical analysis of the phenomena governing the flow of a compressible
fluid; introduction to flow in two and three dimensions; Prandtl-Meyer
expansions; small perturbations in subsonic and supersonic flows;
method of characteristics. Prerequisite: Mech Eng or Aero Eng 331. (Co-
listed with Mech Eng 431).

AERO ENG 435 Turbulent Flows - Theory, Measurements and
Modeling (LEC 3.0)
Navier-Stokes equations; statistical description and mean-flow
equations; behavior of free shear and wall bounded flows; the energy
cascade; turbulence spectra and Kolmogorov hypothesis; measurement
techniques: PIV, hot-wires, LDV; turbulence modeling for transport
processes and closure schemes for RANS equations; evaluation of model
constants, introduction to LES, DNS and hybrid-RANS. Prerequisite:
Mech Eng 331 or Aero Eng 331 or Mech Eng 339 or Aero Eng 339 or
equivalent. (Co-listed with Mech Eng 435).

AERO ENG 437 Physical Gas Dynamics I (LEC 3.0)
Features of high temperature gas flows including the development of
the necessary background from kinetic theory, statistical mechanics,
chemical thermodynamics and chemical kinetics. Equilibrium and
Nonequilibrium gas properties and gas flows are included. Prerequisite:
Mech Eng or Aero Eng 331. (Co-listed with Mech Eng 437).

AERO ENG 457 Markov Decision Processes (LEC 3.0)
Introduction to Markov Decision Processes and Dynamic Programming.
Application to Inventory Control and other optimization and control topics.
Prerequisite: Graduate standing in background of probability or statistics.
(Co-listed with Comp Eng 457, Mech Eng 447, Eng Mgt 457 and Comp
Sci 457).

AERO ENG 458 Adaptive Critic Designs (LEC 3.0)
Review of Neurocontrol and Optimization, Introduction to Approximate
Dynamic Programming (ADP), Reinforcement Learning (RL), Combined
Concepts of ADP and RL - Heuristic Dynamic Programming (HDP),
Dual Heuristic Programming (DHP), Global Dual Heuristic Programming
(GDHP), and Case Studies. Prerequisite: Elec Eng 368 Neural Networks
or equivalent (Computational Intelligence Comp Eng 301) (Co-listed with
Comp Eng, Elec Eng, Mech Eng and Sys Eng 458).

AERO ENG 479 Analysis And Synthesis Of Mechanical And
Aerospace Systems (LEC 3.0)
A unified treatment of modern system theory for the Mechanical
and Aerospace Engineering Controls Analyst, including analysis
and synthesis of linear and nonlinear systems, compensation and
optimization of continuous and discrete systems, and theory of adaptivity.
Prerequisite: Mech Eng 381 or Aero Eng 381. (Co-listed with Mech Eng
479).

AERO ENG 484 Analysis Of Laminated Composite Structures (LEC
3.0)
An overview of isotropic beams, plates, and shells. Bending, vibration,
and buckling of laminated composite beams and plates: exact and
approximate solutions. Development of composite shell theory and
simplified solutions. Analysis of composite structures including transverse
shear deformation and thermal effects. Prerequisite: Mech Eng 382 or
Aero Eng 311. (Co-listed with Mech Eng 484).

AERO ENG 485 Mechanics Of Composite Materials (LEC 3.0)
Effective moduli of spherical, cylindrical and lamellar systems.
Micromechanics of fiber-matrix interfaces and unidirectional composites.
Application of shear leg and other approximate theories to interfaces
and composites including fiber pull-out, debonding and matrix cracking.
Prerequisite: Mech Eng 382 or Aero Eng 311. (Co-listed with Mech Eng
485).

AERO ENG 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a
thesis or dissertation. Consent of instructor required.
AERO ENG 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this fee for less than three (3) semester hours for resident students.

AERO ENG 495 Continuous Registration (LEC 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Biological Sciences (BIO SCI)

BIO SCI 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

BIO SCI 301 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

BIO SCI 310 Seminar (RSD 1.0)
Presentation of a scientific paper concerned with current topics in biological sciences. Prerequisite: Senior standing.

BIO SCI 311 Bioinformatics (LEC 3.0)
The course will familiarize students with the application of computational methods to biology, as viewed from both perspectives. It will introduce problems in molecular, structural, morphological, and biodiversity informatics, and will discuss principles, algorithms, and software to address them. Prerequisites: Bio Sci 110 or 111 and Comp Sci 53/54 or 74/78. (Co-listed with Comp Sci 311).

BIO SCI 315 Developmental Biology (LEC 3.0)
Study of the patterns of development of the vertebrate embryo, the molecular mechanisms of tissue induction, and interactions among developing tissues. Prerequisite: Bio Sci 211.

BIO SCI 321 Pathogenic Microbiology (LEC 3.0)
A study of medically important microorganisms. Students will learn about the properties that enable organisms to cause disease as well as the disease process within the host. Special emphasis will be placed on recent advances in the molecular genetics of host pathogen interaction. Prerequisite: Bio Sci 221 or Civ Eng 261.

BIO SCI 325 Microbiology In Bioengineering (LEC 3.0)
General introduction to prokaryotic and eukaryotic microorganisms and viruses. Consideration of various parameters affecting the growth, basic techniques of culture, and industrial applications of microorganisms. Prerequisite: Bio Sci 211.

BIO SCI 328 Nutritional And Medicinal Properties Of Plants (LEC 3.0)
A survey of the biochemical and physiological functions of mineral elements, vitamins, and other organic compounds from plants necessary in human nutrition; and an overview of the medicinal derivatives of various plants, their effects and uses. Prerequisites: Bio Sci 110 or Bio Sci 111; and Bio Sci 211.

BIO SCI 331 Molecular Genetics (LEC 3.0)
A study of the properties and functions of DNA that make this macromolecule unique in the universe. Examples of replication, transcription, translation, repair, and regulation will be examined in viruses, prokaryotes, and eukaryotes. Prerequisites: Bio Sci 231 and Bio Sci 211.

BIO SCI 332 Molecular Genetics Laboratory (LAB 2.0)
This course provides experience in the use of a variety of DNA manipulation techniques that are common to molecular studies. These include DNA extraction, restriction mapping, Southern blotting, recombinant plasmid construction, DNA sequencing and analysis, and polymerase chain reaction. Prerequisite: Preceded or accompanied by Bio Sci 331.

BIO SCI 334 Genomics (LEC 3.0)
This course offers a general overview of the field of genomics. Topics covered include genome sequencing and annotation, transcriptomics, proteomics, metabolomics, genomic variation, and an overview of human, and several animal, plant, and microbial genome projects.

BIO SCI 335 Cancer Cell Biology (LEC 3.0)
Advanced biology course examining cellular processes that go awry during tumorigenesis. We will discuss cell cycle controls, signal transduction pathways, DNA repair, telomerase, apoptosis, cell migration and adhesion that are altered in cancer cells. Prerequisite: Bio Sci 211.

BIO SCI 340 Biomaterials I (LEC 3.0)
This course will introduce senior undergraduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. Prerequisite: Senior undergraduate standing. (Co-listed with Cer Eng 340, Met Eng 340, Chem Eng 340).

BIO SCI 341 Tissue Engineering I (LEC 3.0)
The course will introduce senior undergraduate students to the principles and clinical applications of tissue engineering including the use of biomaterials scaffolds, living cells and signaling factors to develop implantable parts for the restoration, maintenance, or replacement of biological tissues and organs. Prerequisite: Senior standing. (Co-listed with MS&E 341).

BIO SCI 342 Exercise Physiology (LEC 3.0)
Covers cardiovascular, pulmonary, and metabolic responses to aerobic and anaerobic muscular activities, work capacities, nutritional factors in performance, and role of exercise in health. Prerequisite: Bio Sci 110 or Bio Sci 111.

BIO SCI 345 Comparative Chordate Anatomy (LEC 2.0 and LAB 2.0)
An integrated, comparative study of chordate structures and systems, with emphasis on evolution, development and function. Includes examination of gross anatomy and histology of selected forms. Prerequisites: Bio Sci 113, Bio Sci 114.

BIO SCI 351 Introduction to Environmental Microbiology (LEC 3.0)
Environmental Microbiology is an interdisciplinary study of how microorganisms can impact humans and applied to solve problems such as water treatment and environmental cleanup of contaminants. This course differs from Bio Sci 451 as no NSF-style report or presentation is required. Prerequisite: Bio Sci 221.

BIO SCI 352 Biological Effects Of Radiation (LEC 3.0)
Introduction to biological effects of ionizing radiation including mode of induction of mutations, effects on the developing fetus and specific tissues plus therapeutic applications of various types of radiation. Prerequisites: Bio Sci 110 or Bio Sci 111; and Chem 3.
BIO SCI 354 Freshwater Ecology (LEC 3.0)
The ecology of streams, lakes, and wetlands. The course will cover the physical and chemical characteristics of freshwater environments, the diversity of life in freshwaters, biogeochemical processes, and threats to freshwater systems. Prerequisite: Bio Sci 251.

BIO SCI 358 Advanced Biodiversity (LEC 3.0)
This course focuses on the enhancement and reduction of biodiversity and modern techniques of measuring and monitoring it. Topics include biogeography, community structure, competition, predation, food webs, ecology-biology relationships, environmental change, and human impact. Additional costs and a week-long field trip are required. Prerequisite: Bio Sci 235 or Bio Sci 251.

BIO SCI 364 Global Ecology (LEC 3.0)
This class covers ecological topics at large scales, emphasizing global scales. Topics include global energy balance, biogeochemical cycles of water, carbon, nitrogen, and other biologically important elements, and global biodiversity. Prerequisite: Bio Sci 251.

BIO SCI 370 Toxicology (LEC 3.0)
A study of natural and man-made toxicants, various possible routes of exposure, absorption, distribution, biotransformation, specific target sites, and mechanisms involved in elicitation of toxic effects, as well as detoxification and excretion. Prerequisites: Bio Sci 211, Bio Sci 231, at least Junior standing.

BIO SCI 375 Biological Design and Innovation I (LAB 3.0)
Students identify significant problems in biological/biomedical sciences, and then design and implement innovative solutions using advanced techniques. Students present and defend proposals and results. Prerequisite: At least two 200 level or higher Biology courses.

BIO SCI 381 Immunology (LEC 3.0)
A study of the principles of immunology, including biological and biochemical aspects of the immune response, immunology, serology, immunoglobulin and T-cell mediated allergies, tumor and transplantation immunology, autoimmune diseases, and the role of immunity in host defense. Prerequisites: Chem 223 or Chem 363 and Bio Sci 211.

BIO SCI 382 Neurobiology (LEC 3.0)
An intermediate course in cellular neurobiology. Emphasis will be placed on the unique properties of neurons and other excitable cells. Topics covered include the structure and biophysical properties of neurons, synaptic transmission, neurochemistry, signal transduction, neuropharmacology and neurodevelopment. Prerequisite: Bio Sci 211.

BIO SCI 383 Pharmacology (LEC 3.0)
The basic principles of drug action, pharmacokinetics, pharmacodynamics and toxicity. We will emphasize the actions of drugs used to treat cardiovascular and nervous system disorders. Students will review the primary literature to prepare both written and oral reports on drug actions. Prerequisite: Bio Sci 211.

BIO SCI 388 Biomedical Problems (LEC 3.0)
This course will use a problem-based learning approach to examine biological aspects of various medical conditions. Students will work in groups and individually to answer problems related to diagnostic testing and evaluation of diseases and other medical conditions. Prerequisites: Bio Sci 242 or 244 or 246.

BIO SCI 390 Undergraduate Research (IND 1.0-3.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours for graduation credit. Subject and credit to be arranged with the instructor. Prerequisite: Consent of instructor.

BIO SCI 391 General Virology (LEC 3.0)
An overview of the field of virology, including plant, animal, and bacterial viruses. Discussions will include morphology, classification, virus-host interactions, genetics, clinical and industrial aspects of viruses, and viruses as model systems for basic biological studies. Prerequisites: Bio Sci 110 or 111; Bio Sci 211, 221, Chem 1, 3, 221.

BIO SCI 400 Special Problems (IND 0.0-6.0)
Graduate problems or readings on specific subjects or projects in the department. Prerequisite: Consent of the instructor.

BIO SCI 401 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

BIO SCI 402 Problems In Applied And Environmental Biology (LEC 0.0-3.0)
Overview of major areas of research in applied biology and environmental science with a focus on interdisciplinary approaches used on S&T campus in ongoing research. Prerequisite: Acceptance to Graduate Program.

BIO SCI 410 Graduate Seminar (RSD 0.0-6.0)
Presentation and discussion of current topics in Applied and Environmental Biology.

BIO SCI 418 Plant Stress Physiology (LEC 3.0)

BIO SCI 421 Advanced Microbial Metabolism (LEC 3.0)
A survey of the diverse metabolic properties of microorganisms. Course material will emphasize major metabolic pathways and how they relate to microbial diversity and microbial ecology. Prerequisite: Bio Sci 221 or an equivalent course.

BIO SCI 422 Biomolecules (LEC 3.0)
Demonstration of the principles of modern biochemistry as they relate to the structure and function of the major macromolecules of the cell. An emphasis will be placed on reading and interpreting scientific literature and scientific writing. Prerequisites: Bio Sci 211 and/or Chem 361 or an equivalent course.

BIO SCI 435 Advanced Cancer Cell Biology (LEC 3.0)
Graduate level biology course examining cellular processes that go awry during tumorigenesis. We will discuss cell cycle controls, signal transduction pathways, DNA repair, telomerase, apoptosis, cell migration and adhesion that are altered in cancer cells. In addition to lecture, will include a weekly section to examine primary cancer literature. Prerequisite: Bio Sci 211.

BIO SCI 440 Biomaterials II (LEC 3.0)
This course will introduce graduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. A term paper and oral presentation are required. Prerequisite: Graduate Standing. (Co-listed with Cer Eng 440, Met Eng 440, Chem Eng 440).
**BIO SCI 441 Tissue Engineering II** (LEC 3.0)
The course will introduce graduate students to the principles and clinical applications of tissue engineering including the use of biomaterials, scaffolds, living cells and signaling factors to develop implantable parts for the restoration, maintenance, or replacement of biological tissues and organs. A related topic term paper and oral presentation are expected. Prerequisite: Graduate standing. (Co-listed with MS&E 441).

**BIO SCI 442 Mammalian Physiology** (LEC 3.0)
Advanced study of the physiology of mammalian organ systems with a focus on membrane biophysics, endocrine control of metabolism, organ interactions, and homeostatic mechanisms. Prerequisites: Bio Sci 211 plus either Bio Sci 215 or Bio Sci 242.

**BIO SCI 451 Environmental Microbiology** (LEC 3.0)
Topics to be explored in this course will include but are not limited to microbial growth and metabolic kinetics, life in extreme conditions, biogeochemical cycling, bioremediation of contaminants, waterborne pathogens and environmental biotechnology. Prerequisite: Must be a graduate student.

**BIO SCI 452 Astrobiology** (LEC 3.0)
The origins of life on earth and the possibility of life on extraterrestrial bodies will be explored in this course through lectures and journal article discussions. In addition, the means to study extraterrestrial environments will be considered. Prerequisite: Graduate standing.

**BIO SCI 454 Advanced Freshwater Ecology** (LEC 3.0)
The ecology of streams, lakes, and wetlands. The course will cover the physical and chemical characteristics of freshwater environments, the diversity of life in freshwaters, biogeochemical processes, and threats to freshwater systems. Research proposal and additional readings required for graduate credit. Prerequisite: Graduate student standing.

**BIO SCI 455 Bioremediation** (LEC 3.0)
During this course, the use of microorganisms and other living organisms for the remediation of contaminated environments will be explored along with the techniques necessary for monitoring their activities. Prerequisite: Graduate standing.

**BIO SCI 461 Molecular Cell Biology** (LEC 3.0)
Advanced study of the biology of eukaryotic cells, including biomembranes and membrane transport, subcellular organelles, cellular energetics, protein sorting, cytoskeletal elements, cell to cell signalling, regulation of the cell cycle, and tissue organization. Prerequisite: Bio Sci 211 or equivalent.

**BIO SCI 470 Advanced Toxicology** (LEC 3.0)
We will discuss the toxicity and mechanisms of action of natural and man-made toxicants. The impact of toxicants on both human health and the environment will be considered. Students will be assigned to independent literature search and write a report. Prerequisites: Bio Sci 211 and Bio Sci 231.

**BIO SCI 475 Techniques In Applied And Environmental Biology** (LEC 3.0)
Students will have the opportunity for hands on experience with the various techniques used in the modern biology laboratory. Techniques will include gene cloning, DNA sequencing, protein purification, growth and development of various model organisms, data acquisition. Prerequisite: Graduate standing.

**BIO SCI 490 Graduate Research** (IND 0.0-15)
Investigation of an advanced nature leading to the preparation of a thesis or dissertation.

**BIO SCI 493 Oral Examination** (IND 0.0)
(Variable) After completion of all other program requirements, oral examinations for on-campus M.S./PH.D students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

### Business (BUS)

**BUS 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**BUS 301 Special Topics** (LEC 0.0-6.0)
This is designed to give the department an opportunity to test a new course. Variable title.

**BUS 305 Accounting Essentials** (LEC 1.5)
This course is an introduction to the essentials of financial and managerial accounting for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit in this course cannot be applied to any major or minor in Business, IS&T, or Economics. Prerequisite: Senior or Junior standing; 3.0 GPA required.

**BUS 306 Management and Business Law Essentials** (LEC 1.5)
This course is an introduction to the essentials of management and business law for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit in this course cannot be applied to any major or minor in Business, IS&T, or Economics. Prerequisite: Senior or Junior Standing; 3.0 GPA required.

**BUS 308 Operations Management Essentials** (LEC 1.5)
This course is an introduction to the essentials of operations management for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit in this course cannot be applied to any major or minor in Business, IS&T, or Economics. Prerequisite: Senior or Junior Standing; 3.0 GPA required.

**BUS 309 Mathematics and Statistics Essentials** (LEC 1.5)
This course is an introduction to the essentials of mathematics and statistics for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit in this course cannot be applied to any major or minor in Business, IS&T, or Economics. Prerequisite: Senior or Junior Standing; 3.0 GPA required.

**BUS 311 Business Negotiations** (LEC 3.0)
The purpose of this course is to understand the practices and processes of negotiation so that you can negotiate successfully in a variety of settings. The course is designed to be relevant to the broad spectrum of negotiation problems faced by managers, consultants, etc. Because almost everyone negotiates all the time, this course is relevant to almost any student. Prerequisite: Upperclassmen or graduate status.
**BUS 312 Management Information Systems Essentials** (LEC 1.5)
This course is an introduction to the essentials of management information systems for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit in this course cannot be applied to any major or minor in Business, IS&T, or Economics. Prerequisite: Senior or Junior Standing; 3.0 GPA required.

**BUS 315 Introduction to Teambuilding and Leadership** (LEC 3.0)
This course covers an introduction to leadership styles, principles, models, issues, and applications through analytical and intellectual examination. Key components of teams are introduced, with opportunities to practice and develop both leadership and teambuilding skills.

**BUS 320 Managerial Accounting** (LEC 3.0)
Emphasizes internal use of accounting information in establishing plans and objectives, controlling operations, and making decisions involved with management of an enterprise (the determination of costs relevant to a specific purpose such as inventory valuation, control of current operation, or special decisions). Prerequisites: Bus 120 or Eng Mgt 147.

**BUS 350 Customer Focus and Satisfaction** (LEC 3.0)
Major emphasis is given to the concept of customer focus, with coverage of techniques for obtaining customer needs, measuring customer satisfaction, developing products and services to satisfy customers, and maximizing the benefits of customer feedback. A semester long HoQ project will be done. Prerequisites: MKT 311 or MKT 307 or Eng Mgt 251. (Co-listed with MKT 350).

**BUS 360 Business Operations** (LEC 3.0)
This course examines the concepts, processes, and institutions that are fundamental to an understanding of business operations within organizations. Emphasis is on the management and organization of manufacturing and service operations and the application of quantitative methods to the solution of strategic, tactical and operational problems. Prerequisites: Math 8 or Math 12 or Math 14; any Statistics course; Bus 120 or Eng Mgt 147.

**BUS 370 Human Resource Management** (LEC 3.0)
The course examines employee selection, performance appraisal, training and development, compensation, legal issues, and labor relations. Prerequisite: Bus 110.

**BUS 375 International Business** (LEC 3.0)
This survey course will deal with business concepts, analytical processes and philosophical bases for international business operations. Emphasis is on environmental dynamics, multinational business organizations, cultural and economic constraints, unique international business practices and international operations, strategy and policy. Prerequisite: MKT 311 or MKT 407 or Eng Mgt 251.

**BUS 380 Strategic Management** (LEC 3.0)
Study of the formulation and implementation of corporate, business and functional strategies designed to achieve organizational objectives. Case studies and research reports may be used extensively. Prerequisites: MKT 311 or Eng Mgt 251; Finance 250 or Eng Mgt 252; Senior standing.

**BUS 390 Undergraduate Research** (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

**BUS 396 Business Models for Entrepreneurship and Innovation** (LEC 3.0)
This course uses problem-based learning to expand student insight into the nature, development, and application of business models. It increases the practical skills and knowledge required to generate original models of value creation for both entrepreneurial start-ups and corporate innovation. Prerequisite: Senior or graduate standing.

**BUS 397 Senior Business Design I** (LEC 1.0)
In this course, students will become familiar with the principles of entrepreneurship; learn about the basic purpose, content and structure of business plans; and develop business presentation skills through practice. At the end of the semester, student teams will give presentations to a bank in an attempt to secure a loan to run the business the following semester. Prerequisite: Senior Standing.

**BUS 398 Senior Business Design II** (LEC 2.0)
In this course, students will be expected to carry out the business plans created in Bus 397. Progress reports are submitted roughly every 3 weeks during the semester. At the end of the semester, students terminate the business organization and profits are donated to a non-profit organization in the team’s name. Prerequisite: Bus 397.

**BUS 400 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Prerequisite: Admission to the MBA program.

**BUS 401 Special Topics** (LEC 0.0-6.0)
This is designed to give the department an opportunity to test a new course. Variable title.

**BUS 405 Graduate Accounting Essentials** (LEC 1.5)
This course is an introduction to the essentials of financial and managerial accounting for running a business. It’s designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit cannot be applied to any major or minor in Business, IS&T, or Economics. Additional case or report required. Prerequisite: Bachelor Degree.

**BUS 406 Graduate Management and Business Law Essentials** (LEC 1.5)
This course is an introduction to the essentials of management and business law for running a business. It’s designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit cannot be applied to any major or minor in Business, IS&T, or Economics. Additional case study or report required. Prerequisite: Bachelor Degree.

**BUS 408 Graduate Operations Management Essentials** (LEC 1.5)
This course is an introduction to the essentials of operations management for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit cannot be applied to any major or minor in Business, IS&T, or Economics. Additional case study or report required. Prerequisite: Bachelor Degree.

**BUS 409 Graduate Mathematics and Statistics Essentials** (LEC 1.5)
This course is an introduction to the essentials of mathematics and statistics for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit cannot be applied to any major or minor in Business, IS&T, or Economics. Additional case study or report required. Prerequisite: Bachelor Degree.
BUS 412 Graduate Management Information Systems Essentials (LEC 1.5)
This course is an introduction to the essentials of management information systems for running a business. It is designed for students planning to enter the MBA program. Credit in this course cannot be applied to any major or minor in Business, IS&T, or Economics. Additional case or report required. Prerequisite: Bachelor Degree.

BUS 415 Teambuilding and Leadership in Business Settings (LEC 3.0)
This course covers leadership styles, principles, models, issues, and applications through analytical and intellectual examination. Key components of teams are introduced, with opportunities to practice and develop both leadership and teambuilding skills. Case studies required.

BUS 421 Teambuilding and Leadership (LEC 3.0)
This class will teach students how to work well in teams and lead teams and organizations. Management, networking, presentation skills, and sustainable business practices will be covered. MBA core. Prerequisite: Graduate standing.

BUS 422 International Marketing (LEC 3.0)
This course focuses on the challenges faced by business managers as they deal with a competitive global market. The course will examine various topics related to international marketing such as cultural differences, economic differences, differences in product and technical standards, global advertising, and international pricing and segmentation. MBA core. Prerequisite: Graduate standing.

BUS 423 Corporate Information Systems Management (LEC 3.0)
This course is designed primarily for potential managerial end users as managers, entrepreneurs, or business professionals in a technology-enabled business environment; it helps students learn how to use and manage information to revitalize business processes, improve business decision-making, manage IT projects, and gain competitive advantages. MBA core. Prerequisite: Graduate standing.

BUS 424 Managerial Accounting and Control (LEC 3.0)
This course covers managerial accounting and its critical role in decision making, monitoring, and controlling business processes. MBA core. Prerequisite: Graduate standing.

BUS 425 Supply Chain and Project Management (LEC 3.0)
This course covers supply chain management and its critical role in developing and maintaining effective and efficient processes in the organization, including operations and project management processes and principles. MBA core. Prerequisite: Graduate standing.

BUS 426 Integration of Business Areas (LEC 3.0)
Students will acquire knowledge to integrate the business functions to maximize performance efficiency and effectiveness. It will be covered through case studies and readings. MBA core. Prerequisite: Graduate standing.

BUS 427 Managerial Finance (LEC 3.0)
This course covers the use of financial tools to manage the organization. The main focus is the strategic decision-making process of modern managers responsible for major financial decisions. Topics include financial policy, capital investment analysis, dividend policy, capital structure, and other contemporary corporate finance issues. MBA core. Prerequisite: Graduate standing.

BUS 450 Advanced Customer Focus and Satisfaction (LEC 3.0)
Major emphasis is given to the concept of customer focus, with coverage of techniques for obtaining customer needs, measuring customer satisfaction, developing products and services to satisfy customers, and maximizing the benefits of customer feedback. Individual focused research is included. Prerequisite: MKT 311 or MKT 307 or Eng Mgt 251. (Co-listed with MKT 450).

BUS 471 Advanced Business Negotiations (LEC 3.0)
The purpose of this course is to understand the practices and processes of negotiation so that you can negotiate successfully in a variety of settings. The course is designed to be relevant to the broad spectrum of negotiation problems faced by managers, consultants, etc. A negotiation project is also required. Prerequisite: Graduate status.

BUS 475 Advanced International Business (LEC 3.0)
Business concepts, analytical processes and philosophical bases for international business operations. Emphasis is on environmental dynamics, multinational business organizations, cultural and economic constraints, unique international business practices and international operations, strategy and policy. Research project required. Prerequisite: MKT 311 or MKT 407 or Eng Mgt 251.

BUS 490 Research (IND 0.0-9.0)
Research investigation of an advanced nature leading to a major report suitable for publication in a journal or in a conference proceedings. Prerequisite: Permission of the instructor.

BUS 491 Internship (IND 0.0-6.0)
Students apply critical thinking skills and discipline specific knowledge in a work setting based on a project designed by the advisor and employer. Activities will vary depending on the student’s background and the setting. Requires major report and formal presentation to sponsoring organization. Prerequisite: Bus 420.

BUS 493 Oral Examination (IND 0.0)
After completion of all other requirements, oral examinations for on-campus M.B.A./Ph.D. students may be processed during intersession. Off-campus M.B.A. students must be enrolled in oral examination and must have paid an oral examination fee at the time defense/oral examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

BUS 496 Project Research (IND 0.0-9.0)
The research project will involve students applying research techniques and discipline specific knowledge working on a project designed by the advisor, often working with a business organization. Requires major report and formal presentation to sponsoring organization. Prerequisite: Permission of the instructor.

BUS 499 Practicum (IND 0.0-6.0)
This course is similar to the Bus 491 Internship course. The difference is that this course is intended for students who are already employed by an organization for whom they wish to continue working. Prerequisite: Bus Core.

Ceramic Engineering (CER ENG)

CER ENG 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.
CER ENG 301 Special Topics (LEC 3.0 and LAB 1.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CER ENG 306 Mechanical Properties Of Ceramics (LEC 3.0 and LAB 1.0)
This course will treat the theory and testing practice related to design based on the mechanical properties of ceramics. The course also includes a laboratory consisting of experiments for the characterization of the mechanical properties of ceramics. Prerequisite: Civ Eng 110.

CER ENG 308 Electrical Ceramics (LAB 1.0 and LEC 2.0)
The application and design of ceramics for the electrical industry is discussed. Particular emphasis is placed on how ceramic materials are altered to meet the needs of a specific application. The laboratory acquaints the student with measurements which are used for electrical property evaluation. Prerequisite: Cer Eng 284.

CER ENG 315 Organic Additives In Ceramic Processing (LEC 2.0)
Basic chemistry, structure and properties or organic additives used in the ceramics industry; solvents, binders, plasticizers, dispersants. Use of organic additives in ceramic processing. Prerequisites: Cer Eng 203 and 231.

CER ENG 331 Ceramic Processing (LEC 3.0)
Powder, colloidal and sol-gel processing, forming methods, drying, sintering and grain growth. Relation of processing steps to densification and microstructure development. Prerequisite: Senior standing.

CER ENG 333 Microelectronic Ceramic Processing (LEC 3.0)
Materials, processing and design of microelectronic ceramics are covered. Introduction to devices, triaxial ceramics, high aluminas, tape fabrication, metallizations, thick film processing and glass-to-metal seals. Prerequisites: Cer Eng 203 & 242.

CER ENG 338 Thermal Properties Of Ceramics (LEC 3.0)
This course will teach the crystal physics underlying heat capacity, internal energy, phonon and photon conduction, and thermal expansion. These properties will be used to rationalize the behavior of a wide variety of ceramic materials in severe thermal environments. Prerequisite: Senior Standing.

CER ENG 340 Biomaterials I (LEC 3.0)
This course will introduce senior undergraduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. Prerequisite: Senior undergraduate standing. (Co-listed with Bio Sci 340, Met Eng 340, Chem Eng 340).

CER ENG 352 International Engineering and Design (LEC 3.0)
A multi-disciplinary engineering course focused on sustainable design and technology transfer to developing countries. Course includes elements of traditional capstone design classes. Experiential learning through competitions and/or field work is a major component of the class. Prerequisite: Senior standing, instructor approval. (Co-listed with Geo Eng 352 and Met Eng 352).

CER ENG 362 Thermomechanical/Electrical/Optical Properties Lab (LAB 1.0)
Laboratory consisting of three separate modules of experiments for the characterization of the thermomechanical, electrical and optical properties of ceramics. The student will choose one of the three modules. Prerequisite: Civ Eng 110 or Cer Eng 284.

CER ENG 364 Refractories (LEC 3.0)
The manufacture, properties, uses, performance, and testing of basic, neutral and acid refractories. Prerequisite: Cer Eng 259.

CER ENG 369 Glass Science And Engineering (LEC 3.0)
The development, manufacturing methods, applications, and properties of flat, fiber, container, chemical, and special purpose glasses. Composition/property relationships for glasses and nucleation-crystallization processes for glass-ceramics are also covered. Prerequisite: Cer Eng 103.

CER ENG 371 Dielectric And Electrical Properties Of Oxides (LEC 3.0)
The processes occurring in inorganic materials under the influence of an electric field are considered from basic principles. Emphasis is placed on application to real systems. Prerequisite: Cer Eng 284.

CER ENG 377 Principles Of Engineering Materials (LEC 3.0)
Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Aero Eng 377, Chem Eng 347, Physics 377, Met Eng 377).

CER ENG 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

CER ENG 392 X-Ray Diffraction Analysis (LAB 1.0 and LEC 2.0)
Theory and practical aspects of x-ray diffraction analysis are covered including diffraction theory, qualitative and quantitative analysis techniques, electronic databases, and operation of modern powder diffractometers. Students cannot receive credit for both Cer Eng 292 and Cer Eng 392. Prerequisite: Preceded or accompanied by Cer Eng 291.

CER ENG 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

CER ENG 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CER ENG 405 Interfacial Phenomena (LEC 3.0)
The nature and constitution of inorganic interfaces, surface processes and consequences, epitaxy, thermal grooving, UHV techniques, field emission-ionization and evaporation, surface models, adsorption and nucleation.

CER ENG 416 Composite Materials (LEC 3.0)
The objective of this course is to give the students an understanding of the processing, design, and mechanical behavior of composite materials. The course will treat both fiber reinforced and laminate-based composites with an emphasis on the macromechanical behavior of these composites with respect to their architecture. Prerequisite: Graduate Standing.

CER ENG 418 Optical Properties Of Materials (LEC 3.0)
The objective of this course is to give the student a fundamental understanding of the structure-optical property relationships exhibited by isotropic and anisotropic materials. Topics will include the wave/particle nature of light, how light interacts with materials, color, and applications such as lasers, fiber optic communication systems, electro-optics, and integrated optics. Prerequisites: Physics 24 or 25 and Math 22.

CER ENG 423 Sintering And Microstructure Development (LEC 3.0)
Theory and practice of densification, microstructure evolution, effect of processing and material factors, grain boundary migration, grain growth. Prerequisite: Graduate standing.
CHEM ENG 301 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CHEM ENG 320 Chemical Process Flowsheeting (LAB 1.0 and LEC 2.0)
The development, implementation, and evaluation of methods for determining the mathematical model of a chemical process, ordering the equations in the mathematical model, and solving the model. Prerequisite: Math 204 or graduate standing.

CHEM ENG 333 Intermediate Separation Processes (LEC 3.0)
Fundamentals of separation operations such as extraction and distillation; rates of diffusion in equilibrium stages and continuous contactors; efficiencies; multistage contactors; performance of equipment; phase equilibrium data; multicomponent separation. Prerequisite: Chem Eng 235 or graduate standing.

CHEM ENG 335 Intermediate Transport Phenomena (LEC 3.0)
The similarities of flow of momentum, heat and mass transfer and the applications of these underlying principles are stressed. Course is primarily for seniors and beginning graduate students. Prerequisite: Chem Eng 237 or Chem Eng 263 or graduate standing.

CHEM ENG 339 Introduction to Molecular Modeling and Simulation (LEC 3.0)
An introduction to the concepts of molecular-based modeling and simulations, their connections to other engineering approaches and their role in multiscale modeling. Major methodologies such as molecular dynamics and lattice and off-lattice Monte Carlo, and special case studies are discussed. Prerequisite: Chem Eng 247.

CHEM ENG 340 Biomaterials I (LEC 3.0)
This course will introduce senior undergraduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. Prerequisite: Senior undergraduate standing. (Co-listed with Cer Eng 340, Bio Sci 340, Met Eng 340).

CHEM ENG 341 Physical Property Estimation (LEC 3.0)
Study of techniques for estimating and correlating thermodynamic and transport properties of gases and liquids. Prerequisite: Chem Eng 235 or graduate standing.

CHEM ENG 346 Introduction to Nanomaterials (LEC 3.0)
Introduction to the fundamentals of nanomaterials and recent developments on nanomaterials. Topics include physical and chemical properties, synthesis, processing, and applications of nanomaterials. Example nanomaterials include nanoparticles, nanotubes, and nanowires. Prerequisite: Chem Eng 145, or Met Eng 125 or Chem 3.

CHEM ENG 347 Principles Of Engineering Materials (LEC 3.0)
Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Aero Eng 377, Physics 377, Met Eng 377, Cer Eng 377).

CHEM ENG 349 Structure And Properties Of Polymers (LEC 3.0)
A study of the parameters affecting structure and properties of polymers. Syntheses, mechanisms, and kinetic factors are emphasized from the standpoint of structural properties. Prerequisite: Chem Eng 235 or graduate standing.

Chemical Engineering (CHEM ENG)

CHEM ENG 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.
CHEM ENG 350 Risk Assessment and Reduction (LEC 3.0)
Safe, secure manufacturing facilities protect the health of employees and the public, preserve the environment, and increase profitability. Methods for systematically identifying hazards and estimating risk improve the safety performance and security of manufacturing facilities. Prerequisite: Senior or Graduate Standing. (Co-listed with Eng Mgt 350).

CHEM ENG 351 Principles Of Environmental Monitoring (LEC 3.0)
This course introduces the fundamentals of particle technology, including particle characterization, transport, sampling, and processing. In addition, students will learn about the basic design of some industrial particulate systems and environmental and safety issues related to particulate handling. Prerequisites: Chem Eng 231 and Physics 24, or graduate standing.

CHEM ENG 355 Intermediate Process Dynamics And Control (LEC 3.0)
A study of the dynamic properties of engineering operations and the interrelationships which result when these operations are combined into processes. Formulation of equations to describe open-loop and closed-loop systems. Prerequisite: Chem Eng 235 or graduate standing.

CHEM ENG 358 Intermediate Chemical Process Safety (LEC 3.0)
The identification and quantification of risks involved in the processing of hazardous and/or toxic materials are studied. Methods to design safety systems or alter the chemical process to reduce or eliminate the risks are covered. Prerequisite: Graduate Standing.

CHEM ENG 359 Plantwide Process Control (LEC 3.0)
Synthesis of control schemes for continuous and batch chemical plants from concept to implementation. Multiloop control, RGA, SVD, constraint control, multivariable model predictive control, control sequence descriptions. Design project involving a moderately complicated multivariable control problem. Prerequisites: Chem Eng 251, Elec Eng 231, Elec Eng 235 or graduate standing. (Co-listed with El Eng 332).

CHEM ENG 365 Biochemical Reactors (LEC 3.0)
Application of chemical engineering principles to biochemical reactors, and human physiology. Emphasis on cells as chemical reactors, enzyme catalysis and biological transport phenomena. Prerequisite: Preceded or accompanied by Chem Eng 281 or graduate standing.

CHEM ENG 371 Environmental Chemodynamics (LEC 3.0)
Interphase transport of chemicals and energy in the environment. Application of the process oriented aspects of chemical engineering and science to situations found in the environment. Prerequisite: Chem Eng 237 or Chem Eng 263 or graduate standing.

CHEM ENG 372 Alternative Fuels (LEC 3.0)
Global energy outlook and available resources are discussed. Alternative energy options and their technologies are covered. Associated environmental concerns and technology are assessed. Special emphases are placed on renewable energies, transportation fuels, energy efficiencies, and clean technologies. Prerequisite: Chem Eng 235 or senior or graduate standing.

CHEM ENG 373 Pollution Prevention Via Process Engineering (LEC 3.0)
To arrive at environmentally benign process design, each processing system will be considered as an inter-connection of elementary units. Systematic methods capitalizing on synergistic process integrations will be employed. Linear, nonlinear and integer optimization, mass/heat exchange networks, and reactor and reaction networks will be used. Prerequisite: Chem Eng 235 or graduate standing.

CHEM ENG 379 Industrial Pollution Control (LEC 3.0)
The study of water, air, and thermal pollution control methods and the application of these methods to the solution of pollution problems in the chemical industry. Prerequisite: Chem Eng 235 or graduate standing.

CHEM ENG 381 Corrosion And Its Prevention (LEC 3.0)
A study of the theories of corrosion and its application to corrosion and its prevention. Prerequisite: Chem 243 or Cer Eng 259. (Co-listed with Met Eng 381).

CHEM ENG 382 Hazardous Materials Management (LEC 2.0 and LAB 1.0)
Major themes: hazard identification and characterization; safety, health and environmental management; and the protection of safety, health and environment. Students will have an understanding of work place and environmental hazards in order to be able to facilitate their management and control. The course will include an intensive 30 hour hands-on workshop. Prerequisite: ChBE 235 or graduate standing.

CHEM ENG 383 Intermediate Chemical Reactor Design (LEC 3.0)
A study of homogeneous and heterogeneous catalyzed and noncatalyzed reaction kinetics for flow and batch chemical reactors. Application to reactor design is stressed. Prerequisite: Chem Eng 281 or graduate standing.

CHEM ENG 384 Interdisciplinary Problems In Manufacturing Automation (LAB 1.0 and LEC 2.0)
The course will cover material necessary to design a product and the fixtures required to manufacture the product. Participants will gain experience with CAD/CAM software while carrying out an actual manufacturing design project. (Co-listed with Mech Eng 344, Eng Mgt 344).

CHEM ENG 385 Patent Law (LEC 3.0)
A presentation of the relationship between patent law and technology for students involved with developing and protecting new technology or pursuing a career in patent law. Course includes an intense study of patentability and preparation and prosecution of patent applications. Prerequisite: Senior or graduate standing. (Co-listed with Eng Mgt 369).

CHEM ENG 387 Interfacial Phenomena In Chemical Engineering (LEC 3.0)
The course deals with the effects of surfaces on transport phenomena and on the role of surface active agents. Topics include fundamentals of thermodynamics, momentum, heat and mass transfer at interfaces and of surfactants. Some applications are included. Prerequisite: Chem Eng 237 or Chem Eng 263 or graduate standing.

CHEM ENG 388 Intermediate Process Design (LEC 3.0)
Study of newer unit operations, fluidization, chromatographic absorption, new developments in operations previously studied. Comparison of operations which might be selected for the same end result in an industrial process. Prerequisite: Chem Eng 235 or graduate standing.

CHEM ENG 389 Industrial Chemical Processes (LEC 3.0)
Detailed study of various industrial chemical manufacturing processes including underlying chemistry, reaction pathways and separation processes. Prerequisite: Chem Eng 235 or Chem 221, or graduate standing. (Co-listed with Chem 325).

CHEM ENG 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

CHEM ENG 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.
CHEM ENG 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CHEM ENG 410 Seminar (RSD 0.0-6.0)
Discussion of current topics.

CHEM ENG 420 Applied Mathematics In Chemical Engineering (LAB 1.0 and LEC 2.0)
An introduction to numerical methods for ordinary and partial differential equations arising in chemical engineering, bioengineering, and environmental engineering applications. Topics include finite difference and finite element methods; other numerical and analytical methods if time permits.

CHEM ENG 421 Applied Optimization In Chemical Engineering (LEC 3.0)
An introduction to modern optimization techniques having applications in engineering economics, data analysis, process design and dynamics; methods such as Fibonacci, Partan, steep ascent, geometric, mathematical and dynamic programming.

CHEM ENG 425 Philosophy of Scientific Research (LEC 3.0)
Organization and planning of research. Introduction to the philosophy and management of scientific research, particularly issues related to ethics, plagiarism, ownership of intellectual properties, research techniques, technical presentations and time management. The course will address these issues by integrating with case studies. (Co-listed with IDE 425, Civ Eng 485, Env Eng 485, Elec Eng 481, Comp Eng 481).

CHEM ENG 431 Advanced Fluid Flow (LEC 3.0)

CHEM ENG 433 Advanced Transport Phenomena (LEC 3.0)
Course is concerned with all aspects of transport phenomena. Complete expressions for heat, mass and momentum transfer in all three coordinate systems are applied under both laminar and turbulent conditions. Prerequisite: Chem Eng 335.

CHEM ENG 440 Biomaterials II (LEC 3.0)
This course will introduce graduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, materials-tissue compatibility, and degradation of biomaterials. A term paper and oral presentation are required. Prerequisite: Graduate Standing. (Co-listed with Cer Eng 440, Bio Sci 440, Met Eng 440).

CHEM ENG 443 Nanomaterials (LEC 3.0)
Introduction of the fundamentals of nanomaterials and recent developments on nanomaterials. Topics include physical and chemical properties, synthesis, processing, and applications of nanomaterials. Example nanomaterials include nanoparticles, nanotubes, and nanowires. Students will need to complete a project related to nanomaterials. Prerequisite: Graduate Standing. (Co-listed with MS&E 443).

CHEM ENG 445 Advanced Chemical Engineering Thermodynamics (LEC 3.0)
Extension of thermodynamic principles as applied to nonideal systems. Use of existing thermodynamic data and correlations with emphasis on applications of chemical engineering problems in energy, mass and momentum transfer.

CHEM ENG 446 Molecular Modeling and Simulation (LEC 3.0)
Study of molecular-based modeling and simulation methodologies and their connections with each other and to multiscale modeling and other engineering approaches. Molecular Dynamics, Monte Carlo, Brownian Dynamics, statistical mechanics, and application cases in engineering and science are included. Prerequisite: Chem Eng 445.

CHEM ENG 449 Plasma Polymerization (LEC 3.0)
Fundamental aspects of polymer formation in plasma (weakly ionized gas), and properties of polymers formed by such a process are studied. Prerequisite: Chem Eng 375.

CHEM ENG 470 Physicochemical Operations In Environmental Engineering Systems (LEC 3.0)
Course covers physicochemical operations and design in water, wastewater and aqueous hazardous waste treatment systems including coagulation, precipitation, sedimentation, filtration, gas transfer, chemical oxidation and disinfection, adsorption, ion exchange. Prerequisite: Civ Eng 230 or equivalent. (Co-listed with Env Eng 462 and Civ Eng 462).

CHEM ENG 481 Advanced Chemical Reactor Design (LEC 3.0)
A study of homogeneous and heterogeneous reaction kinetics and catalysis with special emphasis on effects of mixing in design and scale-up of chemical reactors.

CHEM ENG 488 Advanced Chemical Process Design (LAB 1.0 and LEC 2.0)
The use of advanced methods of economic, engineering, optimizing, and control techniques in planning, designing, and operating chemical process industries. Topics may be adjusted to include those of special interest or need in the above fields.

CHEM ENG 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

CHEM ENG 491 Internship (IND 0.0-15)
Students working toward a doctor of engineering degree will select, with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

CHEM ENG 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

CHEM ENG 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Chemistry (CHEM)
CHEM 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Prerequisite: Preceded or accompanied by Chem 4 or an equivalent training program approved by S&T. Consent of instructor required.

CHEM 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CHEM 310 Undergraduate Seminar (RSD 1.0)
Written and oral presentations of current topics in chemistry. This course may serve as part of the capstone requirement for chemistry majors.

CHEM 321 Intermediate Organic Chemistry I (LEC 3.0)
An advanced course designed to give the student a mastery of the fundamentals of organic chemical reactions and theory. Prerequisite: Chem 223.

CHEM 323 Intermediate Organic Chemistry II (LEC 3.0)
A systematic study of organic reactions, their mechanisms and synthetic applications. Prerequisite: Chem 223.

CHEM 325 Industrial Chemical Processes (LEC 3.0)
Detailed study of various industrial chemical manufacturing processes including underlying chemistry, reaction pathways and separation processes. Prerequisite: Chem Eng 235 or Chem 221, or graduate standing. (Co-listed with Chem Eng 389).

CHEM 328 Organic Synthesis And Spectroscopic Analysis (LEC 1.0 and LAB 2.0)

CHEM 331 Selected Topics In Inorganic Chemistry (LEC 3.0)
A study of inorganic chemistry with emphasis on physical methods. General subjects covered include: molecular structure, bonding, complexes, spectroscopy, and reaction rates.

CHEM 343 Introduction To Quantum Chemistry (LEC 3.0)
A study of molecular structures and spectroscopy, statistical thermodynamics, kinetic theory, chemical kinetics, crystals, and liquids. Prerequisites: Math 22, Physics 24 or Physics 25.

CHEM 344 Advanced Physical Chemistry (LEC 3.0)
Advanced undergraduate treatments of special topics of physical chemistry, which may include statistical mechanics, kinetics, group theory, or spectroscopy. Prerequisite: Chem 343.

CHEM 346 Chemical Thermodynamics (LEC 3.0)
A study of the laws of thermodynamics with application to chemical systems. Emphasis is placed on partial molal functions. Prerequisite: Chem 243.

CHEM 355 Instrumental Methods Of Chemical Analysis (LEC 3.0 and LAB 1.0)
Principles and analytical applications of molecular spectroscopy, chromatographic separations, mass spectrometry, and radiochemistry. A brief overview of instrument electronics, signal generation and processing, and automated analysis is also provided. Prerequisites: Chem 4, Chem 151, Chem 223, Chem 243.

CHEM 361 General Biochemistry (LEC 3.0)
A resume of the important aspects of quantitative and physical chemistry in biochemical processes. General subjects covered include: proteins, nucleic acids, enzymes, carbohydrates and lipids. Prerequisite: Chem 223.

CHEM 362 General Biochemistry Laboratory (LAB 2.0)
Experiments are integrated with the lectures and cover the chemical and physical properties of proteins, enzymes, nucleic acids, carbohydrates and lipids. Prerequisites: Preceded or accompanied by Chem 361 and Chem 4 or an equivalent training program approved by S&T.

CHEM 363 Metabolism (LEC 3.0)

CHEM 367 Industrial Biochemistry (LEC 3.0)
A study of the problems involved in the utilization of biological systems for the production of bulk chemicals, the preparation of biologicals and the treatment of waste from plants producing biologicals and foodstuffs. Prerequisite: Junior standing.

CHEM 375 Principles Of Environmental Monitoring (LEC 3.0)
This course provides an overview of environmental monitoring methodologies. Discussion covers thermodynamic and kinetic processes that affect chemical transport and fate in the environment. Federal environmental regulations and remediation technologies are also covered with specific examples. Prerequisites: Chem 221, Physics 25.

CHEM 381 Chemistry And Inherent Properties Of Polymers (LEC 3.0)
A basic study of the organic chemistry of natural and synthetic high polymers, their inherent properties and their uses in plastic, fiber, rubber, resin, food, paper and soap industries. Prerequisite: Chem 223.

CHEM 384 Polymer Science Laboratory (LEC 1.0 and LAB 2.0)
Lectures and laboratory experiments dealing with polymerization reactions, solution properties and bulk or solid properties will be presented. Each student will prepare polymers and carry out all characterization experiments on actual samples. Prerequisite: Chem 381 or Chem Eng 375, preceded or accompanied by Chem 4 or an equivalent training program approved by S&T.

CHEM 385 Fundamentals Of Protective Coating I (LEC 3.0)
Study of the basic principles of protective coatings with particular reference to the paint and varnish industry. Classifications, manufacture, properties and uses of protective coatings. Prerequisite: Chem 223.

CHEM 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Does not lead to the preparation of a thesis. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor. Preparation of a written, detailed report is required of the student. Prerequisite: Must meet departmental requirements for instruction in laboratory safety. Consent of instructor required.

CHEM 400 Special Problems (IND 0.0-6.0)
Problems or reading on specific subjects or projects in the department. Consent of instructor required.

CHEM 401 Special Topics (LEC 2.0 and LAB 1.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CHEM 410 Seminar (RSD 1.0)
Discussion of current topics.

CHEM 411 Introduction to Chemistry Research (LEC 1.0)
An introduction to chemical research topics of interest to the department presented by different faculty members. Special emphasis will also be placed on a discussion of ethics, plagiarism, codes of conduct, research notebooks, publishing, and presentations. Prerequisite: Graduate Student Status.
CHEM 423 Advanced Synthetic Organic Chemistry (LEC 3.0)
A discussion of a large number of synthetically useful reactions involving enolates and enamines; nucleophilic additions to carbonyl compounds; functional group interconversions, thermal pericyclic reactions; organometallic compounds; carboxylations, carbenes and free radicals as reactive intermediates; aromatic substitutions; and multistep synthesis. Prerequisite: Chem 321 or Chem 323.

CHEM 425 Physical Organic Chemistry (LEC 3.0)
An advanced course in theoretical organic chemistry treating molecular orbital theory, free energy relationships, transition state theory, and other fundamental topics. Prerequisite: Chem 321.

CHEM 428 Spectrometric Identification of Organic Compounds (LEC 3.0)
Overview of MS and IR techniques in the characterization of organic compounds; CD/ORD; 1H, 13C, and heteronuclear NMR spectroscopy in the structural analysis; applications of APT, DEPT, 1H-1H COSY, HETCOR, HMBC, HMB, INADEQUATE, TOCSY, NOE AND NOESY, and dynamic NMR. Prerequisite: Chem 223.

CHEM 432 Bioinorganic Chemistry (LEC 3.0)
Metalloligand molecules, including metalloenzymes and other metalloproteins; oxygen carriers; ion transport and other iron proteins; copper proteins; cancer agents and cures; nitrogen-fixation, etc. Prerequisite: Chem 331.

CHEM 433 Nanomaterials Synthesis, Properties and Applications (LEC 3.0)
Chemistry of nanomaterials. Understanding the fundamentals of nanoscience and technology. Studying the different synthesis strategies for nanomaterials and their characterization. Understanding the properties of nanomaterials and their possible applications. Introducing the concept for device fabrication. Prerequisite: Chem 331.

CHEM 435 Principles Of Inorganic Chemistry (LEC 3.0)
A systematic study of modern and theoretical inorganic chemistry, based on the periodic classification. Prerequisites: Chem 237, Chem 331 and Chem 343.

CHEM 436 X-ray Crystallography (LEC 2.0 and LAB 2.0)
Molecular and crystal structure determination by single crystal x-ray diffraction methods. Brief coverage of relation to neutron and electron diffraction.

CHEM 437 Principles Of Inorganic Chemistry (LEC 3.0)

CHEM 438 Inorganic Materials Chemistry (LEC 3.0)
Chemical processing of solid materials. Introduction to point groups, space groups, and x-ray diffraction. Bonding in solids - from molecular orbital theory to band theory. Nonstoichiometric materials and Kroger-Vink notation. Optical and electrical properties of semiconductors. Epitaxial growth. Quantum effects in nanophase materials. Prerequisite: Chem 331 or permission of instructor.

CHEM 441 Physical Chemistry Of Surfaces (LEC 3.0)
Adsorption at liquid interfaces and properties of surface films. Physical and chemical adsorption on solid surfaces. Catalysis.

CHEM 444 Spectroscopy (LEC 3.0)
Introduction to the interaction of electromagnetic radiation with matter. Emphasis on the ultraviolet, visible, and radio portions of the spectrum. Prerequisite: Chem 343 or equivalent.
CHEM 484 Polymer Physical Chemistry And Analysis (LEC 3.0)
A study of the physical properties of macromolecular systems including polymer solutions, gels, bulk polymers and rubbers. The chemical characterization of polymers based on their thermal, spectroscopic, microstructure and molecular weight is also discussed. Prerequisites: Chem 223 and Chem 243.

CHEM 486 Inorganic Polymers (LEC 3.0)
A basic study of inorganic natural and synthetic polymers, their formation and reactivity, their inherent properties, methods of characterization and applications. Prerequisite: Chem 237 or equivalent.

CHEM 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Prerequisite: Must meet departmental requirements for instruction in laboratory safety. Consent of instructor required.

CHEM 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or facilities. In no case shall this be for less than three (3) semester hours for resident students.

CHEM 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Civil Engineering (CIV ENG)

CIV ENG 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

CIV ENG 301 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CIV ENG 302 Geomatics (LEC 3.0)
Horizontal and vertical geodetic datums and networks. Theory, calculations and applications of State Plane Coordinate Systems. Introduction to Geographic and Land Information Systems: hardware and software issues; data quality and accuracy; resource, environmental, cadastral and governmental applications; databases; GIS/LIS trends. Introduction to Global Positioning Systems (GPS): Project planning, data collection, data processing and network adjustment applications, Kinematic and RealTime GPS applications, hardware and software options and costs. Prerequisite: CIV Eng 1 with grade of "C" or better.

CIV ENG 304 Legal Aspects Of Boundary Surveying (LEC 3.0)
The U.S. Public Land Survey System (USPLSS): original GLO survey instructions and procedures. Resurveys on the USPLSS law, standards, procedures with emphasis on Missouri. Rights in real property; statute, case and administrative law applied to boundaries. Simultaneous and sequence conveyances. Unwritten rights in real property. Riparian boundaries. Writing and interpreting boundary descriptions. Land surveyor duties and responsibilities. Prerequisite: CIV Eng 1 with grade of "C" or better.

CIV ENG 306 Surveying Systems (LEC 3.0)
Celestial observations for azimuths. Introduction to State Plane Coordinate systems. Theory and calculations. Route surveying and geometrics, horizontal, spiral and vertical curves. Surveying aspects of residential and commercial subdivision design: lot layout, rights of way, easements, setbacks, platting, planning and zoning constraints, application of surveying software. Instrumentation: total stations, electronic levels, instrument calibrations. Prerequisite: CIV Eng 1 with grade of "C" or better.

CIV ENG 310 Seminar (LEC 1.0)
Discussion of current topics. Prerequisite: Senior standing.

CIV ENG 311 Geometric Design Of Highways (LEC 2.0 and LAB 1.0)
Development and applications of concepts of geometric design for rural and urban highways. Design controls and criteria; elements of design, including sight distance, horizontal and vertical alignment; cross-section elements; highway types; intersection design elements; types of interchanges and interchange design elements; grade separations and clearance; development of visual elements. Prerequisite: CIV Eng 211 with grade of "C" or better.

CIV ENG 312 Bituminous Materials (LEC 2.0 and LAB 1.0)
Properties, types, and grades of bituminous materials are presented. Emphasis is placed on usage, distress, surface treatment design, and asphalt concrete mix properties, behavior, design manufacture, and construction. Prerequisite: Preceded or accompanied by CIV Eng 216.

CIV ENG 313 Composition And Properties Of Concrete (LEC 3.0)
Properties of plastic and hardened concrete and the influence of cements, aggregates, water and admixtures upon these properties. The microstructure of cement gel and other factors are related to the behavior of hardened concrete under various types of loading and environments, drying shrinkage, creep and relaxation, fatigue, fracture, and durability. Introduction to statistical quality control of concrete production. Prerequisite: CIV Eng 216 with a grade of "C" or better.

CIV ENG 314 Geosynthetics In Engineering (LEC 3.0)
Geotechnical principles are applied to design of geosynthetic systems for foundation support, earth retention, drainage, and disposal of hazardous conventional wastes. Geosynthetic testing and identification. Emphasis is on design of geosynthetic earth reinforcement, roadway stabilization, filters, and waste containment systems. Prerequisite: CIV Eng 215 with grade of "C" or better.

CIV ENG 315 Intermediate Soil Mechanics (LEC 3.0)
General principles of soil mechanics and their applications, including mineralogy, soil structure, flow through porous media, shear strength, slope stability and consolidation. Prerequisites: CIV Eng 215 with grade of "C" or better.

CIV ENG 316 Geotechnical Earthquake Engineering (LEC 3.0)
Geotechnical earthquake hazards and mitigations, damage to structures, plate tectonics, seismicity, wave propagation, characterization of ground motions, theory of vibrations (1-DOF), effect of local soil conditions on ground response, development of design ground motions, liquefaction, dynamic lateral earth pressures and slope stability/deformation. Prerequisites: CIV Eng 215 with a grade of "C" or better.

CIV ENG 317 Asphalt Pavement Design (LEC 3.0)
Structural design of flexible pavements including loading characteristics, properties of pavement components, stress distribution, and the effects of climatic variables on design criteria. Prerequisite: CIV Eng 216 with a grade of "C" or better.
CIV ENG 318 Smart Materials And Sensors (LEC 2.0 and LAB 1.0)
Smart structures with fiber reinforced polymer (FRP) composites and advanced sensors. Multidisciplinary topics include characterization, performance, and fabrication of composite structures; fiber optic, resistance, and piezoelectric systems for strain sensing; and applications of smart composite structures. Laboratory and team activities involve manufacturing, measurement systems, instrumented structures, and performance tests on a large-scale smart composite bridge. Prerequisites: Senior Standing and Math 204. (Co-listed with Aero Eng 329, Mech Eng 329 and Elec Eng 329).

CIV ENG 319 Applied Mechanics In Structural Engineering (LEC 3.0)
A study of the basic relationships involved in the mechanics of structures. Topics include basic elasticity, failure criteria, fundamental theories of bending and buckling of plates and cylindrical shells for practical application in analysis and design of bridge, building floors, and shell roofs. Prerequisite: Civ Eng 217 with grade of "C" or better. (Co-listed with Arch Eng 319).

CIV ENG 320 Structural Analysis II (LEC 3.0)
Classical displacement and force methods applied to structures of advanced design. Analysis of indeterminate structures such as continuous beams, arches, cables, and two and three dimensional frames, and trusses. Analysis of indeterminate structures involving temperature and support settlements effects. Prerequisites: Civ Eng 217 or Arch Eng 217. (Co-listed with Arch Eng 320).

CIV ENG 322 Analysis And Design Of Wood Structures (LEC 3.0)
A critical review of theory and practice in design of modern wood structures. Effect of plant origin and physical structure of wood on its mechanical strength; fasteners and their significance in design; development of design criteria and their application to plane and three dimensional structures. Prerequisite: Civ Eng 217 with grade of "C" or better. (Co-listed with Arch Eng 322).

CIV ENG 323 Computer Methods of Structural Analysis (LEC 3.0)
Force and displacement matrix methods and computer methods applied to structural analysis. Analysis of indeterminate structures such as continuous beams, and two and three dimensional frames and trusses. Analysis of indeterminate structures involving temperature and support settlements effects using computer methods formulation. Prerequisite: Civ Eng 217 with grade of "C" or better. (Co-listed with Arch Eng 323).

CIV ENG 326 Advanced Steel Structures Design (LEC 3.0)
The design of structural steel systems into a final integrated structure. Plate girders, composite systems, stability, connections, rigid frames, single and multistory buildings, and similar type problems of interest to the student. Use of the computer as a tool to aid in the design will be emphasized. Prerequisite: Civ Eng 221 with a grade of "C" or better. (Co-listed with Arch Eng 326).

CIV ENG 327 Advanced Concrete Structures Design (LEC 3.0)
The design of structural concrete systems into a final integrated structure. Two-way slabs, long columns, connections, and discontinuity regions, deflections and cracking of beams and slabs, ACI design criteria, and similar type problems of interest to the student. Use of the computer as a tool to aid in the design will be emphasized. Prerequisite: Civ Eng 223 with a grade of "C" or better. (Co-listed with Arch Eng 327).

CIV ENG 328 Prestressed Concrete Design (LEC 3.0)
Behavior of steel and concrete under sustained load. Analysis and design of pre-tensioned and post-tensioned reinforced concrete members and the combining of such members into an integral structure. Prerequisite: Civ Eng 223 with a grade of "C" or better. (Co-listed with Arch Eng 328).

CIV ENG 329 Foundation Engineering II (LEC 3.0)
Classical earth pressure theories. Analysis of shallow and deep foundations to include bearing capacity and settlement of footings, rafts, piles, and drilled piers. Analysis of stability and design of retaining walls and anchored bulkheads. Prerequisites: Civ Eng 229 with a grade of "C" or better. (Co-listed with Arch Eng 329).

CIV ENG 330 Unsteady Flow Hydraulics (LEC 3.0)
The study of unsteady flow and its effect on closed water systems and in open channels. Prerequisites: Civ Eng 230 with a grade of "C" or better.

CIV ENG 331 Hydraulics Of Open Channels (LEC 3.0)
The phenomena accompanying the flow of water in open channels, such as uniform and varied flow, critical conditions, backwater curves, hydraulic jump, hydraulic drop and applications are studied in detail. Prerequisite: Civ Eng 230 with a grade of "C" or better.

CIV ENG 332 Transport Processes in Environmental Flows (LEC 3.0)
Dynamics, mixing and contaminant transport in surface water bodies, including rivers and lakes. Buoyancy modifications to the mixing and dynamics of pollutant discharges and surface water bodies. Transport of sediments. Exchange processes at the air/water and sediment/water interfaces. Prerequisite: At least a "C" in Civ Eng 230.

CIV ENG 333 Intermediate Hydraulic Engineering (LEC 3.0)
Application of fluid mechanics principles to the design. Kinematics of fluid motion, conservation of mass, linear and angular momentum, and energy. Requirements for similarity of fluid flow. Introduction to dynamics of fluid flows and viscous incompressible flows. Prerequisite: Civ Eng 230 with a grade of "C" or better.

CIV ENG 335 Water Infrastructure Engineering (LEC 2.0 and LAB 1.0)
Fundamental principles underlying comprehensive water infrastructure development; sanitary sewers, sanitary treatment facilities, stormwater sewers, stormwater detention, water power development, and hydraulic structures. The student is responsible for the planning and design of a water infrastructure development project. Prerequisite: Civ Eng 230 with a grade of "C" or better.

CIV ENG 337 River Mechanics And Sediment Transport (LEC 3.0)
Formation of rivers and the laws governing river regulation and improvements, including navigation and flood protection. Principles governing sediment transport. Prerequisite: Civ Eng 230 with a grade of "C" or better.

CIV ENG 338 Hydrologic Engineering (LEC 3.0)
A study of current up-to-date hydrologic techniques involving design of hydrologic input for bridges, culverts, reservoirs. Techniques involve extreme value statistics, model hydrographs, routing, etc. Prerequisite: Civ Eng 234 with a grade of "C" or better.

CIV ENG 341 Professional Aspects Of Engineering Practice (LEC 3.0)
A study of engineering registration laws, regulations, rules of professional responsibility and standards of practice. Review of causative factors of selected failures and their relationship to professional responsibility. Prerequisite: Senior standing.

CIV ENG 342 Construction Planning and Scheduling Strategies (LEC 3.0)
The goal of this course is to assist participants in gaining an understanding of schedule control techniques and the application of tools such as Primavera Software. Content areas to be addressed include: development of baseline schedules, progress monitoring and updating, recovery schedules, resource application and leveling. Prerequisite: Civ Eng or Arch Eng 248. (Co-listed with Arch Eng 342).
CIV ENG 345 Construction Methods (LEC 3.0)
Introduction to construction planning, selection of equipment and familiarization with standard methods for horizontal and vertical construction. Application of network analysis and schedules to project control. Prerequisite: Civ Eng 248 with a grade of "C" or better. (Co-listed with Arch Eng 345).

CIV ENG 346 Management Of Construction Costs (LEC 3.0)
Management of construction projects from inception to completion: estimates, role of network preplanning, project monitoring and control. Prerequisites: Civ Eng 248 with a grade of "C" or better. (Co-listed with Arch Eng 346).

CIV ENG 348 Green Engineering: Analysis of Constructed Facilities (LEC 3.0)
Environmentally sound design and construction practices. Includes design issues, material selection and site issues that can reduce the impact on the environment caused by the construction process. LEED certification covered in depth. Prerequisites: Civ Eng 248 or Arch Eng 248; and Junior Standing. (Co-listed with Arch Eng 348).

CIV ENG 349 Engineering And Construction Contract Specifications (LEC 3.0)
Legal and business aspects of contracts and contracting procedure in the construction industry. Topics include formulation of contracts in common law, engineering services contracts, and construction project contract documents and contract administration issues. Prerequisite: Civ Eng 248 with a grade of "C" or better. (Co-listed with Arch Eng 349).

CIV ENG 351 Transportation Applications of Geophysics (LEC 2.0 and LAB 1.0)
Overview of geophysical and non-destructive test methods that are commonly used to investigate transportation structures and their foundations. Emphasis is placed on bridge system substructure, bridge system superstructure, pavement, roadway subsidence, subsurface characterization and vibration measurements. Prerequisite: Junior level standing or higher. (Co-listed with Geo Eng 361 and Geophys 361).

CIV ENG 353 Traffic Engineering (LEC 3.0)
Driver, vehicle, and roadway characteristics; traffic control devices; traffic studies; intersection capacity, intersection design, traffic safety, and evaluation of traffic improvements. Traffic laws and ordinances, traffic engineering, traffic circulation, parking design, and forecasting traffic impacts. Prerequisite: Civ Eng 211 with a grade of "C" or better.

CIV ENG 356 Concrete Pavement Design (LEC 3.0)
Design of rigid pavements including loading characteristics, properties of pavement components, stress distribution, and the effects of climatic variables on design criteria. Prerequisite: Civ Eng 216 with a grade of "C" or better.

CIV ENG 360 Environmental Law And Regulations (LEC 3.0)
This course provides comprehensive coverage of environmental laws and regulations dealing with air, water, wastewater, and other media. The primary focus is permitting, reporting, and compliance protocols. The course topics include U.S. and international legal systems and judicial processes, liability, enforcement, Clean Air Act, Clean Water Act (NPDES) permitting), Safe Drinking Water Act, OSGA, TSCA, RCRA, AND CERCLA. Case studies will be emphasized. (Co-listed with Env Eng 360).

CIV ENG 361 Remediation Of Contaminated Groundwater And Soil (LEC 2.0 and LAB 1.0)
Course covers current in-situ and ex-situ remediation technologies. Current literature and case studies are utilized to provide the focus for class discussions and projects. Prerequisites: Civ Eng 265, Geo Eng 337 or Graduate Standing. (Co-listed with Env Eng 361).

CIV ENG 362 Public Health Engineering (LEC 3.0)
A comprehensive course dealing with the environmental aspects of public health. Prerequisite: Civ Eng 261 with a grade of "C" or better. (Co-listed with Env Eng 362).

CIV ENG 363 Solid Waste Management (LEC 3.0)
A systematic study of the sources, amounts and characteristics of solid wastes and methods used for their collection, reclamation, and ultimate disposal. Prerequisite: Civ Eng 261 with grade of "C" or better; or graduate standing. (Co-listed with Env Eng 363).

CIV ENG 364 Environmental Systems Modeling (LEC 3.0)
Introductory course in modeling environmental systems. Course will focus on contaminant fate and transport in the environment. Models will be developed that will include physical, chemical and biological reactions and processes that impact this fate. Prerequisites: Env Eng/Civ Eng 261, Env Eng/Civ Eng 262 and Env Eng/Civ Eng 263; or Graduate standing. (Co-listed with Env Eng 364).

This course will examine the concepts regarding the continued advancement of humankind while maintaining our ecological niche on earth. Key topics include: population growth, poverty, and impacts of development; energy consumption, sources, storage, conservation and policy; water quality and quantity; materials and building; and policy implications. Prerequisite: Senior or graduate standing. (Co-listed with Env Eng 365 and Arch Eng 365).

CIV ENG 366 Indoor Air Pollution (LEC 3.0)
By developing a practical understanding of indoor air pollution sources, physics, chemistry and consequences, students will learn how radon, cigarette smoke, VOCs from furnishings, and so forth affect indoor air quality and apply engineering analyses to specify ventilation rates, choose furnishings and minimize occupant exposure to pollutants. Prerequisite: Civ Eng 261 or Mech Eng 371 or Graduate Status. (Co-listed with Env Eng 366 and Arch Eng 366).

CIV ENG 367 Introduction To Air Pollution (LEC 3.0)
Introduction to the field of air pollution dealing with sources, effects, federal legislation, transport and dispersion and principles of engineering control. Prerequisite: Civ Eng 230; or graduate standing. (Co-listed with Env Eng 367).

CIV ENG 368 Air Pollution Control Methods (LEC 3.0)
Study of the design principles and application of the state-of-the-art control techniques to gaseous and particulate emissions from fossil fuel combustion, industrial and transportation sources. Prerequisite: Civ Eng 230; or graduate standing. (Co-listed with Env Eng 368).

CIV ENG 369 Environmental Engineering Design (LEC 2.0 and LAB 1.0)
Functionral design of water and wastewater facilities and other environmental cleanup systems. Prerequisite: Civ Eng 265 or Env Eng 265. (Co-listed with Env Eng 369).
CIV ENG 373 Air Transportation (LEC 2.0 and LAB 1.0)
Runway configuration, airfield capacity, geometrics and terminal layout and design. Aircraft performance; navigation and air traffic control; airport planning and design; airline operations; aviation systems planning. Prerequisite: Civ Eng 211 with a grade of "C" or better.

CIV ENG 374 Infrastructure Strengthening With Composites (LEC 3.0)
The course presents composite materials and includes principles of reinforcing and strengthening for flexure, shear, and ductility enhancement in buildings and bridges. It covers the design of existing members strengthened with externally bonded laminates and near surface mounted composites. Case studies are discussed. Prerequisites: Civ Eng / Arch Eng 217, Civ Eng / Arch Eng 223. (Co-listed with Arch Eng 374).

CIV ENG 375 Low-Rise Building Analysis And Design (LEC 3.0)
Characterization of various design loads, load combinations, general methodology of structural designs against lateral loads, code-oriented design procedures, distribution of lateral loads in structural systems, application of the International Building Code in design of loadbearing wall systems, building frame system and moment-resisting frame systems. Prerequisite: Preceded and/or accompanied by Civ - Arch Eng 221 or Civ-Arch Eng 223. (Co-listed with Arch Eng 375).

CIV ENG 380 Water Resources And Wastewater Engineering (LEC 3.0)
Application of engineering principles to the planning and design of multipurpose projects involving water resources development and wastewater collection/treatment/disposal/systems. Latest concepts in engineering analysis are applied to evaluation of alternative solutions. Prerequisites: Civ Eng 233, 235, 265. (Co-listed with Env Eng 380).

CIV ENG 382 Teaching Engineering (LEC 3.0)
Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Eng Mgt 370, Env Eng 382, Comp Eng 382, Elec Eng 382).

CIV ENG 384 Structural Dynamics (LEC 3.0)
This course deals with fundamental concepts and structural responses under dynamic loads. Hand calculations and computer methods are developed. Specific topics include resonance, beating phenomenon, equation of motion, dynamic properties, frequencies and mode shapes, and modal and Ritz analyses. Prerequisites: IDE 150 or equivalent; Civ/Arch Eng 217 or equivalent. (Co-listed with Arch Eng 384).

CIV ENG 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

CIV ENG 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

CIV ENG 401 Special Topics (RSD 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

CIV ENG 410 Seminar (RSD 0.0-6.0)
Discussion of current topics.

CIV ENG 411 Transportation Systems Analysis (LEC 3.0)
Concepts and principles fundamental to the planning, design, operation, and management of transportation systems using a systems perspective to transportation problems. Concepts from economics, engineering, operations research, management, psychology, and public policy analysis are used throughout. Topics include linear and non-linear programming, dynamic programming, supply-demand microeconomic framework, analysis of transportation demand, system performance, network equilibrium, simulation and associated case studies. Prerequisite: Civ Eng 353.

CIV ENG 412 Computer Modeling in Geotechnical Engineering (LEC 3.0)
Survey of computer methods of analyzing and modeling complex geotechnical engineering problems. Computer applications, data analysis, and result interpretations. Topics include constitutive modeling, foundation engineering, seepage, unsaturated flow problem, slope stability analysis, consolidation, excavation, tunneling, and dynamic soil-structure interaction. Prerequisite: Civ Eng 215 and graduate standing.

CIV ENG 413 Dynamics Of Earth Materials (LEC 3.0)
Theory of vibration, spectral response, site-specific response spectra, detailed design of retaining structures, pile and machine foundations, soil structure interaction. Dynamic soil properties, including degradation of soil properties and liquefaction, seismic slope stability analysis problem solving. Select research topics and use of computer codes. Prerequisite: Preceded or accompanied by Civ Eng 316.

CIV ENG 414 Measurement Of Soil Properties (LEC 2.0 and LAB 1.0)
Laboratory determination of soil properties with emphasis on practical. Applications of test data. Tests include classification, atterberg limits, consolidation, compaction, triaxial shear tests with pore pressure measurement, and direct shear tests. Preparation of technical reports. Prerequisite: Preceded or accompanied by Civ Eng 315.

CIV ENG 415 Advanced Soil Mechanics (LEC 3.0)
Advanced topics and recent advances in theoretical soil mechanics. Topics may include stress distribution, failure theories, shear failure in ideal soils, consolidation and settlement, physico-chemical properties, and clay mineralogy. Prerequisite: Civ Eng 315.

CIV ENG 416 Soil Stabilization (LEC 3.0)
The application of mineralogical and physicochemical principles to soil stabilization problems and stabilization techniques for highway and foundation applications. Prerequisite: Civ Eng 315.

CIV ENG 417 Earth Dams And Related Problems (LEC 3.0)
The exploration for and selection of site and materials, seepage analysis, slope stability and design, embankment design, compaction, instrumentation and construction operations as they pertain to earth and rockfill dams. Prerequisite: Civ Eng 315.

CIV ENG 419 Advanced Behavior Of Reinforced And Prestressed Concrete (LEC 3.0)
Behavior of reinforced and prestressed concrete sections, members and wall/shell-type elements subjected to bending, axial load, shear and torsion. Confinement of concrete. Various truss model theories applicable to main members and strut-tie model applicable to disturbed regions, joints, and connections. Prerequisite: Civ Eng 223 with grade of "C" or better.

CIV ENG 421 Plastic Analysis And Design Of Metal Structures (LEC 3.0)
Behavior of engineering materials in the inelastic stress range. Analysis and design of elementary structural members and frames.
CIV ENG 422 Analysis And Design Of Plates And Shells I (LEC 3.0)
Fundamental theories of bending and buckling of plates for practical applications in analysis and design of bridge and building floors, highway and airport pavements, and structural plate components. Shell theory with application to tanks, pressure vessels, shell roofs, and folded plate construction. Prerequisite: Preceded or accompanied by Civ Eng 323.

CIV ENG 424 Structural Dynamics And Earthquake Engineering (LEC 3.0)
Behavior of structural materials, elements, and systems under earthquake loads; computer methods for response analysis of lumped and distributed mass models, eigensolution techniques, response spectral analysis, design of 2-D and 3-D seismic resistant structures with current design codes. Prerequisite: Civ/Arch Eng 384 or equivalent.

CIV ENG 425 Finite Element Application In Structural Design (LEC 3.0)

CIV ENG 426 Advanced Design In Steel And Lightweight Structures (LEC 3.0)
A critical evaluation of the theories of design and actual behavior of metal components and their connections. The basis of the development of the pertaining codes will be considered. Prerequisite: Preceded or accompanied by Civ Eng 323.

CIV ENG 428 Analysis Of Nonlinear Structures (LEC 3.0)
Inelastic behavior of structural members and connections; formulation of various models for steel and reinforced concrete including elasto-plastic, bilinear, trilinear, Ramberg-Osgood, Cheng-Mertz, and Cheng-Lou; matrix analysis of 2-D and 3-D building structures for geometric and material nonlinearity; dynamic and stability analysis. Prerequisite: Preceded or accompanied by Civ Eng 323.

CIV ENG 429 Foundation Engineering III (LEC 3.0)
A critical study of modern concepts of foundation engineering including current procedure for the application of soil mechanics principles to the design of foundations, embankments and retaining structures. Case histories will be emphasized with the student making successive design decisions.

CIV ENG 430 Stochastic Theory of Structural Dynamics (LEC 3.0)

CIV ENG 431 Advanced Hydraulics And Hydraulic Engineering (LEC 0.0-6.0)
Studies in the field of hydraulic engineering to fit the needs of a particular student or class. Each student makes a complete design of a hydraulic development in one of the following fields: water power, sanitation, river and harbor projects. Prerequisite: Civ Eng 230.

CIV ENG 435 Hydraulic Structures (LEC 0.0-3.0)
Gravity, arch, multiple arch, and buttress dams including appurtenances such as spillways, penstocks and gates. Latter part of course is designed to needs of the individual student with applications to river and harbor structures, canal and irrigation structures, and sewage structures. Prerequisites: Civ Eng 223 and 230.

CIV ENG 438 Advanced Hydrology (LEC 3.0)
A study of methods used in modern hydrologic analysis and design. Items of study include hydrography analysis, maximum possible storm, infiltration, design flood determination and project feasibility. Prerequisite: Civ Eng 233.

CIV ENG 440 Urban Hydrology (LEC 3.0)
Studies of the influence of urban areas on their hydrology. Special emphasis on the principles of spatially varied unsteady flow. Model hydrographs leading toward determination of design storm flow are utilized to obtain information necessary for design of storm sewers, channels, and hydraulic structures common to urban areas. Prerequisite: Civ Eng 233.

CIV ENG 442 Construction Administration, Planning And Control (LEC 3.0)
Study of construction project development and execution, ranging from preliminary engineering to project turnover. Key topics include bidding strategies, quality control, conceptual estimating, scheduling, progress and cost control, value engineering, safety and construction productivity. Prerequisite: Preceded or accompanied by Civ Eng 345.

CIV ENG 443 Contract Formulation And Project Delivery Systems (LEC 3.0)
Project life-cycle planning and management. Roles and responsibilities of contract participants. Construction contract formulation. Obtaining work by negotiating and by bidding. Forms and variations of project delivery systems. Prerequisite: Civ Eng 345 or Civ Eng 349.

CIV ENG 445 Advanced Construction Engineering (LEC 3.0)
Study of the temporary structures and plant used in construction. Key topics include legal implications, codes and regulations, falsework, slipforming, bridge construction supports, and protection of adjacent facilities. Prerequisite: Preceded or accompanied by Civ Eng 345.

CIV ENG 453 Transportation Planning (LEC 3.0)
Study of urban development, mobility patterns, and the transportation network. Transportation modeling techniques; transportation control plans to improve air quality; consideration of the transportation disadvantaged; transportation planning in smaller cities and rural areas. Access management and site impact analysis of traffic generators. Prerequisite: Civ Eng 353 or consent of instructor.

CIV ENG 456 Traffic Modeling and Simulation (LEC 3.0)
Fundamentals of system simulation, components of a simulation model, traffic flow simulation approaches, traffic flow simulation software and their applications, building simulation models, verification and validation of a simulation model, output analysis, variance reduction techniques, role of simulation in Intelligent Transportation Systems (ITS). Prerequisites: Stat 213, Civ Eng 211 preceded or accompanied by Civ Eng 353.

CIV ENG 457 Traffic Flow Theory and Characteristics (LEC 3.0)
This course will cover advanced theories of traffic flow, traffic flow characteristics, statistical distributions of traffic flow parameters, traffic stream models, car following models, shock wave analysis, queuing analysis, traffic flow models for intersections, traffic simulation. Prerequisites: Preceded or accompanied by Civ Eng 353, knowledge of statistics, graduate standing or consent of instructor.
CIV ENG 460 Chemical Principles In Environmental Engineering
(LEC 3.0)
The course develops fundamental chemical and physical principles underlying environmental engineering systems including drinking water, groundwater, and wastewater treatment; and natural environmental processes. Topics include adsorption, complex formation, acid-base equilibria, solubility, mass transfer and diffusion, electrochemistry, and chemical kinetics. Prerequisite: Graduate Standing. (Co-listed with Env Eng 460).

CIV ENG 461 Biological Principles In Environmental Engineering Systems
(LAB 1.0 and LEC 2.0)
Course covers the fundamental biological and biochemical principles involved in natural and engineered biological systems. (Co-listed with Env En 461).

CIV ENG 462 Physicochemical Operations In Environmental Engineering Systems
(LEC 3.0)
Course covers physicochemical operations and design in water, wastewater and aqueous hazardous waste treatment systems including coagulation, precipitation, sedimentation, filtration, gas transfer, chemical oxidation and disinfection, adsorption, ion exchange. Prerequisite: Civ Eng 230 or equivalent. (Co-listed with Env Eng 462 and Chem Eng 470).

CIV ENG 463 Biological Operations In Environmental Engineering Systems
(LEC 3.0)
Course covers biological operations and design in water, wastewater and aqueous hazardous waste treatment systems including modeling of biological treatment processes; and design of activated sludge systems, trickling filters, rotating biological contractors, lagoons, nitrification and denitrification, and digestion processes. Prerequisite: Civ Eng 230 or equivalent. (Co-listed with Env Eng 463).

CIV ENG 464 Industrial And Hazardous Waste Treatment
(LAB 1.0 and LEC 2.0)
Course covers fundamentals of industrial and hazardous wastewater treatment systems and characterization including physical, chemical and biological processes and laboratory pilot plant investigations. (Co-listed with Env En 464).

CIV ENG 465 Environmental Engineering Analysis Laboratory
(LAB 2.0 and LEC 1.0)
Environmental Engineering analytical principles and techniques applied to the quantitative measurement of water, wastewater and natural characteristics, and application of advanced instrumentation methods in Environmental Engineering. Prerequisite: Civ Eng 261 or equivalent, with a grade of "C" or better. (Co-listed with Env Eng 465).

CIV ENG 467 Environmental Chemistry
(LAB 1.0 and LEC 2.0)
This course covers the fundamental and applied aspects of environmental chemistry including inorganic, organic, and analytical chemical principles. The course emphasizes the aquatic environment and covers gas laws and solubility, chemical modeling, equilibria, acid-base and complexation relationships, oxidation and photochemical reactions. Prerequisite: Graduate standing in engineering or science curricula. (Co-listed with Env En 467).

CIV ENG 485 Philosophy of Scientific Research
(LEC 3.0)
Organization and planning of research. Introduction to the philosophy and management of scientific research, particularly issues related to ethics, plagiarism, ownership of intellectual properties, research techniques, technical presentations and time management. The course will address these issues by integrating with case studies. (Co-listed with Chem Eng 425, IDE 425, Env Eng 485, Elec Eng 481, Comp Eng 481).

CIV ENG 490 Research
(IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

CIV ENG 493 Oral Examination
(IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

CIV ENG 495 Continuous Registration
(IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Computer Engineering (COMP ENG)

COMP ENG 300 Special Problems
(IND 1.0-6.0)
problems or readings on specific subjects or projects in the department. Consent of instructor required.

COMP ENG 301 Special Topics
(LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

COMP ENG 311 Introduction To VLSI Design
(LEC 3.0)
An introduction to the design and analysis of digital integrated circuits (ICs). Topics include basic manufacturing techniques, transistor-level design and analysis of logic and memory circuits, logic timing, and parasitics. Computer aided design tools are used to develop circuits in the lab. Prerequisites: Elec Eng 121 and Comp Eng 111.

COMP ENG 312 Digital Systems Design Laboratory
(LAB 1.0 and LEC 2.0)
Experimental studies of problems with high speed digital signals in circuits. Student designs, wires, tests, and programs a microprocessor based single board computer project. A FPGA design is programmed and tested. Prerequisite: Comp Eng 213 or 313.

COMP ENG 313 Principles of Computer Architecture
(LEC 3.0)
Principles of performance measurement and instruction set design; advanced issues in pipelining; instruction level parallelism (dynamic scheduling, branch prediction, multi-issue processors); memory hierarchies for superscalar processors; multiprocessors; multi-threading; storage systems; and interconnection networks. Prerequisite: Comp Eng 215.

COMP ENG 314 Embedded Processor System Design
(LEC 3.0)
Development of hardware and software for embedded systems, including real-time operating systems, advanced programming, communication schemes, hardware peripherals and sensors, control methodologies, printed-circuit board design, interrupts, microcontrollers, and hardware-software co-design. One or more team design projects. Prerequisites: Comp Eng 213 or equivalent and 80x51 processor experience.
COMP ENG 315 Digital Computer Design (LEC 3.0)
Organization of modern digital computers; design of processors, memory systems and I/O units, hardware-software tradeoffs in different levels of computer system design. Prerequisites: Comp Eng 213 and Comp Eng 214.

COMP ENG 316 Advanced Microcomputer System Design (LEC 3.0)
The design of digital systems based on advanced microprocessors. Introduction to microcomputer logic development systems, I/O interfaces. Assembly and high level language tradeoffs. Hardware and software laboratory projects required. Prerequisite: Comp Eng 313.

COMP ENG 317 Fault-Tolerant Digital Systems (LEC 3.0)
Design and analysis of fault-tolerant digital systems. Fault models, hardware redundancy, information redundancy, evaluation techniques, system design procedures. Prerequisites: Comp Eng 111 and Comp Eng 112.

COMP ENG 318 Digital System Modeling (LEC 3.0)
Digital system modeling for simulation, synthesis, and rapid system prototyping. Structural and behavioral models, concurrent and sequential language elements, resolved signals, generics, configuration, test benches, processes and case studies. Prerequisite: Comp Eng 111 with a grade of "C" or better.

COMP ENG 319 Digital Network Design (LEC 3.0)
Design of computer networks with emphasis on network architecture, protocols and standards, performance considerations, and network technologies. Topics include: LAN, MAN, WAN, congestion/control, routing, addressing, broadcasting, multicasting, switching, and internetworking. A modeling tool is used for network design and simulation. Prerequisite: Comp Eng 213 or computer hardware competency.

COMP ENG 325 Optical Computing (LEC 3.0)
Introduction to the principles, subsystems, and architectures of optical computing. Topics include characteristics of optical devices; optical implementations of memory, logic elements, and processors; and computational structures. Prerequisite: Comp Eng 111 or equivalent. (Co-listed with Elec Eng 325).

COMP ENG 331 Real-Time Systems (LEC 3.0)
Introduction to real-time (R-T) systems and R-T kernels, also known as R-T operating systems, with an emphasis on scheduling algorithms. The course also includes specification, analysis, design and validation techniques for R-T systems. Course includes a team project to design an appropriate R-T operating system. Prerequisite: Comp Eng 213 or Comp Sci 284.

COMP ENG 342 Real-Time Digital Signal Processing (LEC 2.0 and LAB 1.0)
Introduction to the use of programmable DSP chips. Includes real-time data acquisition, signal generation, interrupt-driven programs, high-level language, and assembly level routines. Applications to real-time systems are also presented. Prerequisite: Elec Eng 215 or Elec Eng 267.

COMP ENG 345 Digital Image Processing (LEC 3.0)
Fundamentals of human perception, sampling and quantization, image transforms, enhancement, restoration, channel and source coding. Prerequisite: Elec Eng 267 (Co-listed with Elec Eng 345).

COMP ENG 347 Machine Vision (LEC 3.0)
Image information, image filtering, template matching, histogram transformations, edge detection, boundary detection, region growing and pattern recognition. Complementary laboratory exercises are required. Prerequisites: Comp Eng 111 and preceded or accompanied by Elec Eng 267. (Co-listed with Elec Eng 347).

COMP ENG 348 Wireless Networks (LAB 1.0 and LEC 2.0)
Introduction to wireless communications and networking. Topics include transmission fundamentals, wireless channel, coding techniques and error control, satellite and cellular networks, cordless systems, mobile IP and management, multiple access techniques and wireless protocols, wireless LAN, IEEE 802.11, and adhoc and sensor networks. Prerequisites: Hardware competency, Elec Eng 243 or Comp Eng 213 and graduate standing. (Co-listed with Elec Eng 348 and Sys Eng 348).

COMP ENG 349 Trustworthy, Survivable Computer Networks (LEC 3.0)
This course examines basic issues in network management, testing, and security; it also discusses key encryption, key management, authentication, intrusion detection, malicious attack, and insider threats. Security of electronic mail and electronic commerce systems is also presented. Prerequisite: Comp Eng 319 or Comp Sci 265.

COMP ENG 354 Mathematical Logic I (LEC 3.0)
A mathematical introduction to logic with some applications. Functional and relational languages, satisfaction, soundness and completeness theorems, compactness theorems. Examples from Mathematics, Philosophy, Computer Science, and/or Computer Engineering. Prerequisite: Philos 15 with junior standing or Math 305 or Comp Sci 253 or Comp Eng 111. (Co-listed with Comp Sci 354, Philos 354 and Math 354).

COMP ENG 358 Computational Intelligence (LEC 3.0)
Introduction to Computational Intelligence (CI), Biological and Artificial Neuron, Neural Networks, Evolutionary Computing, Swarm Intelligence, Artificial Immune Systems, Fuzzy Systems, and Hybrid Systems. CI application case studies covered include digital systems, control, power systems, forecasting, and time-series predictions. Prerequisite: Comp Sci 153 or programming competency. (Co-listed with Elec Eng 367 and Sys Eng 367).

COMP ENG 372 Signal Integrity In High-Speed Digital & Mixed Signal Design (LEC 3.0)
Signal integrity ensures signals transmitted over a propagation path maintain sufficient fidelity for proper receiver operation. Compromised signal integrity is often associated with parasitics (e.g. unintentional inductance, capacitance). Theory and CAD tools used for signal integrity analysis of functioning designs. Prerequisites: Elec Eng 271 or Comp Eng 213, and Senior standing. (Co-listed with Elec Eng 372).

COMP ENG 378 Mechatronics (LAB 1.0 and LEC 2.0)
This course will introduce students to the basics of mechatronics (i.e., the integration of mechanical, electrical, computer, and control systems). Students will learn the fundamentals of sensors and actuators for mechanical systems, computer interfacing, microcontrollers, real-time software, and control. Prerequisite: Mech Eng 279 or equivalent. (Co-listed with Mech Eng 378, Aero Eng 378 and Elec Eng 378).

COMP ENG 382 Teaching Engineering (LEC 3.0)
Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Eng Mgt 370, Env Eng 382, Elec Eng 382, Civ Eng 382).

COMP ENG 388 Introduction to Robotics (LEC 3.0)
This course provides an introduction to robotics, covering robot hardware, fundamental kinematics, trajectories, differential motion, robotic decision making, and an overview of current topics in robotics. Prerequisite: A “C” or better in both Math 208 and Comp Sci 153. (Co-listed with Comp Sci 345 and Elec Eng 388).
COMP ENG 390 Undergraduate Research (IND 1.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

COMP ENG 391 Computer Engineering Senior Project I (LAB 0.50 and RSD 0.50)
A complete design cycle. Working in small teams, students will design, document, analyze, implement, and test a product. Topics include: Iteration in design, prototyping, group dynamics, design reviews, making effective presentations, concurrent design, designing for test, ethics and standards, testing and evaluation. Prerequisites: Stat 217, Comp Eng 111, Econ 121 or 122, Sp&M S 85, English 160, Comp Eng 213, 214, 215, and Elec Eng 121.

COMP ENG 392 Computer Engineering Senior Project II (LAB 3.0)
A continuation of Comp Eng 391. Prerequisite: Comp Eng 391.

COMP ENG 400 Special Problems (IND 1.0-6.0)
Problems or readings on specific subjects or projects in the department. Prerequisite: Consent of the instructor.

COMP ENG 401 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title. Prerequisite: Consent of the instructor.

COMP ENG 404 Advanced Topics in Data Mining (LEC 3.0)
Advanced topics of current interest in the field of data mining. This course involves reading seminal and state-of-the-art papers as well as conducting topical research projects including design, implementation, experimentation, analysis, and written and oral reporting components. Prerequisite: A "C" or better grade in Comp Sci 301 Introduction to Data Mining. (Co-listed with Comp Sci 444 and Sys Eng 404).

COMP ENG 409 Design Automation of VLSI Systems (LEC 3.0)
This course covers fundamentals in VLSI design automation. Topics include logic synthesis, design planning and optimization, placement and routing, parasitic extraction, circuit simulation, timing analysis, design verification and testing. Prerequisite: Comp Eng 311.

COMP ENG 411 Advanced VLSI Design (LEC 3.0)
Advanced topics in chip-level VLSI design, including issues related to high-performance, low-power, analog and mixed-signal circuits, reliability, noise and coupling mechanisms, computer aided design tools, and recent advances and trends in the field. Prerequisite: Comp Eng 311 is required.

COMP ENG 412 Digital Logic (LEC 3.0)
Digital logic analysis, synthesis and simulation. Design automation of digital systems. Prerequisites: Comp Eng 111 and Comp Eng 112.

COMP ENG 415 Advanced Computer Architecture I (LEC 3.0)
Advanced topics in computer structures, parallel processors, and computer networks. Emphasis on their design, applications, and performance. Prerequisite: Comp Eng 313 or Comp Eng 315.

COMP ENG 416 Advanced Computer Architecture II (LEC 3.0)
Continuation of Computer Engineering 415. Prerequisite: Comp Eng 415.

COMP ENG 417 Network Performance Analysis (LEC 3.0)
Provides an introduction to performance modeling and analysis of computer networks. Topics include stochastic processes; performance measurement and monitoring; quantitative models for network performance, e.g., Markovian models for queues; simulation; and statistical analysis of experiments. Prerequisites: Comp Eng 319 or Comp Sci 365; Stat 217 or 343. (Co-listed with Comp Sci 417).

COMP ENG 419 Network Centric Systems (LEC 3.0)
Network-centric systems comprises a diverse category of complex systems with the primary purpose is providing network-type services. Network-centric systems are also known as collaborative systems. This course address the intersection between network engineering and the needs of systems architecting and engineering. Prerequisite: Sys Eng 469 or graduate standing. (Co-listed with Sys Eng 419).

COMP ENG 439 Clustering Algorithms (LEC 3.0)
An introduction to cluster analysis and clustering algorithms rooted in computational intelligence, computer science and statistics. Clustering in sequential data, massive data and high dimensional data. Students will be evaluated by individual or group research projects and research presentations. Prerequisite: At least one graduate course in statistics, data mining, algorithms, computational intelligence, or neural networks, consistent with student’s degree program. (Co-listed with Elec Eng 439, Sys Eng 439, Comp Sci 449 and Stat 439).

COMP ENG 443 Wireless Ad hoc and Sensor Networks (LEC 3.0)
Introduction to ad hoc and sensor networks, IEEE standards, heterogeneity, quality of service, wireless channel issues, energy awareness, power and topology control, routing, scheduling, rate adaptation, self-organization, admission and flow control, energy harvesting, security and trust levels, hardware and applications. Prerequisite: Comp Eng 348 or Comp Eng 349 or equivalent. (Co-listed with Elec Eng 443 and Sys Eng 443).

COMP ENG 448 High Speed Networks (LAB 1.0 and LEC 2.0)
A state-of-the-art survey of high-speed networks, modeling and simulation, quality of service (QoS) for multimedia applications and management schemes, TCP congestion control, ATM and Internet traffic management, Internet Service Architecture (ISA), and Internet routing protocols. Prerequisites: Comp Eng 319 and hardware competency for ECE students. Comp Sci 365 for computer science students, or consent of the instructor.

COMP ENG 449 Network-Centric Systems Reliability and Security (LEC 3.0)
This course presents reliability and fault tolerance for network-centric systems, including models, metrics, and analysis techniques. This course also concentrates on security, including technical tools and methods for audit and assessment as well as management and policy issues. Prerequisite: Sys Eng/Comp Eng 419 or Comp Eng 349. (Co-listed with Sys Eng 449).

COMP ENG 457 Markov Decision Processes (LEC 3.0)
Introduction to Markov Decision Processes and Dynamic Programming. Application to Inventory Control and other optimization and control topics. Prerequisite: Graduate standing in background of probability or statistics. (Co-listed with Mech Eng 447, Aero Eng 457, Eng Mgt 457 and Comp Sci 457).

COMP ENG 458 Adaptive Critic Designs (LEC 3.0)
Review of Neurocontrol and Optimization, Introduction to Approximate Dynamic Programming (ADP), Reinforcement Learning (RL), Combined Concepts of ADP and RL - Heuristic Dynamic Programming (HDP), Dual Heuristic Programming (DHP), Global Dual Heuristic Programming (GDHP), and Case Studies. Prerequisite: Elec Eng 368 Neural Networks or equivalent (Computational Intelligence Comp Eng 301) (Co-listed with Elec Eng, Mech Eng, Aero Eng and Sys Eng 458).
**COMP ENG 481 Philosophy of Scientific Research** (LEC 3.0)
Organization and planning of research. Introduction to the philosophy and management of scientific research, particularly issues related to ethics, plagiarism, ownership of intellectual properties, research techniques, technical presentations and time management. The course will address these issues by integrating with case studies. (Co-listed with Chem Eng 425, IDE 425, Civ Eng 485, Env Eng 485, Elec Eng 481).

**COMP ENG 488 Advanced Topics in Robotics** (LEC 3.0)
This course covers advanced topics in robotics, including perception, robotic path planning, robotic system integration, and computational intelligence topics for robotics. A term project including both written and oral components will be required. Prerequisite: A "C" or better in either Comp Sci 345 or Mech Eng 349 or Aero Eng 349. (Co-listed with Comp Sci 445 and Elec Eng 488).

**COMP ENG 490 Special Research And Thesis** (IND 1.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Prerequisite: Consent of the instructor required.

**COMP ENG 493 Oral Examination** (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be performed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**COMP ENG 495 Continuous Registration** (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except for the dissertation, and are away from the campus, must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

**Computer Science (COMP SCI)**

**COMP SCI 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**COMP SCI 301 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**COMP SCI 302 Agile Software Development** (LEC 3.0)
Understand principles of agile software development and contrast them with prescriptive processes. Specifically: Eliciting, organizing, and prioritizing requirements; Design processes; Understand how a particular process promotes quality; Estimate costs and measure project progress and productivity. Prerequisite: A "C" or better grade in Comp Sci 206.

**COMP SCI 307 Software Testing And Quality Assurance** (LEC 3.0)
It covers unit testing, subsystem testing, system testing, object-oriented testing, testing specification, test case management, software quality factors and criteria, software quality requirement analysis and specification, software process improvement, and software total quality management. Prerequisite: A "C" or better grade in Comp Sci 253.

**COMP SCI 308 Object-Oriented Analysis And Design** (LEC 3.0)
This course will explore principles, mechanisms, and methodologies in object-oriented analysis and design. An object-oriented programming language will be used as the vehicle for the exploration. Prerequisite: A "C" or better grade in Comp Sci 253.

**COMP SCI 310 Seminar** (IND 0.0-6.0)
Discussion of current topics. Prerequisite: Senior standing.

**COMP SCI 311 Bioinformatics** (LEC 3.0)
The course will familiarize students with the application of computational methods to biology, as viewed from both perspectives. It will introduce problems in molecular, structural, morphological, and biodiversity informatics, and will discuss principles, algorithms, and software to address them. Prerequisites: Bio Sci 110 or 111 and Comp Sci 53/54 or 74/78. (Co-listed with Bio Sci 311).

**COMP SCI 317 Intellectual Property For Computer Scientists** (LEC 3.0)
A presentation of the relationship between the law of intellectual property and computer science. Topics include the application of copyright principles to computer programs, protection of computer programs through patents and trade secret law, and the effect of various agreements which are frequently encountered by the computer scientist. Prerequisite: Senior or graduate standing.

**COMP SCI 325 Analysis Of Algorithms** (LEC 3.0)
The purpose of this course is to teach the techniques needed to analyze algorithms. The focus of the presentation is on the practical application of these techniques to such as sorting, backtracking, and graph algorithms. Prerequisite: A "C" or better grade in Comp Sci 253.

**COMP SCI 328 Object-Oriented Numerical Modeling I** (LEC 3.0)
A study of object-oriented modeling of the scientific domain. Techniques and methodologies will be developed enabling the student to build a class library of reusable software appropriate for scientific application. Applications will be drawn from mechanics, finance, and engineering. Prerequisites: A "C" or better grade in both Comp Sci 228 and Comp Sci 153; a "C" or better grade in one of Math 208, 203, 229.

**COMP SCI 329 Object-Oriented Numerical Modeling II** (LEC 3.0)
A continued study of object-oriented modeling of the scientific domain. Advanced applications include models posed as balance laws, integral equations, and stochastic simulations. Prerequisite: A "C" or better grade in Comp Sci 328.

**COMP SCI 338 Database Systems** (LEC 3.0)
This course introduces the advanced database concepts of normalization and functional dependencies, transaction models, concurrency and locking, timestamping, serializability, recovery techniques, and query planning and optimization. Students will participate in programming projects. Prerequisite: A "C" or better grade in both Comp Sci 128 and Comp Sci 238.

**COMP SCI 342 Java Gui & Visualization** (LEC 3.0)
COMP SCI 345 Introduction to Robotics (LEC 3.0)
This course provides an introduction to robotics, covering robot hardware, fundamental kinematics, trajectories, differential motion, robotic decision making, and an overview of current topics in robotics. Prerequisite: A "C" or better in both Math 208 and Comp Sci 153. (Co-listed with Comp Eng 388 and Elec Eng 388).

COMP SCI 347 Introduction To Artificial Intelligence (LEC 3.0)
A modern introduction to AI, covering important topics of current interest such as search algorithms, heuristics, game trees, knowledge representation, reasoning, computational intelligence, and machine learning. Students will implement course concepts covering selected AI topics. Prerequisite: A "C" or better grade in Comp Sci 253.

COMP SCI 348 Evolutionary Computing (LEC 3.0)
Introduces evolutionary algorithms, a class of stochastic, population-based algorithms inspired by natural evolution theory (e.g., genetic algorithms), capable of solving complex problems for which other techniques fail. Students will implement course concepts, tackling science, engineering and/or business problems. Prerequisite: A "C" or better grade in both Comp Sci 253 and in a Statistics course.

COMP SCI 353 Multimedia Systems (LEC 3.0)
This course introduces the concepts and components of Multimedia information systems. Topics include: Introduction to Multimedia Data, Multimedia Date Compression, Techniques and Standards, Indexing and Retrieval, Data Storage Organization, Communication and Synchronization, Applications-Media OnDemand Systems, Video Conferencing, Digital Libraries. Prerequisite: A "C" or better grade in Comp Sci 153.

COMP SCI 354 Mathematical Logic I (LEC 3.0)
A mathematical introduction to logic with some applications. Functional and relational languages, satisfaction, soundness and completeness theorems, compactness theorems. Examples from Mathematics, Philosophy, Computer Science, and/or Computer Engineering. Prerequisite: Philos 15 with junior standing or Math 305 or Comp Sci 253 or Comp Eng 111. (Co-listed with Math 354, Philos 354 and Comp Eng 354.).

COMP SCI 356 The Structure of a Compiler (LEC 3.0)
Review of Backus normal form language descriptors and basic parsing concepts. Polish and matrix notation as intermediate forms, and target code representation. Introduction to the basic building blocks of a compiler: syntax scanning, expression translation, symbol table manipulation, code generation, local optimization, and storage allocation. Prerequisite: A "C" or better grade in both Comp Sci 256 and Comp Sci 253.

COMP SCI 358 Interactive Computer Graphics (LEC 3.0)
Applications and functional capabilities of current computer graphics systems. Interactive graphics programming including windowing, clipping, segmentation, mathematical modeling, two and three dimensional transformations, data structures, perspective views, antialiasing and software design. Prerequisite: A "C" or better grade in both Comp Sci 228 and Comp Sci 253.

COMP SCI 362 Security Operations & Program Management (LEC 3.0)
An overview of information security operations, access control, risk management, systems and application life cycle management, physical security, business continuity planning, telecommunications security, disaster recovery, software piracy, investigations, ethics and more. There will be extensive reporting, planning and policy writing. Prerequisite: A "C" or better grade in all of: operating systems, computer networking, and a writing emphasized course.

COMP SCI 365 Computer Communications And Networks (LEC 3.0)
Network architecture model including physical protocols for data transmission and error detection/correction, data link concepts, LAN protocols, internetworking, reliable end to end service, security, and application services. Students will implement course concepts on an actual computer network. Prerequisite: A "C" or better grade in Comp Sci 284.

COMP SCI 366 Regression Analysis (LEC 3.0)
Simple linear regression, multiple regression, regression diagnostics, multicollinearity, measures of influence and leverage, model selection techniques, polynomial models, regression with autocorrelated errors, introduction to non-linear regression. Prerequisites: Math 22 and one of Stat 211, 213, 215, 217, or 343. (Co-listed with Stat 346).

COMP SCI 381 The Structure Of Operating Systems (LEC 3.0)
The hardware and software requirements for operating systems for uniprogramming, multiprogramming, multiprocessing, time sharing, real time and virtual systems. The concepts of supervisors, interrupt handlers, input/output control systems, and memory mapping are discussed in detail. Prerequisite: A "C" or better grade in Comp Sci 284.

COMP SCI 384 Distributed Operating Systems (LEC 3.0)
This is a study of modern operating systems, particularly distributed operating systems. Topics include a review of network systems and interprocess communication, causality, distributed state maintenance, failure detection, reconfiguration and recovery, load balancing, distributed file systems, distributed mutual exclusion, and stable property detection including deadlock detection. A group project in Distributed Systems programming will be required. Prerequisite: A "C" or better grade in both Comp Sci 284 and Comp Sci 253.

COMP SCI 387 Introduction to Parallel Programming and Algorithms (LEC 3.0)
Parallel and pipelined algorithms, architectures, network topologies, message passing, process scheduling and synchronization. Parallel programming on clusters. Cost, speedup and efficiency analysis. Prerequisite: A "C" or better grade in both Comp Sci 284 and Comp Sci 253.

COMP SCI 388 Introduction to High Performance Computer Architecture (LEC 3.0)
Overviews high performance architecture of computing systems and covers various architectural/hardware and software/algorithmic means that enhance performance. Uniprocessor and concurrent systems are investigated. Various computational models are studied and linked to commercial systems. Prerequisite: A "C" or better grade in both Comp Eng 213 and Comp Sci 253.

COMP SCI 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Does not lead to the preparation of a thesis. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the faculty supervisor.

COMP SCI 397 Software Systems Development I (LEC 3.0)
Class members will work in small teams to develop a complete software system beginning with end-user interviews and concluding with end-user training. Prerequisite: A "C" or better grade in both Comp Sci 266 and 100 credit hours completed.
COMP SCI 398 Software Systems Development II (LEC 3.0)
This course is an optional continuation of Comp Sci 397. Those interested in project management should take this course since participants become officers or group leaders in the class "corporation." This course is especially important for those going straight into industry upon graduation. Students with coop experience may find this course redundant. Prerequisite: A "C" or better grade in Comp Sci 397.

COMP SCI 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

COMP SCI 401 Special Topics (LEC 3.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

COMP SCI 406 Software Engineering II (LEC 3.0)
A quantitative approach to measuring costs/productivity in software projects. The material covered will be software metrics used in the life cycle and the student will present topical material. Prerequisite: A "C" or better grade in Comp Sci 206.

COMP SCI 409 Software Requirements Engineering (LEC 3.0)
This course will cover advanced methods, processes, and technique for discovering, analyzing, specifying and managing software requirements of a software system from multiple perspectives. It will discuss both functional and non-functional requirements analysis. Prerequisite: A "C" or better grade in Comp Sci 206.

COMP SCI 410 Seminar (RSD 1.0)
Discussion of current topics.

COMP SCI 417 Network Performance Analysis (LEC 3.0)
Provides an introduction to performance modeling and analysis of computer networks. Topics include stochastic processes; performance measurement and monitoring; quantitative models for network performance, e.g., Markovian models for queues; simulation; and statistical analysis of experiments. Prerequisites: Comp Eng 319 or Comp Sci 365; Stat 217 or 343. (Co-listed with Comp Eng 417).

COMP SCI 425 Algorithms II (LEC 3.0)
Covers selected classical and recent developments in the design and analysis of algorithms, such as sophisticated data structures, amortized complexity, advanced graph theory, and network flow techniques. Prerequisite: A "C” or better grade in Comp Sci 325.

COMP SCI 426 Theory Of Computation (LEC 3.0)
Turing machines and other machines. Godel numbering and unsolvability results. Machines with restricted memory access and limited computing time. Recursive functions, computable functionals and the classification of unsolvable problems. Prerequisite: A "C" or better grade in Comp Sci 220.

COMP SCI 431 Pervasive Computing (LEC 3.0)
Pervasive computing aims to seamlessly integrate computing with our everyday activities, so that people do not need to be aware of computing artifacts. This course will introduce various techniques needed to realize pervasive computing, such as position tracking and ad-hoc networking. Prerequisite: A "C" or better grade in either Comp Sci 365 or Comp Eng 319.

COMP SCI 437 Web Data Management and XML (LEC 3.0)
Management of semi-structured data models and XML, query languages such as Xquery, XML indexing, and mapping of XML data to other data models and vice-versa, XML views and schema management, advanced topics include change-detection, web mining and security of XML data. Prerequisite: A "C" or better grade in Comp Sci 338.

COMP SCI 438 Heterogeneous and Mobile Databases (LEC 3.0)
This course extensively discusses multitabase systems (MDBS) and mobile data access systems (MDAS). Moreover, it will study traditional distributed database issues within the framework of MDBSs and MDASs. Prerequisite: A "C" or better grade in Comp Sci 338.

COMP SCI 439 Object-Oriented Database Systems (LEC 3.0)
This course will include a study of the origins of object-oriented database manipulation languages, their evolution, currently available systems, application to the management of data, problem solving using the technology, and future directions. Prerequisite: A "C" or better grade in Comp Sci 308.

COMP SCI 444 Advanced Topics In Data Mining (LEC 3.0)
Advanced topics of current interest in the field of data mining. This course involves reading seminal and state-of-the-art papers as well as conducting topical research projects including design, implementation, experimentation, analysis, and written and oral reporting components. Prerequisite: A "C" or better grade in Comp Sci 301 Introduction to Data Mining. (Co-listed with Comp Eng 404 and Sys Eng 404).

COMP SCI 447 Advanced Topics In Artificial Intelligence (LEC 3.0)
Advanced topics of current interest in the field of artificial intelligence. This course involves reading seminal and state-of-the-art papers as well as conducting topical research projects including design, implementation, experimentation, analysis, and written and oral reporting components. Prerequisite: A "C" or better grade in one of Comp Sci 347, Comp Sci 348 or Comp Eng 358.

COMP SCI 448 Advanced Evolutionary Computing (LEC 3.0)
Advanced topics in evolutionary algorithms, a class of stochastic, population-based algorithms inspired by natural evolution theory, capable of solving complex problems for which other techniques fail. Students will conduct challenging research projects involving advanced concept implementation, empirical studies, statistical analysis, and paper writing. Prerequisite: A "C" or better grade in Comp Sci 348.

COMP SCI 449 Clustering Algorithms (LEC 3.0)
An introduction to cluster analysis and clustering algorithms rooted in computational intelligence, computer science and statistics. Clustering in sequential data, massive data and high dimensional data. Students will be evaluated by individual or group research projects and research presentations. Prerequisite: At least one graduate course in statistics, data mining, algorithms, computational intelligence, or neural networks, consistent with student's degree program. (Co-listed with Comp Eng 439, Elec Eng 439, Sys Eng 439 and Stat 439).

COMP SCI 456 Theory Of Compiling (LEC 3.0)
Properties of formal grammars and languages, language-preserving transformations, syntax-directed parsing, classes of parsing methods and the grammars for which they are suited, control flow analysis, and the theoretical framework of local and global program optimization methods. Prerequisite: A "C" or better grade in Comp Sci 356.

COMP SCI 457 Markov Decision Processes (LEC 3.0)
Introduction to Markov Decision Processes and Dynamic Programming. Application to Inventory Control and other optimization and control topics. Prerequisite: Graduate standing in background of probability or statistics. (Co-listed with Comp Eng 457, Mech Eng 447, Aero Eng 457 and Eng Mgt 457).
COMP SCI 458 Computer Graphics And Realistic Modeling (LEC 3.0)
Algorithms, data structures, software design and strategies used to achieve realism in computer graphics of three-dimensional objects. Application of color, shading, texturing, antialiasing, solid modeling, hidden surface removal and image processing techniques. Prerequisite: A "C" or better grade in Comp Sci 358.

COMP SCI 461 Privacy Preserving Data Integration and Analysis (LEC 3.0)
This course covers basic tools, in statistics and cryptography, commonly used to design privacy-preserving and secure protocols in a distributed environment as well as recent advances in the field of privacy-preserving data analysis, data sanitization and information retrieval. Prerequisite: A "C" or better grade in both Comp Sci 338 and Comp Sci 262.

COMP SCI 463 Computer Security (LEC 3.0)
The course presents various vulnerabilities and threats to information in cyberspace and the principles and techniques for preventing and detecting threats, and recovering from attacks. The course deals with various aspects and layers of security: data-level, network-level, system-level, and application-level security. Prerequisite: A "C" or better grade in both Comp Sci 263 and Comp Sci 325.

COMP SCI 465 Advanced Topics in Wireless Networks (LEC 3.0)
Introduces the fundamentals and recent advances in wireless networking. Coverage includes cellular networks, wireless and mobile ad hoc networks, wireless mesh networks, sensor networks and wireless LANs with a focus on network operation. Special topics selected from the literature on wireless network security will also be addressed. Prerequisite: A "C" or better grade in Comp Sci 365 or equivalent.

COMP SCI 467 Mobile And Sensor Data Management (LEC 3.0)
Architectures of mobile computing systems; Mobile-IP support in mobile computing systems; location data management, Broadcasting and indexing, replication control; caching, fault tolerance and reliability of mobile systems; adhoc and sensor routing schemes, key management. Prerequisite: Comp Sci 265.

COMP SCI 468 Advanced Network Security (LEC 3.0)
Topics covered include network security issues such as authentication, anonymity, traceback, denial of service, confidentiality, forensics, etc. in wired and wireless networks. Students will have a clear, in-depth understanding of state of the art network security attacks and defenses. Prerequisite: A "C" or better grade in either Comp Eng 349 or Comp Sci 365.

COMP SCI 484 Distributed Systems Theory And Analysis (LEC 3.0)
Analysis of the problems of state maintenance and correctness in concurrent computing systems using formal methods such as Hoare Logic, Temporal Logic, and Symbolic Model Checking. Prerequisite: A "C" or better grade in Comp Sci 384.

COMP SCI 487 Topics in Parallel and Distributed Computing (LEC 3.0)
Introduction of parallel and distributed computing fundamentals and advanced research topics. Students present research papers selected from the current literature on P&D computing paradigms. A term paper and oral presentation are required. Prerequisite: A "C" or better grade in Comp Sci 387 or equivalent background.

COMP SCI 490 Research (IND 0.0-16)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

COMP SCI 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/ comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

COMP SCI 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Electrical Engineering (ELEC ENG)

ELEC ENG 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

ELEC ENG 301 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

ELEC ENG 302 Extra High Voltage Engineering (LEC 2.0 and LAB 1.0)
The physical phenomena associated with high voltage dielectric breakdown are presented. Methods of generating and measuring high voltages and currents are explained. Demonstration of design and performance. Field trips to companies for laboratory testing of high voltage according to industry standards will serve as the lab part of the course. Prerequisite: Senior standing.

ELEC ENG 304 Electric Power Quality (LEC 3.0)
Definitions of power quality, types of power quality problems; sources of sags, transient overvoltages and harmonics; distribution overcurrent protection methods and their effect on power quality and reliability; harmonic analysis, principles of controlling harmonics, devices for filtering harmonics; power quality improvement methods. Prerequisite: Elec Eng 205 or Elec Eng 207.

ELEC ENG 305 Electric Drive Systems (LEC 3.0)
Course content is roughly 1/3 power electronics, 1/3 applied control and 1/3 electric machinery and focuses on analysis, simulation, and control design of electric drive based speed, torque, and position control systems. Prerequisites: Elec Eng 205 and Elec Eng 231.

ELEC ENG 307 Power Systems Engineering (LEC 3.0)
Network analysis applied to power systems; the load flow concept; economic operation of power systems; synchronous machine reactances and transient stability; symmetrical components and asymmetrical faults; protective relaying. Prerequisite: Elec Eng 207.

ELEC ENG 309 Electric-Drive Vehicles (LEC 3.0)
Course covers introductory topics related to understanding/analysis of electric, hybrid/plug-in hybrid power trains. Classification of hybrid drivetrains, driving cycles, energy storage systems, mechanical coupling devices, automotive applications of fuel cells and introduction to power converters. Prerequisite: Senior standing and Physics 24.
ELEC ENG 323 Classical Optics (LEC 3.0)
Physical optics and advanced topics in geometrical optics. Topics include ray propagation, electromagnetic propagation, mirrors, lenses, interference, diffraction, polarization, imaging systems, and guided waves. Prerequisites: Math 22 and Physics 24 or 25. (Co-listed with Physics 232).

ELEC ENG 324 Fourier Optics (LEC 3.0)
Applications of Fourier analysis and linear systems theory to optics. Topics include scalar diffraction theory, Fourier transforming properties of lenses, optical information processing, and imaging systems. Prerequisites: Elec Eng 265 & 271 or Physics 208 & 321. (Co-listed with Physics 324).

ELEC ENG 325 Optical Computing (LEC 3.0)
Introduction to the principles, subsystems, and architectures of optical computing. Topics include characteristics of optical devices; optical implementations of memory, logic elements, and processors; and computational structures. Prerequisite: Comp Eng 111 or equivalent. (Co-listed with Comp Eng 325).

ELEC ENG 326 Fiber And Integrated Optics (LEC 3.0)
Introduction to optical waveguides and their applications to communication and sensing. Topics include dielectric waveguide theory, optical fiber characteristics, integrated optic circuits, coupled-mode theory, optical communication systems, and photonic sensors. Prerequisite: Elec Eng 271 or Physics 321. (Co-listed with Physics 326).

ELEC ENG 329 Smart Materials And Sensors (LAB 1.0 and LEC 2.0)
Smart structures with fiber reinforced polymer (FRP) composites and advanced sensors. Multidisciplinary topics include characterization, performance, and fabrication of composite structures; fiber optic, resistance, and piezoelectric systems for strain sensing; and applications of smart composite structures. Laboratory and team activities involve manufacturing, measurement systems, instrumented structures, and performance tests on a large-scale smart composite bridge. Prerequisites: Senior standing and Math 204. (Co-listed with Aero Eng 329, Mech Eng 329 and Civ Eng 318).

ELEC ENG 331 Digital Control (LEC 3.0)
Analysis and design of digital control systems. Review of z-transforms; root locus and frequency response methods; state space analysis and design techniques; controllability, observability and estimation. Examination of digital control algorithms. Prerequisite: Elec Eng 231.

ELEC ENG 332 Plantwide Process Control (LEC 3.0)
Synthesis of control schemes for continuous and batch chemical plants from concept to implementation. Multiloop control, RGA, SVD, constraint control, multivariable model predictive control, control sequence descriptions. Design project involving a moderately complicated multivariable control problem. Prerequisites: Chem Eng 251, Elec Eng 231, Elec Eng 235 or graduate standing. (Co-listed with Chem Eng 359).

ELEC ENG 333 System Simulation And Identification (LEC 3.0)

ELEC ENG 335 Advanced Plc (LEC 2.0 and LAB 1.0)
Advanced programmable logic controller (PLC) programming, function block, structured text, function chart, sequencer. Factory communications, system simulation, human-machine interface (HMI) programming. Advanced PID control. Network security and reliability. Class-wide project. Prerequisite: Elec Eng 235.

ELEC ENG 337 Neural Networks For Control (LEC 3.0)
Introduction to artificial neural networks and various supervised and unsupervised learning techniques. Detailed analysis of some of the neural networks that are used in control and identification of dynamical systems. Applications of neural networks in the area of Control. Case studies and a term project. Prerequisite: Elec Eng 265.

ELEC ENG 338 Fuzzy Logic Control (LEC 3.0)
A mathematical introduction to the analysis, synthesis, and design of control systems using fuzzy sets and fuzzy logic. A study of the fundamentals of fuzzy sets, operations on these sets, and their geometrical interpretations. Methodologies to design fuzzy models and feedback controllers for dynamical systems. Various applications and case studies. Prerequisite: Elec Eng 265.

ELEC ENG 341 Digital Signal Processing (LEC 3.0)
Spectral representations, sampling, quantization, z-transforms, digital filters and discrete transforms including the Fast Fourier transform. Prerequisite: Elec Eng 267.

ELEC ENG 343 Communications Systems II (LEC 3.0)
Random signals and their characterization; noise performance of amplitude, angle and pulse modulation systems; digital data transmission; use of coding for error control. Prerequisite: Elec Eng 243.

ELEC ENG 344 Stochastic Signal Analysis I (LEC 3.0)
Introduction to the application of probabilistic models to typical electrical engineering problems. Topics include: methods for describing random voltages, random digital signals, correlation, linear mean-square estimation, linear transformation of random digital signals, and bit-error rate calculation for communication systems. Prerequisites: Math 204 and Elec Eng 153.

ELEC ENG 345 Digital Image Processing (LEC 3.0)
Fundamentals of human perception, sampling and quantization, image transforms, enhancement, restoration, channel and source coding. Prerequisite: Elec Eng 267. (Co-listed with Comp Eng 345).

ELEC ENG 347 Machine Vision (LEC 3.0)
Image information, image filtering, template matching, histogram transformations, edge detection, boundary detection, region growing and pattern recognition. Complementary laboratory exercises are required. Prerequisites: Comp Eng 111 and preceded or accompanied by Elec Eng 267. (Co-listed with Comp Eng 347).

ELEC ENG 348 Wireless Networks (LAB 1.0 and LEC 2.0)
Introduction to wireless communications and networking. Topics include transmission fundamentals, wireless channel, coding techniques and error control, satellite and cellular networks, cordless systems, mobile IP and management, multiple access techniques and wireless protocols, wireless LAN, IEEE 802.11, and adhoc and sensor networks. Prerequisites: Hardware competency, Elec Eng 243 or Comp Eng 213 and graduate standing. (Co-listed with Comp Eng 348 and Sys Eng 348).

ELEC ENG 351 Advanced Electronic Circuits (LEC 3.0)
Application of feedback theory, oscillators and frequency standards, precision analog techniques, low-power circuit design, interfacing sensors, designing for high reliability, electronics for harsh environments. Prerequisite: Elec Eng 254.

ELEC ENG 352 Photovoltaic Systems Engineering (LEC 3.0)
Physics and characteristics of photovoltaic (solar) cell technologies, electronic control of alternative energy sources, site selection, array design, energy storage methods, electrical code compliance, stand-alone systems, grid-intertie systems, legal and economic considerations. Prerequisite: Senior or graduate standing in Science or Engineering.
**ELEC ENG 353 Power Electronics** (LEC 3.0)
Analysis, design, modeling, and control of switching mode power converter circuits for ac-dc, dc-dc, dc-ac, and ac-ac conversion. Power semiconductor devices, passive components, and non-ideal sources and loads. Applications to industry, consumer goods, electric vehicles, and alternative energy. Prerequisite: Elec Eng 253.

**ELEC ENG 354 Power Electronics Laboratory** (LAB 2.0)
An introduction to power electronic circuits is presented. Students will construct several dc/dc, dc/ac and ac/dc converters. Various switching algorithms, including pulse with modulation, delta modulation, and hysteresis control will be developed to regulate and control the respective circuits. Prerequisite: Co-requisite Elec Eng 353.

**ELEC ENG 355 High-Frequency Amplifiers** (LEC 3.0)
Analysis and design of high frequency amplifiers. Topics include parameter conversions, activity and passivity, stability criteria, device operating conditions, Smith chart usage, matching networks, microstrip, scattering parameters, and practical applications. Prerequisites: Elec Eng 254, 271.

**ELEC ENG 357 Communication Circuits** (LEC 3.0)
Analysis and design of circuits used in communication systems. Topics include RF semiconductor devices, low-noise amplifiers, mixers, modulators, crystal oscillators, AGC circuits, high-power RF amplifiers, phase-locked loops, impedance matching, and frequency-selective networks and transformers. Prerequisites: Elec Eng 254, preceded or accompanied by Elec Eng 243.

**ELEC ENG 361 Computer-Aided Network Design** (LEC 3.0)
Analysis and design of active and passive electric networks. Theory and computer application, including methods for automatic formulation of network state equations, network tolerance, network optimization, and device modeling. Prerequisites: Elec Eng 253, 267.

**ELEC ENG 363 Introduction To Circuit Synthesis** (LEC 3.0)

**ELEC ENG 367 Computational Intelligence** (LEC 3.0)
Introduction to Computational Intelligence (CI), Biological and Artificial Neuron, Neural Networks, Evolutionary Computing, Swarm Intelligence, Artificial Immune Systems, Fuzzy Systems, and Hybrid Systems. CI application case studies covered include digital systems, control, power systems, forecasting, and time-series predictions. Prerequisite: Comp Sci 153 or programming competency. (Co-listed with Comp Eng 358 and Sys Eng 367).

**ELEC ENG 368 Introduction To Neural Networks & Applications** (LEC 3.0)
Introduction to artificial neural network architectures, adaline, madaline, back propagation, BAM, and Hopfield memory, counterpropagation networks, self organizing maps, adaptive resonance theory, are the topics covered. Students experiment with the use of artificial neural networks in engineering through semester projects. Prerequisites: Math 204 or 229; graduate standing. (Co-listed with Sys Eng 378).

**ELEC ENG 371 Interference Control in Electronic Systems** (LEC 3.0)
Principles of high frequency effects in PCBs and components, generation of unwanted radio-frequency (RF) signals by ICs, RF radiation mechanisms, shielding, and immunity against electrostatic discharge and RF signals. Prerequisites: Elec Eng 217 and 271.

**ELEC ENG 372 Signal Integrity In High-Speed Digital & Mixed Signal Design** (LEC 3.0)
Signal integrity ensures signals transmitted over a propagation path maintain sufficient fidelity for proper receiver operation. Compromised signal integrity is often associated with parasitics (e.g. unintentional inductance, capacitance). Theory and CAD tools used for signal integrity analysis of functioning designs. Prerequisites: Elec Eng 271 or Comp Eng 213, and Senior standing. (Co-listed with Comp Eng 372).

**ELEC ENG 373 Antennas And Propagation** (LEC 3.0)
Propagated fields of elemental dipole, directivity and gain, radiation resistance, the half-wave dipole, wire antennas, arrays, broadband antennas, aperture antennas, horn antennas, and antenna temperature. Prerequisite: Elec Eng 271.

**ELEC ENG 374 Wave Propagation and Transmission Lines** (LEC 3.0)
The materials in this course are intended to provide a) follow up electromagnetics related courses, b) electromagnetics related career including RF design and c) a graduate degree in electromagnetic related fields an in-depth understanding of the basics of wave propagation and transmission lines. Prerequisite: Elec Eng 271.

**ELEC ENG 375 Nondestructive Testing** (LEC 3.0)
Principles and applications of various means of non-destructive testing of metallic materials. Radiological inspection methods, ultrasonic testing, magnetic methods, electrical and eddy current methods and others. Prerequisite: Physics 24 or 25. (Co-listed with Met Eng 305).

**ELEC ENG 377 Microwave And Millimeter Wave Engineering And Design** (LEC 3.0)
Introduce senior and graduate students to the concept of microwave an millimeter wave engineering and component design such as waveguide, couplers, detectors, mixers, etc., including network theory and scattering matrix. Finally, their application in various microwave circuits will be discussed. Prerequisites: Elec Eng 253, 271.

**ELEC ENG 378 Mechatronics** (LEC 2.0 and LAB 1.0)
This course will introduce students to the basics of mechatronics (i.e., the integration of mechanical, electrical, computer, and control systems). Students will learn the fundamentals of sensors and actuators for mechanical systems, computer interfacing, microcontrollers, real-time software, and control. Prerequisite: Mech Eng 279 or equivalent. (Co-listed with Mech Eng 378, Aero Eng 378 and Comp Eng 378).

**ELEC ENG 379 Microwave Principles For Mixed-Signal Design** (LEC 3.0)
Transmission lines; coupled transmission lines; microwave network analysis; impedance matching and tuning; design of microwave amplifiers and oscillators. Prerequisite: Elec Eng 271.

**ELEC ENG 382 Teaching Engineering** (LEC 3.0)
Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Eng Mgt 370, Env Eng 382, Comp Eng 382, Civ Eng 382).

**ELEC ENG 388 Introduction to Robotics** (LEC 3.0)
This course provides an introduction to robotics, covering robot hardware, fundamental kinematics, trajectories, differential motion, robotic decision making, and an overview of current topics in robotics. Prerequisite: A "C" or better in both Math 208 and Comp Sci 153. (Co-listed with Comp Sci 345 and Comp Eng 388).
ELEC ENG 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

ELEC ENG 391 Electrical Engineering Senior Project I (LAB 0.50 and RSD 0.50)
A complete design cycle. Working in small teams, students will design, document, analyze, implement and test a product. Topics include: Iteration in design, prototyping, group dynamics, design reviews, making effective presentations, concurrent design, designing for test, ethics and standards, testing and evaluation. Prerequisites: Stat 217, Comp Eng 111, Econ 121 or 122, Sp&M S 85, English 160, at least 3 of the following: Elec Eng 205, Elec Eng 207, Elec Eng 215, Elec Eng 217, Elec Eng 271, Elec Eng 253.

ELEC ENG 392 Electrical Engineering Senior Project II (LAB 3.0)
A continuation of EI Eng 391. Prerequisite: Elec Eng 391 with a grade of "C" or better.

ELEC ENG 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

ELEC ENG 401 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

ELEC ENG 402 Advanced Theory Of Electric Machines (LEC 3.0)
Energy conversion, reference frame theory, transient and dynamic modeling of ac machines, simulation of ac machines, parameter identification, model-order reduction, advanced topics depending on semester taught. Prerequisite: Elec Eng 205.

ELEC ENG 403 Power System Reliability (LEC 3.0)

ELEC ENG 404 Power System Operations (LEC 3.0)
Optimal dispatch operations, economic loading of power plants, mathematical optimization, locational marginal pricing, optimal power flow; effect of hydro and wind power plants on system economics; contingency analysis and system security, state estimation. Prerequisite: Elec Eng 307.

ELEC ENG 405 Power System Protection (LEC 3.0)
Protective relaying incorporating electromechanical, solid state and computer relaying methods for high voltage transmission systems; instrument transformers; generator, transformer, line and bus protection; effect of system grounding; pilot protection and out of step relaying principles. Prerequisite: Elec Eng 303 and 307.

ELEC ENG 406 Power System Stability (LEC 3.0)
Synchronous machine theory and modelling; AC transmission; power system loads; excitation systems; control of active and reactive power; small signal stability; transient stability; voltage stability; mid-term and long-term stability; subsynchronous oscillations; stability improvement. Prerequisite: Elec Eng 207 or similar course.

ELEC ENG 407 Surge Phenomena In Power Systems (LEC 3.0)
Study of transmission system insulation, distributed constant lines, terminations, multiple reflections, lighting performance, characteristics of sustained and switching overvoltages, surge voltages due to system faults, energizing and reclosing of circuit breakers. Methods of reducing overvoltages to acceptable levels. Prerequisite: Elec Eng 307.

ELEC ENG 408 Computer Methods In Power System Analysis (LEC 3.0)
Algorithms for large scale system solution, non-linear systems, ordinary differential equations, eigenvalue problems, modal information, and optimization. Applications to power systems analysis. Prerequisite: Elec Eng 207 or similar course.

ELEC ENG 409 Advanced Electric Drive Vehicles (LEC 3.0)
This course covers an entire range of advanced topics related to the analysis, design, control, simulation, and optimization of electric, hybrid, and plug-in hybrid power-trains including the automotive applications of adjustable speed motor drives, energy storage systems, and advanced power converters. Prerequisite: Elec Eng 305 or Elec Eng 353.

ELEC ENG 420 Semiconductor Devices (LEC 3.0)
Properties of semiconductors, junctions and transistors; high frequency and high-current effects; recombination processes; field-effect devices, semiconductor devices and microcircuits. Prerequisite: Graduate status in Elec Eng.

ELEC ENG 422 Integrated Microsystems Engineering (LEC 1.5 and LAB 1.5)
Theory and practice of multidisciplinary integrated microsystem technologies. The topics include (1) micromachining technology, (2) review of mechanical, optical, microfluidic and (bio) chemical microsensors and microactuators, (3) hands-on lab session for design, fabrication, and characterization of microsystems. Prerequisite: Graduate standing.

ELEC ENG 425 Electromagnetic Optics (LEC 3.0)
Propagation, control, and modulation of laser radiation. Topics include optical polarization, interference, layered and anisotropic media, electro-optic devices, acousto-optic devices, and nonlinear optics. Prerequisite: Elec Eng 271 or Physics 321.

ELEC ENG 429 Advanced Topics in Optics and Devices (LEC 3.0)
Advanced topics of current interest in optics and devices. Selected topics include semiconductor materials, electronic devices, wave-based sensing, fiber optic systems, optoelectronics, and photonic engineering. Prerequisite: Graduate standing.

ELEC ENG 431 Linear Control Systems (LEC 3.0)
Review of linear algebra, state variable formulations, solutions of state equations; controllability and observability; multivariable systems, matrix-fraction decompositions; design of state and output feedback controllers and observers; introduction to calculus of variations; linear quadratic regulators. Prerequisite: Elec Eng 231.

ELEC ENG 432 Optimal Control And Estimation (LEC 3.0)
Review of linear quadratic regulators (LQR), LQR extensions; constrained optimization (Pontragin’s minimum principle); review of probability theory and random processes; optimal prediction and filters; frequency domain properties of LQR and Kalman filters; linear quadratic Gaussian (LQG) control; model uncertainties, frequency shaping, LQG/LTR design methodology. Prerequisite: Elec Eng 431.

ELEC ENG 433 Current Topics In Control Theory (LEC 3.0)
Topics of current interest in control theory literature. Offered as interest and demand warrant. Prerequisite: Consent of instructor.
ELEC ENG 434 Nonlinear Control Systems (LEC 3.0)
Numerical solution methods, describing function analysis, direct and indirect methods of Liapunov stability, applications to the Lure problem - Popov circle criterion. Applications to system design and feedback linearizations. Prerequisite: Elec Eng 431.

ELEC ENG 438 Robust Control Systems (LEC 3.0)
Performance and robustness of multivariable systems, linear fractional transformations, LQG/LTR advanced loop shaping, Youla parameterization, H∞ (subscript infinity) optimal control, mixed H (subscript 2) and H (subscript infinity) control, controller synthesis for multiple objective optimal control, linear matrix inequalities theory and case studies. Prerequisite: Elec Eng 431.

ELEC ENG 439 Clustering Algorithms (LEC 3.0)
An introduction to cluster analysis and clustering algorithms rooted in computational intelligence, computer science and statistics. Clustering in sequential data, massive data and high dimensional data. Students will be evaluated by individual or group research projects and research presentations. Prerequisite: At least one graduate course in statistics, data mining, algorithms, computational intelligence, or neural networks, consistent with student’s degree program. (Co-listed with Comp Eng 439, Sys Eng 439, Comp Sci 449 and Stat 439).

ELEC ENG 441 Digital Signal Processing II (LEC 3.0)
Continuation of Elec Eng 341. Effects of discrete noise sources in digital signal processing; discrete spectral analysis of random signals; discrete time signal detection, estimation, and filtering algorithms. Prerequisites: Elec Eng 341 and 343 or 344 or Stat 343.

ELEC ENG 443 Wireless Ad hoc and Sensor Networks (LEC 3.0)
Introduction to ad hoc and sensor networks, IEEE standards, heterogeneity, quality of service, wireless channel issues, energy awareness, power and topology control, routing, scheduling, rate adaptation, self-organization, admission and flow control, energy harvesting, security and trust levels, hardware and applications. Prerequisite: Comp Eng 348 or Comp Eng 349 or equivalent. (Co-listed with Comp Eng 443 and Sys Eng 443).

ELEC ENG 444 Wireless Ad hoc and Sensor Networks II (LEC 3.0)
Continuous-time stochastic signals, multi-dimensional signals, Wiener and matched filters, LMS equalization, non-linear systems with random inputs, spectral estimation and Markov chains. Prerequisites: Stat 343 or Elec Eng 344.

ELEC ENG 445 Statistical Decision Theory (LEC 3.0)
Classical detection and estimation theory with applications; hypothesis testing, detection of known signals, matched filter receiver implementation, detection of signals with unknown parameters, sequential and nonparametric detection, detection of stochastic signals: Parameter estimation theory with application to modulation. Prerequisite: Elec Eng 344.

ELEC ENG 446 Wireless Communications (LEC 3.0)
Introduction to the principle of wireless communication systems. Topics include: wireless channel characteristics, cellular concepts, channel capacity analysis, transceiver architectures, diversity techniques, multiple access schemes, and practical wireless systems. Prerequisite: Elec Eng 343 or Elec Eng 344 or equivalent.

ELEC ENG 447 Information Theory And Coding (LEC 3.0)
Principles of information generation, transmission and processing; quantitative measure of information, entropy source encoding; channels; mutual information; channel capacity; Shannon’s second theorem for discrete channels; introduction to coding for error controls; continuous information sources. Prerequisites: Elec Eng 343 or Elec Eng 344 or Stat 343.

ELEC ENG 448 Advanced Topics In Communications (LEC 3.0)
Advanced topics of current interest in communications and signal processing such as spread spectrum, digital processing of communications, speech, and radar signals, applications of pattern recognition, communications networks, specialized coding topics. Repeatable for additional credit toward degree each time a different subtitle offered. Prerequisite: Elec Eng 343 or 344.

ELEC ENG 453 Advanced Power Electronics (LEC 3.0)
The purpose of this course is to cover selected areas of power electronics in greater depth. The topics covered include small signal analysis of power converters, voltage- and current- mode control, soft switching techniques, power factor correctors, multi-level converters, and PWM techniques. Prerequisite: Elec Eng 353.

ELEC ENG 454 Power Converter Modeling and Design (LEC 3.0)
Students will integrate electrical, magnetic, and thermal modeling techniques into a design process for switching power converters. A variety of applications will be considered, including dc-dc, ac-dc, and dc-ac converters over a wide power range. Prerequisite: Elec Eng 353.

ELEC ENG 455 Advanced RF & Time Domain Measurements (LEC 2.0 and LAB 1.0)
Advanced measurement techniques and instrumentation: Oscilloscopes (Real time and sampling, A/D conversion errors, Probing, Jitter, Noise), Spectrum analyzer (concepts, applications), Network Analyzer (concepts, calibration), Impedance measurements. Lab experiments are a main part of this class. Prerequisite: Graduate standing.

ELEC ENG 456 Signal Integrity, High Speed Digital and RF Design Laboratory (LAB 3.0)
This is an RF and digital electronics design class. Student groups will design, manufacture and test RF and/or digital circuits during the class. Besides this project work the lecture part will emphasize circuit design, layout, parasitic effects and design for testability. Prerequisite: Elec Eng 271.

ELEC ENG 458 Adaptive Critic Designs (LEC 3.0)
Review of Neurocontrol and Optimization, Introduction to Approximate Dynamic Programming (ADP), Reinforcement Learning (RL), Combined Concepts of ADP and RL - Heuristic Dynamic Programming (HDP), Dual Heuristic Programming (DHP), Global Dual Heuristic Programming (GDHP), and Case Studies. Prerequisite: Elec Eng 368 Neural Networks or equivalent (Computational Intelligence Comp Eng 301) (Co-listed with Comp Eng, Mech Eng, Aero Eng and Sys Eng 458).

ELEC ENG 471 Advanced Electromagnetics I (LEC 3.0)
ELEC ENG 473 Electromagnetic Waves II (LEC 3.0)
Circular waveguides, circular cavities, scattering by cylinders, apertures in cylinders, spherical cavities, orthogonality relationships, source of spherical waves, scattering by spheres, perturbational and variational techniques, microwave networks, probes in cavities, and aperture coupling to cavities. Prerequisite: ELEC ENG 471.

ELEC ENG 474 Computational Electromagnetics (LEC 3.0)
Differential-equation based numerical methods-finite element, finite-difference, and finite-difference time-domain-for solving static and dynamic equations of electromagnetics. Applications considered are multi-conductor transmission lines, Maxwell’s equations for radiation and scattering, and electric machinery. Prerequisite: ELEC ENG 271.

ELEC ENG 475 Topics in EMC and High Speed Digital Design (LEC 3.0)
This course will cover advanced topics in electromagnetic compatibility and high speed digital design that are not traditionally covered in other courses. Topics will depend on the latest developments in the field and on student needs. Prerequisite: ELEC ENG 271.

ELEC ENG 477 Advanced Topics in Antenna Analysis and Design (LEC 3.0)
Introduction and discussion of advanced antenna design issues including: polarization, antenna synthesis and source modeling, broadband antennas, aperture and microstrip antenna simulation and design, and antenna pattern measurement techniques including near-field to far-field transformation. Prerequisite: ELEC ENG 373 or equivalent.

ELEC ENG 481 Philosophy of Scientific Research (LEC 3.0)
Organization and planning of research. Introduction to the philosophy and management of scientific research, particularly issues related to ethics, plagiarism, ownership of intellectual properties, research techniques, technical presentations and time management. The course will address these issues by integrating with case studies. (Co-listed with Chem ENG 425, IDE 425, Civ ENG 485, Env ENG 485, Comp ENG 481).

ELEC ENG 488 Advanced Topics in Robotics (LEC 3.0)
This course covers advanced topics in robotics, including perception, robotic path planning, robotic system integration, and computational intelligence topics for robotics. A term project including both written and oral components will be required. Prerequisite: A "C" or better in either Comp SCI 345 or Mech ENG 349 or Aero ENG 349. (Co-listed with Comp SCI 445 and Comp ENG 488).

ELEC ENG 490 Special Research And Thesis (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

ELEC ENG 491 Internship (IND 0.0-15)
Students working toward a doctor of engineering degree will select, with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

ELEC ENG 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

ELEC ENG 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Engineering Management (ENG MGT)

ENG MGT 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

ENG MGT 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

ENG MGT 308 Economic Decision Analysis (LEC 3.0)
Comprehensive treatment of engineering economy including effects of taxation and inflation; sensitivity analysis; decisions with risk and uncertainty; decision trees and expected value, normally includes solutions on personal computer and student problem report. Prerequisite: Graduate students without previous course in engineering economy because of partial overlap.

ENG MGT 309 Six Sigma (LEC 3.0)
This course is an introduction to the principles of implementing the Six Sigma philosophy and methodology. Topics include tools and methods including process flow diagrams, cause and effect diagrams, failure mode and effects analysis, gage R&R, capability studies, design of experiments and strategy for organizing six sigma techniques in industry. Prerequisite: Graduate standing.

ENG MGT 311 Human Factors (LEC 3.0)
An examination of human-machine systems and the characteristics of people that affect system performance. Topics include applied research methods, systems analysis, and the perceptual, cognitive, physical and social strengths and limitations of human beings. The focus is on user-centered design technology, particularly in manufacturing environments. Prerequisite: Psych 50. (Co-listed with Psych 311).

ENG MGT 313 Managerial Decision Making (LEC 3.0)
Individual and group decision making processes and principles for engineers and technical managers with emphasis on the limitations of human rationality and the roles of social influence and organizational contexts; principles and skills of negotiation. Prerequisite: Senior or graduate standing.

ENG MGT 314 Management for Engineers and Scientists (LEC 3.0)
The transition of the engineer or scientist to manager; study of management roles and theory, organizational systems and behavior, managing and motivating technical personnel, leadership, communication, processes, and customer focus. Prerequisite: Graduate standing.

ENG MGT 320 Technical Entrepreneurship (LEC 3.0)
Student teams develop a complete business plan for a company to develop, manufacture and distribute real technical/product service. Lectures & business fundamentals, patents, market/technical forecasting, legal and tax aspects, venture capital, etc., by instructor and successful technical entrepreneurs. Prerequisite: Senior or graduate standing.
ENG MGT 327 Legal Environment (LEC 3.0)
Study of the effect of the legal environment on the decisions which the engineering manager must make. The course investigates the social forces that produced this environment and the responsibilities incumbent upon the engineer.

ENG MGT 344 Interdisciplinary Problems In Manufacturing Automation (LEC 1.0 and LAB 2.0)
Introduction to basic techniques and skills for concurrent engineering, manufacturing strategies, product design, process planning, manufacturing data management and communication are the topics covered. Students experiment the design process through team projects and structured manufacturing laboratory work. (Co-listed with Mech Eng 344, Chem Eng 384).

ENG MGT 345 Energy and Sustainability Management Engineering (LEC 3.0)
This course explores strategic processes and partnership required for the management of sustainable energy infrastructures and innovation in energy systems. Topics relate to renewable energy, energy efficiencies, energy conversion, energy technology, and economic efficiency of energy sources. Prerequisite: Senior or Graduate Standing.

ENG MGT 350 Risk Assessment and Reduction (LEC 3.0)
Safe, secure manufacturing facilities protect the health of employees and the public, preserve the environment, and increase profitability. Methods for systematically identifying hazards and estimating risk improve the safety performance and security of manufacturing facilities. Prerequisite: Senior or Graduate Standing. (Co-listed with Chem Eng 350).

ENG MGT 351 Industrial Marketing Systems Analysis (LEC 3.0)
Analysis of the factors of engineered products, customers, communication, promotion, personal selling, persuasion and management within a dynamic industrial sales environment.

ENG MGT 354 Integrated Product And Process Design (LEC 3.0)
Emphasize design policies of concurrent engineering and teamwork, and documenting of design process knowledge. Integration of various product realization activities covering important aspects of a product life cycle such as "customer" needs analysis, concept generation, concept selection, product modeling, process development, DFX strategies, and end-of-product life options. Prerequisite: Eng Mgt 253 or Mech Eng 253. (Co-listed with Mech Eng 357).

ENG MGT 356 Value Analysis (LEC 3.0)
An organized effort at analyzing the function of goods or services for the purpose of achieving the basic functions at the lowest overall cost, consistent with achieving the essential characteristics. Covers the basic philosophy, function analysis, FAST diagramming, creativity techniques, evaluation of alternatives, criteria analysis, and value stream mapping. Prerequisite: Senior or graduate standing.

ENG MGT 360 Interdisciplinary Problems In Manufacturing Automation (LEC 3.0)
Prerequisite: Eng Mgt 257 or instructor's permission.

ENG MGT 361 Project Management (LEC 3.0)
Organization structure and staffing; motivation, authority and influence; conflict management; project planning; network systems; pricing, estimating, and cost control; proposal preparation; project information systems; international project management. Prerequisite: Graduate Standing.

ENG MGT 364 Value Analysis (LEC 3.0)
Introduction to basic techniques and skills for concurrent engineering, manufacturing strategies, product design, process planning, manufacturing data management and communication are the topics covered. Students experiment the design process through team projects and structured manufacturing laboratory work. (Co-listed with Mech Eng 344, Chem Eng 384).

ENG MGT 366 Supply Chain Management Systems (LEC 3.0)
This course focuses on the development of logistics management skills related to global supply chains. Particular attention will be given to supply chain systems management as part of the firm's strategic positioning, cultural interactions and transportation sourcing decisions. Prerequisite: Stat 215 or Stat 217.

ENG MGT 367 Advanced Facilities Planning & Design (LAB 1.0 and LEC 2.0)
An integrated approach to the planning and design of facilities; examination of advanced techniques and tools for facility location, space allocation, facility layout materials handling system design, work place design; e.g. mathematical programming and simulation modeling. Prerequisite: Eng Mgt 257 or instructor's permission.

ENG MGT 368 Integrated Product Development (LEC 1.0 and LAB 2.0)
Students in design teams will simulate the industrial concurrent engineering development process. Areas covered will be design, manufacturing, assembly, process quality, cost, supply chain management, and product support. Students will produce a final engineering product at the end of the project. Prerequisite: Eng Mgt 354 or Mech Eng 357 or Mech Eng 253 or Mech Eng 308. (Co-listed with Mech Eng 358).

ENG MGT 369 Patent Law (LEC 3.0)
A presentation of the relationship between patent law and technology for students involved with developing and protecting new technology or pursuing a career in patent law. Course includes an intense study of patentability and preparation and prosecution of patent applications. Prerequisite: Senior or graduate standing. (Co-listed with Chem Eng 385).

ENG MGT 370 Teaching Engineering (LEC 3.0)
Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Env Eng 382, Comp Eng 382, Elec Eng 382, Civ Eng 382).

ENG MGT 372 Production Planning And Scheduling (LEC 3.0)
Introduction to basic techniques of scheduling, manufacturing planning and control, just-in-time systems, capacity management, master production scheduling, single machine processing, constructive Algorithms for flow-shops, scheduling heuristics, intelligent scheduling systems are the topics covered. Prerequisite: Eng Mgt 253.

ENG MGT 373 Intelligent Investing (LEC 3.0)
In this course we examine methods and tools, which support building a personal portfolio that leads to long-term wealth for the owner. The approach is based on the teachings of Benjamin Graham and Warren Buffet.
**ENG MGT 374 Engineering Design Optimization** (LEC 3.0)
This course is an introduction to the theory and practice of optimal design as an element of the engineering design process. The use of optimization as a tool in the various stages of product realization and management of engineering and manufacturing activities is stressed. The course stresses the application of nonlinear programming methods. Prerequisite: Math 204 or 229.

**ENG MGT 375 Total Quality Management** (LEC 3.0)
Examination of various quality assurance concepts and their integration into a comprehensive quality management system: statistical techniques, FMEA’s, design reviews, reliability, vendor qualification, quality audits, customer relations, information systems, organizational relationships, motivation. Prerequisite: Senior or graduate standing.

**ENG MGT 376 Introduction To Quality Engineering** (LEC 3.0)
This course is an introduction to the theory and practice of quality engineering with particular emphasis on the work of Genichi Taguchi. The application of the quality loss function, signal to noise ratio and orthogonal arrays is considered in-depth for generic technology development; system, product and tolerance design; and manufacturing process design. The emphasis of the course is off-line quality control. Other contributions in the field are also considered. Prerequisite: Eng Mgt 375.

**ENG MGT 377 Introduction To Intelligent Systems** (LEC 3.0)
Introduction to the design of intelligent systems. Topics include: definitions of intelligence, rule-based expert systems, uncertainty management, fuzzy logic, fuzzy expert systems, artificial neural networks, genetic algorithms and evolutionary computation, hybrid systems, and data mining. Prerequisite: Graduate or senior standing.

**ENG MGT 381 Management And Methods In Reliability** (LEC 3.0)
Study of basic concepts in reliability as they apply to the efficient operation of industrial systems. Prerequisite: Stat 215, 217, or 343.

**ENG MGT 382 Introduction To Operations Research** (LEC 3.0)
Mathematical methods for modeling and analyzing industrial systems, topics including linear programming, transportation models, and network models. Prerequisite: Stat 215 or Stat 217.

**ENG MGT 383 Packaging Management** (LEC 3.0)
Provides a comprehensive background in the field of packaging and its place in productive systems. Emphasizes the design or economics of the system. Analyzes the management of the packaging function and interrelationship with other functions of an enterprise.

**ENG MGT 385 Statistical Process Control** (LEC 3.0)
The theoretical basis of statistical process control procedures is studied. Quantitative aspects of SPC implementation are introduced in context along with a review of Deming’s principles of quality improvement and a brief introduction to sampling inspection. Prerequisite: Stat 215, or Stat 217.

**ENG MGT 386 Safety Engineering Management** (LEC 3.0)
This course is an introduction to the principles of safety engineering applied to industrial situations. Job safety analysis, reduction of accident rates, protective equipment, safety rules and regulations, environmental hazards, health hazards, and ergonomic hazards are covered. Prerequisite: Senior or graduate standing.

**ENG MGT 390 Undergraduate Research** (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor. Consent of instructor required.

**ENG MGT 400 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**ENG MGT 401 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**ENG MGT 408 Financial Risk Management** (LEC 3.0)
Techniques and methods for managing financial risk, including portfolio theory, Monte Carlo methods, ARIMA, time series forecasting, Value-at-Risk, stress testing, extreme value theory, GARCH and volatility estimation, random variables and probability distributions, real options, decision trees, utility theory, statistical decision techniques, and game theory. Prerequisite: Eng Mgt 137 or 308. (Co-listed with Sys Eng 408).

**ENG MGT 409 Design for Six Sigma** (LEC 3.0)
Principles of Design for Six Sigma for product development. Topics include tools and methods including quality function deployment, concept generation, concept selection, product modeling, process development, DFA strategies, failure mode and effects analysis, design of experiments, TRIZ, and robust design. Prerequisite: Eng Mgt 309.

**ENG MGT 410 Seminar** (IND 0.0-6.0)
Discussion of current topics.

**ENG MGT 411 Human Systems Integration** (LEC 3.0)
This course considers Human Systems Integration (HSI) in a variety of applications including systems acquisition and training, HSI tools, techniques, and procedures. Prerequisite: Eng Mgt 311 or Psych 311.

**ENG MGT 418 Leadership for Engineers** (LEC 3.0)
Provides engineers with a background in leadership concepts and principles; enables students to develop practical skills in leading and managing through multiple personal assessment. Topics include leadership styles, managing commitments, conflict resolution, change management, emotional intelligence, team dynamics and business ethics. Prerequisite: Eng Mgt 313 or Psych 374. (Co-listed with Psych 418).

**ENG MGT 420 Technological Innovation Management** (LEC 3.0)
Technological innovation is new technology creating new products and services. This course studies the issues of managing technological innovation under four topics: 1) Innovation; 2) New Ventures; 3) Corporate Research & 4) R&D Infrastructure. Prerequisite: Eng Mgt 314.

**ENG MGT 434 Advanced Manufacturing Systems Integration** (LAB 1.0 and LEC 2.0)
The integration of new technology and information processing concepts for controlling the manufacturing systems. Advanced topics in computer integrated manufacturing systems, industrial robots, CNC machine tools, programmable controllers, material handling systems, manufacturing planning and control.

**ENG MGT 441 Case Studies In General Management** (LEC 3.0)
A quantitative study of engineering management problems related to the functioning of the industrial enterprise through case studies. Prerequisite: Preceded or accompanied by an Eng Mgt 400 level course.

**ENG MGT 451 Advanced Marketing Management** (LEC 3.0)
Study of marketing decision areas in the technically based firm, including product selection and development, marketing research, market development, distribution, advertising, and promotion. Pricing policies including legal aspects and problems in selecting, training and controlling field sales force. Examination of interaction within consumer and industrial marketing environments. Prerequisites: Eng Mgt 314, Econ 122.
ENG MGT 452 Advanced Financial Management (LEC 3.0)
Principles of financial organization and management in the technological enterprise; demands for funds; internal and external supply of funds; budgetary control; reserve and dividends policy. Emphasizes systems approach and problems of engineering design and automation as they influence financial decisions. Prerequisite: Eng Mgt 137 or 308.

ENG MGT 454 Advanced Production Management (LEC 3.0)
Examination of responsibilities of production manager in the technological enterprise for providing finished goods to meet the quality, price, quantity and specification needs of the market place. Study of functions of production manager. Quantitative approach to decision making in production management. Prerequisites: Senior or graduate standing and advanced mathematical modelling competence.

ENG MGT 456 Advanced Personnel Management (LEC 3.0)
Current practices of procurement and maintenance of technical personnel in research, development, and design organizations. Adaptation of such personnel to the technological enterprise, current practices in personnel administration, labor management relationships. Prerequisite: Eng Mgt 314.

ENG MGT 457 Markov Decision Processes (LEC 3.0)
Introduction to Markov Decision Processes and Dynamic Programming. Application to Inventory Control and other optimization and control topics. Prerequisite: Graduate standing in background of probability or statistics. (Co-listed with Comp Eng 457, Mech Eng 447, Aero Eng 457 and Comp Sci 457).

ENG MGT 458 Case Studies in Project Management (LEC 3.0)
Includes the main components of the Project Management Institute (PMI) Body of Knowledge; case studies in project management including project implementation, organizational structures, project estimating, project scheduling, project risk management, and conflict management. Prerequisite: Eng Mgt 361 or equivalent.

ENG MGT 460 Advanced Topics in Simulation Modeling (LEC 3.0)
Design and analysis of distributed systems using discrete-event simulations and synchronization of distributed models. Design and implementation of finite state automata and simulation models as control execution systems. Functioning of real-time, agent-based, and multipass simulations. Prerequisite: Eng Mgt 356 or Graduate standing.

ENG MGT 461 Global Project Management (LEC 3.0)
In depth and advanced topics in project management including project management methodologies, strategic planning for excellence, project portfolio management, integrated processes, culture, and behavioral excellence; normally includes a hands-on group project. Prerequisite: Eng Mgt 361 or equivalent.

ENG MGT 465 Mathematical Programming (LEC 3.0)
An introduction to linear optimization and its engineering applications; problem modeling, search-based optimization, the simplex method for solving linear problems, multi-objective optimization, discrete dynamic programming. Applications of optimization in the fields such as transportation, project management, manufacturing and facility location will be discussed. Prerequisites: Stat 213 or equivalent and (Eng Mgt 382 or Math 203 or Math 208) (Co-listed with Math 465).

ENG MGT 472 Lean Systems (LEC 3.0)
Lean Systems embodies a total enterprise philosophy built on removing waste. Concepts such as flow, just-in-time, lead times, inventory turns, standardized work, pull system, value streams, quick changeover, workplace organization, and visual controls are discussed to improve system performance. Prerequisite: Graduate standing.

ENG MGT 475 Quality Engineering (LEC 3.0)
This course is an examination of the theory and practice of quality engineering with particular emphasis on the work of Genichi Taguchi. The application of the quality loss function, signal to noise ratio and orthogonal arrays is considered in depth for generic technology development; system, product and tolerance design; and manufacturing process design. The emphasis of the course is off-line quality control. Prerequisites: Eng Mgt 375 and Math 229 or equivalent.

ENG MGT 476 Advanced Engineering Management Science (LEC 3.0)
Solving of managerial problems utilizing management science techniques. Problems are analyzed, modeled and solved using such techniques as linear, goal, dynamic, programming, simulation, statistical analysis or other non-linear methods. Solutions will involve the use of personal or mainframe computers. A study of the current literature in management science will also be conducted. Prerequisite: Eng Mgt 382 or graduate standing.

ENG MGT 477 Tolerance Design (LEC 3.0)
This course is an examination of the theory and practice of allowance allocation for high quality and low cost manufacture of mass-produced consumer products, including technology intensive products, such as automobiles, trucks, military and commercial airplanes, computers and consumer electronics. Prerequisite: Eng Mgt 375 or equivalent.

ENG MGT 480 Investment (LEC 3.0)
An introduction to the theory and practice of investment, including financial markets and instruments, security trading, mutual funds, investment banking, interest rates, risk premiums, the capital asset pricing model, arbitrage pricing theory, market efficiency, bonds and the fixed income market, equity valuation, fundamental and technical analysis. Prerequisite: Eng Mgt 137 or 308. (Co-listed with Sys Eng 480).

ENG MGT 481 Financial Engineering (LEC 3.0)
An introduction to financial engineering, with an emphasis on financial derivatives, including the future markets, the pricing of forwards and futures, forward rate agreements, interest and exchange rate futures, swaps, the options markets, option strategies, the binomial and Black-Scholes models for option valuation, the option Greeks, and volatility smiles. Prerequisites: Eng Mgt 137 or 308. (Co-listed with Sys Eng 481).

ENG MGT 482 Financial Engineering II (LEC 3.0)
This course introduces advanced topics in financial engineering, which includes introduction to Wiener processes, martingales and Itô’s lemma; basic numerical methods for options pricing, exotic options; interest rate models; stochastic volatility models and jump-diffusion models; and value-at-risk. Prerequisite: Eng Mgt/Sys Eng 481. (Co-listed with Sys Eng 482).

ENG MGT 489 Advanced Research Methodology in Engineering Management (LEC 3.0)
An advanced study of research methodology techniques and theories in conducting research activities. The research problems, hypotheses, literature search, data requirements and analyses, interpretation and presentation of results are examined. Prerequisite: Graduate standing.

ENG MGT 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.
**ENG MGT 493 Oral Examination** (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or facilities. In no case shall this be for less than three (3) semester hours for resident students.

**ENG MGT 495 Continuous Registration** (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

## Environmental Engineering (ENV ENG)

**ENV ENG 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department.

**ENV ENG 301 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**ENV ENG 360 Environmental Law And Regulations** (LEC 3.0)
This course provides comprehensive coverage of environmental laws and regulations dealing with air, water, wastewater, and other media. The primary focus is permitting, reporting, and compliance protocols. The course topics include national and international legal systems and judicial processes, liability, enforcement, Clean Air Act, Clean Water Act (NPDES) permitting, Safe Drinking Water Act, OSHA, TSCA, RCRA, and CERCLA. Case studies will be emphasized. (Co-listed with Civ Eng 360).

**ENV ENG 361 Remediation Of Contaminated Groundwater And Soil** (LEC 2.0 and LAB 1.0)
Course covers current in-situ and ex-situ remediation technologies. Current literature and case studies are utilized to provide the focus for class discussions and projects. Prerequisites: Civ Eng 265, Geo Eng 337 or Graduate Standing. (Co-listed with Civ Eng 361).

**ENV ENG 362 Public Health Engineering** (LEC 3.0)
A comprehensive course dealing with the environmental aspects of public health. Prerequisite: Civ Eng 261 with grade of "C" or better. (Co-listed with Civ Eng 362).

**ENV ENG 363 Solid Waste Management** (LEC 3.0)
A systematic study of the sources, amounts and characteristics of solid wastes and methods used for their collection, reclamation, and ultimate disposal. Prerequisite: Civ Eng 261 with grade of "C" or better; or graduate standing. (Co-listed with Civ Eng 363).

**ENV ENG 364 Environmental Systems Modeling** (LEC 3.0)
Introductory course in modeling environmental systems. Course will focus on contaminant fate and transport in the environment. Models will be developed that will include physical, chemical and biological reactions and processes that impact this fate. Prerequisites: Env Eng/Civ Eng 261, Env Eng/Civ Eng 262 and Env Eng/Civ Eng 263; or Graduate standing. (Co-listed with Civ Eng 364).

**ENV ENG 365 Sustainability, Population, Energy, Water, and Materials** (LEC 3.0)
This course will examine the concepts regarding the continued advancement of humankind while maintaining our ecological niche on earth. Key topics include: population growth, poverty, and impacts of development; energy consumption, sources, storage, conservation and policy; water quality and quantity; materials and building; and policy implications. Prerequisite: Senior or graduate standing. (Co-listed with Civ Eng 365 and Arch Eng 365).

**ENV ENG 366 Indoor Air Pollution** (LEC 3.0)
By developing a practical understanding of indoor air pollution sources, physics, chemistry and consequences, students will learn how radon, cigarette smoke, VOCs from furnishings, and so forth affect indoor air quality and apply engineering analyses to specify ventilation rates, choose furnishings and minimize occupant exposure to pollutants. Prerequisite: Civ Eng 261 or Mech Eng 371 or Graduate Status. (Co-listed with Civ Eng 366 and Arch Eng 366).

**ENV ENG 367 Introduction To Air Pollution** (LEC 3.0)
Introduction to the field of air pollution dealing with sources, effects, federal legislation, transport and dispersion and principles of engineering control. Prerequisite: Civ Eng 230 or equivalent; or graduate standing. (Co-listed with Civ Eng 367).

**ENV ENG 368 Air Pollution Control Methods** (LEC 3.0)
Study of the design principles and application of the state-of-the-art control techniques to gaseous and particulate emissions from fossil fuel combustion, industrial and transportation sources. Prerequisite: Civ Eng 230 or equivalent; or graduate standing. (Co-listed with Civ Eng 368).

**ENV ENG 369 Environmental Engineering Design** (LAB 1.0 and LEC 2.0)
Functional design of water and wastewater facilities and other environmental cleanup systems. Prerequisite: Civ Eng 265 or Env Eng 265. (Co-listed with Civ Eng 369).

**ENV ENG 380 Water Resources And Wastewater Engineering** (LEC 3.0)
Application of engineering principles to the planning and design of multipurpose projects involving water resources development and wastewater collection/treatment/disposal systems. Latest concepts in engineering analysis are applied to evaluation of alternative solutions. Prerequisites: Civ Eng 233, 235, 265. (Co-listed with Civ Eng 380).

**ENV ENG 382 Teaching Engineering** (LEC 3.0)
Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Eng Mgt 370, Comp Eng 382, Elec Eng 382, Civ Eng 382).

**ENV ENG 390 Undergraduate Research** (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

**ENV ENG 400 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of the instructor required.

**ENV ENG 401 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.
ENV ENG 410 Seminar (IND 0.0)
Discussion of current topics.

ENV ENG 460 Chemical Principles In Environmental Engineering (LEC 3.0)
The course develops fundamental chemical and physical principles underlying environmental engineering systems including drinking water, groundwater, and wastewater treatment; and natural environmental processes. Topics include adsorption, complex formation, acid-base equilibria, solubility, mass transfer and diffusion, electrochemistry, and chemical kinetics. Prerequisite: Graduate Standing. (Co-listed with Civ Eng 460).

ENV ENG 461 Biological Principles In Environmental Engineering Systems (LEC 2.0 and LAB 1.0)
Course covers the fundamental biological and biochemical principles involved in natural and engineered biological systems. (Co-listed with Civ Eng 461).

ENV ENG 462 Physicochemical Operations In Environmental Engineering Systems (LEC 3.0)
Course covers physicochemical operations and design in water, wastewater and aqueous hazardous waste treatment systems including coagulation, precipitation, sedimentation, filtration, gas transfer, chemical oxidation and disinfection, adsorption, ion exchange. Prerequisite: Civ Eng 230 or equivalent. (Co-listed with Civ Eng 462 and Chem Eng 470).

ENV ENG 463 Biological Operations In Environmental Engineering Systems (LEC 3.0)
Course covers biological operations and design in water, wastewater and aqueous hazardous waste treatment systems including modeling of biological treatment processes; and design of activated sludge systems, trickling filters, rotating biological contractors, lagoons, nitrification and denitrification, and digestion process. Prerequisite: Civ Eng 230 or equivalent. (Co-listed with Civ Eng 463).

ENV ENG 464 Industrial And Hazardous Waste Treatment (LAB 1.0 and LEC 2.0)
Course covers fundamentals of industrial and hazardous wastewater treatment systems and characterization including physical, chemical and biological processes and laboratory pilot plant investigations. (Co-listed with Civ Eng 464).

ENV ENG 465 Environmental Engineering Analysis Laboratory (LEC 1.0 and LAB 2.0)
Environmental Engineering analytical principles and techniques applied to the quantitative measurement of water, wastewater and natural characteristics, and application of advanced instrumentation methods in Environmental Engineering. Prerequisite: Civ Eng 261 or equivalent, with a grade of "C" or better. (Co-listed with Civ Eng 465).

ENV ENG 467 Environmental Chemistry (LEC 2.0 and LAB 1.0)
This course covers the fundamental and applied aspects of environmental chemistry including inorganic, organic, and analytical chemical principles. The course emphasizes the aquatic environmental and covers gas laws and solubility, chemical modeling, equilibria, acid-base and complexation relationships, oxidation and photochemical reactions. Prerequisite: Graduate standing in engineering or science curricula. (Co-listed with Civ Eng 467).

ENV ENG 485 Philosophy of Scientific Research (LEC 3.0)
Organization and planning of research. Introduction to the philosophy and management of scientific research, particularly issues related to ethics, plagiarism, ownership of intellectual properties, research techniques, technical presentations and time management. The course will address these issues by integrating with case studies. (Co-listed with Chem Eng 425, IDE 425, Civ Eng 485, Elec Eng 481, Comp Eng 481).

ENV ENG 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Prerequisite: Consent of instructor.

ENV ENG 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**Explosives Engineering (EXP ENG)**

EXP ENG 301 Special Topics (LEC 1.0 and LAB 2.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

EXP ENG 305 Explosives Handling And Safety (LEC 3.0)
Basic handling & safety for explosives, explosive devices and ordnance related to laboratory handling, testing, manufacturing & storage, for both civil and defense applications.

EXP ENG 307 Principles Of Explosives Engineering (LAB 1.0 and LEC 2.0)
Theory and application of explosives in the mining industry; explosives, initiating systems, characteristics of explosive reactions and rock breakage, fundamentals of blast design, drilling and blasting, regulatory and safety considerations. Prerequisites: Min Eng 151; accompanied or preceded by Civ Eng 215 or Geology 220 or Geology 125; Successful background check. (Co-listed with Min Eng 307).

EXP ENG 309 Commercial Pyrotechnics Operations (LEC 2.0 and LAB 1.0)
Provide participants with training preparing for Missouri Licensed Display Operator (Outdoor) License and advanced lead pyrotechnic operator training. Class work will be complemented by practical training in laboratory sessions, culminating in a full pyrotechnic show, from start to finish. Prerequisites: Both Chem 1 and Chem 2 or their equivalent; US Citizen or permanent resident, Successful background check, resident enrollment at Missouri S&T.

EXP ENG 313 Stage Pyrotechnics and Special Effects (LEC 1.0 and LAB 2.0)
Use of energetic materials in close proximity to audiences. Provide participants with training preparing for Missouri Pyrotechnics Display Operators License. Covers: close proximity indoor and outdoor pyrotechnics and special effects. Working with stage crews and talent, safety and permitting. Prerequisites: Both Chem 1 and Chem 2 or their equivalent; US Citizen or permanent resident, Successful background check, resident enrollment at Missouri S&T.
EXP ENG 350 Blasting Design And Technology (LEC 2.0 and LAB 1.0)
Advanced theory and application of explosives in excavation; detailed underground blast design; specialized blasting including blast casting, construction and pre-splitting. Introduction to blasting research. Examination of field applications. Prerequisites: Min Eng 307. Student must be at least 21 years of age. Successful background check. (Co-listed with Min Eng 350).

EXP ENG 351 Demolition of Buildings and Structures (LEC 2.0 and LAB 1.0)
Provide participants with basics and solid grounding in the equipment, techniques and processes required for the demolition and remediation of mine plant and processing equipment sites and non-mining structures such as buildings, factories, bridges, etc. Field trip required. Prerequisites: Preceded or accompanied by Civ Eng 50 or IDE 140; US citizen or permanent resident; Successful background check.

EXP ENG 400 Special Problems (IND 1.0-3.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

EXP ENG 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

EXP ENG 402 Environmental Controls For Blasting (LEC 2.0 and LAB 1.0)
Advanced blast mechanics; overbreak control including comprehensive coverage of perimeter and smoothwall specialist blasting techniques and geotechnical factors affecting blast vibration, limits analysis monitoring and control; air blast control including limits, monitoring and atmospheric and topographic effects. Prerequisites: Min Eng 307, Successful background check. (Co-listed with Min Eng 402).

EXP ENG 406 Scientific Instrumentation For Explosives Testing & Blasting (LEC 1.0 and LAB 2.0)
Application of scientific principles, equipment description and operation for instrumentation of explosive events including blasting. Topics: Blast chamber design, set up, high-speed photography, motion detection and measurement, explosives sensitivity testing, explosives properties testing, vibration measurement & analysis, destruction & demilitarization. Prerequisite: Exp Eng 307 and Successful background check.

EXP ENG 407 Theory Of High Explosives (LEC 3.0)
Study of the application of chemical thermodynamics and the hydrodynamic theory to determine the properties of high explosives; application of detonation theory to steady-state detonations in real explosives; application of the above to the blasting action of explosives. Prerequisite: Successful background check and Graduate Standing. (Co-listed with Min Eng 407).

EXP ENG 408 Explosives Regulations (LEC 3.0)
Comprehensive coverage of the federal regulations governing the explosives industry, including those governing storage of explosives (ATF), transportation of explosives (DOT and TSA), the environment (EPA) and use of explosives (OSM, MSHA and OSHA). Prerequisite: Graduate standing.

EXP ENG 490 Research (IND 1.0-6.0)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

EXP ENG 497 Graduate Cooperative Experience (LAB 3.0)
Students on an approved internship will complete a project designed by the advisor and employer. The project selected must require that student apply critical thinking skills and discipline specific knowledge in the work setting. A major report and a formal presentation are required. Prerequisite: 12 hours Exp Eng coursework.

EXP ENG 498 Industry Project (LAB 3.0)
Students who are currently employed may complete a project in their work setting designed by the advisor and employer. The project selected must require that student apply critical thinking skills and discipline specific knowledge. A major report and a formal presentation are required. Prerequisite: 12 hours Exp Eng coursework.

Geological Engineering (GEO ENG)

GEO ENG 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

GEO ENG 301 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

GEO ENG 310 Seminar (RSD 0.50)
Discussion of current topics. (Course cannot be used for graduate credit). Prerequisite: Senior standing. (Co-listed with Geology 310, Pet Eng 310).

GEO ENG 311 Introduction to International Engineering and Design Lab (LAB 1.0)
The lab for multi-disciplinary design will be as follows: Students will develop a work plan to address design objectives and other considerations including scheduling, budgeting, environmental impacts, and life cycle design. Prerequisites: Senior standing, instructor approval, accompanied by Geo Eng 345.

GEO ENG 315 Geostatistical Methods in Engineering and Geology (LEC 3.0)
Study of statistical methods in engineering and geological applications including site investigations and environmental data analyses. Introduction to spatial correlation analysis and geostatistical techniques such as kriging for resource evaluation and estimation.

GEO ENG 331 Subsurface Hydrology (LEC 3.0)
Introduction to the theory and engineering concepts of the movement of subsurface fluids. Properties of water and other subsurface fluids. Hydraulic characteristics of earth materials. Engineering problems related to subsurface fluids. Prerequisites: Geo Eng 50, Math 204.

GEO ENG 333 Risk Assessment In Environmental Studies (LEC 3.0)
This course will present the concepts required to assess the human health and environmental risks resulting from contaminants in soil and groundwater. Course topics include evaluation of data sets, exposure calculation, chemical fate and transport, and development of conceptual site models.

GEO ENG 335 Environmental Geological Engineering (LEC 3.0)
Introduction to engineering geologic mapping for site selection for solid waste disposal facilities; landfill site selection, design, permitting, construction, operation, and closeout/reclamation. Prerequisites: Geo Eng 275, accompanied or preceded by Civ Eng 215.
GEO ENG 336 Geophysical Field Methods (LAB 1.0 and LEC 2.0)
Imaging of selected subsurface features and engineering structures using various geophysical tools. Special emphasis is placed on ground penetrating radar and surface wave techniques. One field trip at student expense required. Prerequisite: Junior level standing or higher. (Co-listed with Geophys 336).

GEO ENG 337 Geological Aspects Of Hazardous Waste Management (LEC 3.0)
Nature and classification of hazardous wastes; federal and state regulation for treatment and disposal; geological characterization of facility sites; design of impoundments, storage and containment facilities; ground water monitoring and protection; site permitting and licensing planning. Prerequisite: Geo Eng 275.

GEO ENG 339 Groundwater Remediation (LEC 3.0)
A survey of conventional and innovative techniques for remediation of contaminated groundwater. Topics include groundwater cleanup standards, physico-chemical properties of groundwater and contaminants, fate and transport of contaminants in the subsurface, hydrogeologic site characterization, and selection process of a remedial technology. Various computer programs developed to assist in preliminary selection and design of remediation technologies will be used. Prerequisite: Geo Eng 331.

GEO ENG 341 Engineering Geology And Geotechnics (LEC 3.0)
Study of procedures and techniques used to evaluate geologic factors for site selection and the design of engineered structures. Prerequisite: Geo Eng 275.

GEO ENG 342 Military Geology (LEC 3.0)
This course will familiarize geologists, geophysicists, civil and geological engineers with the fundamental principles of physical geology, geohydrology and geomorphology as applied to military problems, such as development of fortifications, core infrastructure, water resources and combat engineering requirements. Prerequisite: Geo Eng 275 or graduate standing.

GEO ENG 343 Subsurface Exploration (LAB 1.0 and LEC 2.0)
Lectures and field and laboratory exercises in the use of geologic and geophysical techniques for evaluation of subsurface geology and resources. Prerequisite: Civ Eng 215 or Pet Eng 131.

GEO ENG 344 Remote Sensing Technology (LEC 2.0 and LAB 1.0)
Principles of digital image processing including image enhancement and multispectral classification. Emphasis upon design and implementation of remote sensing systems and analysis of remotely sensed data for geotechnical and environmental investigations. Prerequisite: Geo Eng 248. (Co-listed with Geology 344).

GEO ENG 346 Applications Of Geographic Information Systems (LAB 1.0 and LEC 2.0)
Applications of Geographical Information Systems and remote sensing to environmental monitoring, mineral resource exploration, and geotechnical site evaluation. Prerequisite: Geo Eng 275 or consent of instructor. (Co-listed with Geology 346).

GEO ENG 347 Introduction to International Engineering and Design (LEC 2.0)
A multi-disciplinary design course focused on sustainable design and technology transfer to developing countries. Students will develop a work plan to address design objectives and other considerations including scheduling, budgeting, environmental impacts, and life cycle design. Prerequisites: Senior standing, instructor approval, accompanied by Geo Eng 311.

GEO ENG 350 Geological Engineering Design (LAB 1.0 and LEC 2.0)
Geological engineering design is an open-ended project course requiring the collection of data, analysis and synthesis of that data and design of a socially acceptable, economical solution to the selected problem. Oral and written reports are required. Prerequisite: To be taken in the semester before graduation.

GEO ENG 352 International Engineering and Design (LEC 3.0)
A multi-disciplinary engineering course focused on sustainable design and technology transfer to developing countries. Course includes elements of traditional capstone design classes. Experiential learning through competitions and/or field work is a major component of the class. Prerequisite: Senior standing, instructor approval. (Co-listed with Met Eng 352 and Cer Eng 352).

GEO ENG 353 Regional Geological Engineering Problems In North America (LEC 3.0)
A physiographic approach to engineering materials and problems. Course emphasizes the distribution and engineering characteristics of soil and rock to construction and site problems and includes aggregates, foundations, excavations, surface and ground water, slope stability and arctic conditions.

GEO ENG 356 Renewable Energy Systems (LEC 3.0)
Introduction to the theory and performance prediction of typical renewable energy systems such as, but not limited to, those based on energy from the sun, wind and water, and geothermal. The use of environmental data, including stochastic modeling, for renewable energy system (including wind turbine, photovoltaic, and geothermal) design is addressed. Prerequisites: Math 204, Physics 24, and preceded or accompanied by Stat 217 or Geo Eng 315. Junior or senior status is required.

GEO ENG 361 Transportation Applications of Geophysics (LAB 1.0 and LEC 2.0)
Overview of geophysical and non-destructive test methods that are commonly used to investigate transportation structures and their foundations. Emphasis is placed on bridge system substructure, bridge system superstructure, pavement, roadway subsidence, subsurface characterization and vibration measurements. Prerequisite: Junior level standing or higher. (Co-listed with Geophys 361 and Civ Eng 351).

GEO ENG 371 Rock Engineering (LEC 3.0)
Data requirements for design; engineering properties of rock; characterization of fractures and rock masses; stereonet analysis of discontinuities; graphic analysis of failure; ground stress distribution; tunnel construction methods; ground support principles; selection of tunneling equipment; and specifications for underground construction. Prerequisite: Geo Eng 275.

GEO ENG 372 Soil Science In Engineering Practice (LEC 3.0)
A study of the ways in which soils and geologic conditions influence engineered projects. Soil formation, soil chemistry and properties to include composition, organic component, ion exchange and water relationships as well as erosion control and revegetation will be covered. Prerequisite: Geo Eng 275.

GEO ENG 373 Geologic Field Methods (LAB 3.0)
Field practice in geologic mapping and interpretation in the Western United States using topographic base maps and aerial photos. Emphasizes the description and interpretation of stratigraphic sections, sedimentary and tectonic structures. Prerequisite: Two courses in either Geology or Geological Engineering.
GEO ENG 374 Geological Engineering Field Methods (LAB 3.0)
Instruction in methods of field investigation required for geological engineering studies. Course will include procedures for qualitative and quantitative data collection for characterizing surficial geologic conditions, groundwater and surface water investigations, and other engineering activities. Written reports and field trip required.

GEO ENG 375 Aggregates And Quarrying (LEC 3.0)

GEO ENG 376 Environmental Aspects Of Mining (LEC 3.0)
Permitting; the legal environment of reclamation and environmental impact assessment; post-mining land-use selection and mine planning for optimum reclamation of all mines: metal, nonmetal, and coal; unit operations of reclamation; drainage, backfill, soil replacement, revegetation, maintenance, etc. Prerequisites: Geo Eng 50; Min Eng 324 and 326 or prereq/coreq. Civ Eng 215. (Co-listed with Min Eng 376).

GEO ENG 381 Intermediate Subsurface Hydrology And Contaminant Transport Mechs (LEC 3.0)
A study of the physical/chemical properties of rocks and sediments in the subsurface environment. Emphasis is put on waterrock properties such as permeability, capillarity, and mechanical dispersion. Both microscopic and macroscopic approaches are used. Prerequisites: Civ Eng 230 & Geo Eng 331.

GEO ENG 382 Environmental And Engineering Geophysics (LAB 1.0 and LEC 2.0)
An introduction to the theory and application of the gravity, magnetic, resistivity, self-potential, induced polarization and electromagnetic methods as applied to the solution of engineering and environmental problems. Prerequisite: Math 22. (Co-listed with Geophys 382).

GEO ENG 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

GEO ENG 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

GEO ENG 401 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

GEO ENG 410 Seminar (RSD 1.0)
Discussion of current topics. Prerequisite: Graduate student.

GEO ENG 425 Applications in Geological Engineering (LEC 3.0)
Content is focused on practical aspects of geological engineering. Geotechnical, environmental and geohydrologic case studies are presented to illustrate concepts and relate theory to applications.

GEO ENG 431 Advanced Subsurface Hydrology (LEC 3.0)
Advanced treatment of selected topics in subsurface hydrology, including groundwater contamination, contaminant transport, land disposal of wastes, aquifer test analysis, injection well technology, etc. Applied hydrogeologic site analysis and flow and transport modeling through solution of selected case examples. Prerequisite: Geo Eng 331 or equivalent.

GEO ENG 432 Numerical Methods In Subsurface Flow (LEC 3.0)
Development of governing balance equations, constitutive laws and mathematical models of groundwater flow and contaminant transport in porous media. Solution of mathematical models by finite difference and finite element methods for various boundary and initial conditions. Prerequisites: Geo Eng 331, Comp Sci 73.

GEO ENG 435 Advanced Concepts Of Environmental Geological Engineering (LEC 3.0)
Application of the principles of geology to the solution of engineering problems in environmental protection and remediation. Topics will include the study of geologic processes and the evaluation of geologic materials as they affect the potential for groundwater contamination, susceptibility of soils to erosion, characterization of the geologic environment for site suitability and the analysis of the criteria necessary for the selection of technologies for minimizing environmental impact. Prerequisite: Graduate level course in environmental geologic studies.

GEO ENG 441 Geotechnical Construction Practice (LEC 3.0)
Advanced level lecture topics on procedures used for site characterization, standards for earthquake grading and construction, including embankments, building pads, retention structures, roads, levees, and earthen dams. Specific emphasis on preparation of documents involved in such work and engineer’s responsibilities. Prerequisite: Geo Eng 341.

GEO ENG 446 Advanced Remote Sensing And Image Processing (LEC 2.0 and LAB 1.0)
Quantitative methods of utilizing remote sensing technology for terrain analysis. Digital image processing of landsat and/or aircraft scanner data for mineral resource studies and geological engineering applications. Prerequisite: Geo Eng 346. (Co-listed with Geology 446).

GEO ENG 477 Discontinuous Rock (LEC 3.0)
Nature and properties of discontinuous rock masses, genesis and properties of joints, role of joints in rock shear strength, slope of stability of jointed rock, fracture flow hydrogeology. Modeling of the mechanical behavior of fractured rock. Prerequisite: Min Eng 331 or Geo Eng 371.

GEO ENG 482 Surface Waves (MASW) and Ground Penetrating Radar (GPR) (LAB 1.0 and LEC 2.0)
Geological engineering applications of surface wave and ground penetrating radar methods are emphasized. Field data will be acquired, processed and interpreted. Prerequisites: Geo Eng 50 or Civ Eng 215 or equivalent, and graduate standing.

GEO ENG 484 Advanced Engineering And Environmental Geophysics (LEC 3.0)
An introduction to the theory and application of the gravity, magnetic, resistivity, self-potential induced polarization, seismic, electromagnetic and GPR methods as applied to the solution of engineering and environmental problems. Prerequisite: Admission into USAES-S&T Co-operative Degree Program. (Co-listed with Geophys 484).

GEO ENG 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.
**GEO ENG 491 Internship** (IND 0.0-15)
Students working toward a doctor of engineering degree will select, with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

**GEO ENG 493 Oral Examination** (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/ comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**GEO ENG 495 Continuous Registration** (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

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**Geology (GEOLOGY)**

**GEOLOGY 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**GEOLOGY 301 Special Topics** (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**GEOLOGY 305 Hydrogeology** (LEC 3.0)
This course discusses geologic aspects of major surface and subsurface hydrologic systems of North America. Chemical and physical relationships between groundwater and fractures, faults, karst, subsurface pressures, mineral deposits plus both contaminant and hydrocarbon migration are discussed. Prerequisites: Geo Eng 50 or Geology 51, Geology 223 recommended.

**GEOLOGY 307 Physical Oceanography** (LEC 3.0)
An introduction to the study of the physical and geological processes in the world’s oceans including the importance of the oceans to the environment and to life on Earth. Prerequisite: Geology 325 or equivalent.

**GEOLOGY 308 Astronomy and Planetary Science** (LEC 3.0)
Basic principles of astronomy, the origin and evolution of the universe, stellar evolution, and the origin, composition, and processes operating on the planetary bodies in the solar system (besides the Earth). Prerequisite: Entrance requirements for the MST program in Earth Science.

**GEOLOGY 309 Meteorology and Climatology** (LEC 3.0)
An introduction to the atmospheric and climatic systems of the Earth including weather, paleoclimatology, and global climate change. Prerequisite: Geology 325 or equivalent.

**GEOLOGY 310 Seminar** (RSD 0.0-6.0)
Discussion of current topics. Required for two semesters during senior year. (Course cannot be used for graduate credit). Prerequisite: Senior standing. (Co-listed with Geo Eng 310, Pet Eng 310).

**GEOLOGY 312 Ore Microscopy** (LEC 1.0 and LAB 2.0)
A study of polished sections of minerals and ores under reflected light. Includes the preparation of polished sections, the identification of ore minerals, and the study of the textures, associations, and alterations of ore minerals. Prerequisite: Geology 113.

**GEOLOGY 320 Advanced Structural Geology** (LAB 1.0 and LEC 2.0)
The course provides theoretical background, analytical techniques, and hands-on experience for analyzing geologic structures at a variety of scales hand sample to global. Prerequisites: Geology 220, Geophys 381.

**GEOLOGY 324 Advanced Stratigraphy And Basin Evolution** (LEC 3.0)
Advanced topics in sedimentary geology including: tectonic controls on sedimentary basin development, global stratigraphy, regional facies and diagenetic patterns, basin hydrogeology, thermal evolution of basins and distribution of economic resources. Prerequisites: Geology 223, 220, preceded or accompanied by Geology 275 recommended.

**GEOLOGY 326 Advanced Historical Geology** (LEC 2.0 and LAB 1.0)
Study of the physical and biological history of the Earth beginning with the origin of the solar system up to the present. Emphasis will be placed on processes that shaped the Earth and its ecosystems. Prerequisite: Entrance requirements for the MST program in Earth Science.

**GEOLOGY 329 Micropaleontology** (LEC 2.0 and LAB 1.0)
Introduction to the preparation and study of microscopic fossils. Prerequisite: Geology 227.

**GEOLOGY 330 Granites And Rhyolites** (LEC 3.0 and LAB 1.0)
Processes governing the generation and crystallization of felsic magma will be covered, with specific reference to: 1) crust vs mantle sources, 2) melt migration and emplacement, 3) magma chamber dynamics, 4) the volcanic-plutonic connection, and 5) the relationship to tectonic setting. A field trip at the student’s expense is required. Prerequisite: Geology 130.

**GEOLOGY 332 Depositional Systems** (LEC 3.0)
Development of three dimensional depositional models using Walther’s Law, Walther’s Warning and seismic stratigraphy. Emphasis on overall geometries and internal porosity and permeability characteristics of aquifers and hydrocarbon reservoirs. Includes 3-D models for clastic, carbonate and evaporate sequences. Prerequisite: Geology 51 or Geo Eng 50.

**GEOLOGY 333 Advanced Igneous and Metamorphic Petrology** (LAB 1.0 and LEC 3.0)
Processes governing the formation of igneous and metamorphic rocks as constrained by geochemical, isotopic, and thermodynamic data, with particular reference to the relationship between rock suites and tectonic setting. The laboratory will emphasize the description of rock suites in hand sample and thin section. A field trip at the student’s expense is required. Prerequisite: Geology 130.

**GEOLOGY 338 Computer Mapping In Geology** (LEC 2.0 and LAB 1.0)
This course introduces the basics of both surface and subsurface geologic mapping. It introduces procedures and problems associated with digitizing, gridding, contouring, volumetrics and generation of three dimensional diagrams on the PC. Integration of field gathered data with USGS and GSI databases for the purpose of making surface geologic maps is also included. Prerequisite: Geology 51.

**GEOLOGY 340 Petroleum Geology** (LEC 2.0 and LAB 1.0)
Principles of origin, migration, and accumulation of oil and gas. The laboratory introduces the procedures used for exploration, and development of hydrocarbon resources. Prerequisite: Geology 51 or Geo Eng 50 (Introductory Geology course).
GEON 341 Applied Petroleum Geology (LEC 1.0 and LAB 2.0)
The principles of petroleum geology are applied in solving hydrocarbon exploration and development problems. Geological and economical techniques for evaluating hydrocarbon-bearing reservoirs are presented, with methods for decisionmaking under conditions of extreme uncertainty. Prerequisite: Geology 340.

GEON 344 Remote Sensing Technology (LAB 1.0 and LEC 2.0)
Principles of digital image processing including image enhancement and multispectral classification. Emphasis upon design and implementation of remote sensing systems and analysis of remotely sensed data for geotechnical and environmental investigations. Prerequisite: Geo Eng 248. (Co-listed with Geo Eng 344).

GEON 345 Radioactive Waste Management And Remediation (LEC 3.0)
Sources and classes of radioactive waste, long-term decay, spent fuel storage, transport, disposal options, regulatory control, materials issues, site selection and geologic characterization, containment, design and monitoring requirements, domestic and foreign waste disposal programs, economic and environmental issues; history of disposal actions, and conduct of remedial actions and cleanup. Prerequisite: Math 204. (Co-listed with Nuc Eng 345).

GEON 346 Applications Of Geographic Information Systems (LAB 1.0 and LEC 2.0)
Applications of Geographical Information Systems and remote sensing to environmental monitoring, mineral resource exploration, and geotechnical site evaluation. Prerequisite: Geo Eng 275 or consent of instructor. (Co-listed with Geo Eng 346).

GEON 350 Paleoclimatology and Paleoclimates (LEC 3.0)
This course will introduce students to the elements of climate, evidence of climate changes, proxy measurements and paleoclimate models. There is a review of Holocene climates and Archean to Pleistocene paleoclimates. Prerequisite: Geology 52.

GEON 360 Methods Of Karst Hydrogeology (LEC 3.0)
Familiarize geoscientists with the origin and identification of karst features, discuss groundwater movement, engineering problems, water quality and supply in karst areas, and teach investigative techniques including fluorescent dye tracing. Several field trips at student expense will be required. Prerequisite: Geology 51 or Geo Eng 50; Geology 223.

GEON 372 Geological Field Studies (LEC 3.0)
Intensive review of the scientific literature corresponding to a selected geographical region of geologic interest; followed by a 7 to 10 day long field trip to be held over spring break or after the end of the semester. Students will be expected to bear a portion of the field trip expenses. Repeatable for credit. Prerequisites: Geology 51 or Geo Eng 50.

GEON 373 Field Geology (LAB 3.0)
Field practice in geologic mapping and interpretation in the Western United States using topographic base maps and aerial photos. Emphasizes the description and interpretation of stratigraphic sections, sedimentary and tectonic structures. Prerequisite: Two Geology courses.

GEON 374 Advanced Field Geology (LAB 3.0)
Detailed field work in areas related to the projects of Geology 373. Courses to be taken the same summer. A written report on the full summer’s projects is required. Prerequisite: Geology 373.

GEON 375 Applied Geochemistry (LEC 2.0 and LAB 1.0)
Application of the principles of geochemistry and techniques of geochemical analysis in a student research project investigating geochemical processes (mineral deposits, environmental geochemistry, trace element migration, or water-rock interaction). Field trip fee required. Prerequisites: Geology 113 and Geology 275.

GEON 376 Aqueous Geochemistry (LEC 3.0)
Studies of the interaction of water with minerals and organic materials at low temperatures; including processes affecting the migration of elements (alteration, precipitation, and adsorption), the influence of geochemical processes on water composition, weathering, soil formation, and pollution. Field trip fee required. Prerequisite: Geology 275.

GEON 377 Isotope Geochemistry (LAB 1.0 and LEC 2.0)
Introduction to the fundamentals of radiogenic and stable isotopes as used to understand geologic processes. The use of selected isotopic systems in petrology, ore petrogenesis, paleontology, and the global climate systems will be discussed. Prerequisites: Geology 130, 223, 275.

GEON 383 Electrical Methods In Geophysics (LEC 3.0)
The theory and instrumentation for measurements of the electrical properties of the earth. Includes passive and active techniques, the advantages and disadvantages of the various techniques, and geologic interpretations of electrical soundings. Several weekends are spent making a variety of electrical surveys of local features. Prerequisites: Math 325 and Geophys 321.

GEON 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

GEON 394 Coal Petrology (LEC 3.0)
Formation, composition, and properties of coals. Discussion of the geology of selected coal deposits, the analysis of coal, and the optical identification of coal minerals. Prerequisite: Permission of instructor.

GEON 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

GEON 401 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

GEON 405 Geology of Natural Resources (LEC 3.0)
The origin and distribution of economically important natural resources including soils, water resources, metals, non-metals, building materials, petroleum, and other energy resources. Prerequisites: Geology 325 and 326 or equivalents.

GEON 407 Environmental Geology (LEC 3.0)
Overview of environmental problems facing humans. Emphasis will be placed on surface and groundwater pollution, geological hazards, and pressures on Earth’s ecosystems and natural resources by urbanization and population growth. Prerequisites: Geology 325 and 326 or equivalents.

GEON 410 Seminar (RSD 0.0-6.0)
Discussion of current topics.
GEOLOGY 412 Advanced Ore Microscopy (LAB 2.0 and LEC 1.0)
A study of ore suites utilizing various advanced, quantitative ore microscopy techniques including hardness, spectral reflectance, indentation, color, rotation property measurements, fluid inclusion geothermometry, and salinity measurements. Laboratory study includes demonstration and operation of the luminoscope and other microbeam techniques. Prerequisite: Geology 312.

GEOLOGY 413 Clay Mineralogy (LEC 2.0 and LAB 1.0)
Mineral structure, geochemical properties, occurrence, environment, and uses of clays. Determination of physical properties, optics, x-ray diffraction, and thermal features of clays. Field trip fee required. Prerequisites: Geology 113 and 275, or Chem 237, or Civ Eng 315, or Geo Eng 372.

GEOLOGY 420 Analytical Structural Geology (LAB 1.0 and LEC 2.0)
The course provides theoretical background, analytical techniques, and hands-on experience, for quantifying processes that lead to the formation and evolution of rocks and structures produced as a result of deformation at a variety of scales - hand sample to global. Poster and oral presentations, and a research paper required. Prerequisites: Geology 220, Geophys 381.

GEOLOGY 423 Sedimentary Basin Analysis (LEC 3.0)
An advanced study of stratigraphic, diagenetic and tectonic processes in sedimentary basins. Prerequisites: Geology 220, 223, 275 or 375 or 376.

GEOLOGY 425 Advanced Physical Geology (LEC 3.0)
Examination of topics concerned with the physical properties of earth materials, processes affecting change of the surface and interior of the earth, and the driving forces causing these changes. Weekly critical assessment of literature, and an oral presentation and term paper required. Prerequisite: Consent of instructor.

GEOLOGY 431 Clastic Sedimentary Petrology (LEC 2.0 and LAB 1.0)
Petrology and petrography of clastic sedimentary rocks. Emphasis on origin, diagenesis and description of clastic, sedimentary rocks. Prerequisite: Geology 223.

GEOLOGY 432 Carbonate Petrology (LAB 1.0 and LEC 2.0)
Petrology, chemistry and sedimentology of carbonates and other associated chemical sedimentary rocks. Prerequisites: Geology 130, 114, 223 and Chem 3 or equivalent Geology 275 recommended.

GEOLOGY 433 Advanced Igneous Petrology (LAB 1.0 and LEC 2.0)
The genesis of eruptive rocks as evidenced by the physical-chemical conditions of formation of their constituent minerals. A critical examination of various magmatic processes. Use of advanced petrographic techniques. Prerequisite: Geology 234.

GEOLOGY 434 Granite and Rhyolite Petrogenesis (LAB 1.0 and LEC 3.0)
The origin of granites and rhyolites with respect to extreme fractionation, crustal anatexis, magma mixing, and tectonic setting will be explored through critical reading of the literature and examination of hand samples and thin sections from classic geologic terranes. A research paper is required as well as a field trip at the student’s expense. Prerequisite: Geology 130.

GEOLOGY 435 Applied Ore Microscopy (LAB 2.0 and LEC 1.0)
Application of ore microscopic and petrographic techniques to problems in ore beneficiation, pelleting, sintering, smelting, refining, refractories, cement, mining, and exploration. Discussions and laboratories are based upon industrial case histories. Prerequisite: Geology 312.

GEOLOGY 437 Advanced Palynology (LAB 2.0 and LEC 1.0)
Study of the processes of sporopollenin preservation, sedimentation and palynofacies. Major emphasis on independent palynostratigraphic research. Chronicle of Phanerozoic palynology in lectures. Prerequisite: Geology 227 or 329.

GEOLOGY 440 Advanced Geochemistry (LEC 3.0)
A study of the absolute and relative abundance of elements and isotopes in the Earth, principles of element transport, formation of the Earth’s crust, mineral deposits, and soils. Field trip fee required. Prerequisite: Geology 275.

GEOLOGY 443 Advanced Petroleum Geology (LEC 1.0 and LAB 2.0)
Examples of various types of oil and gas accumulation are reviewed in detail. Study of criteria useful in evaluating the petroleum potential of undrilled areas. Special investigation assignment is required. Prerequisite: Geology 340.

GEOLOGY 446 Advanced Remote Sensing And Image Processing (LAB 1.0 and LEC 2.0)
Quantitative methods of utilizing remote sensing technology for terrain analysis. Digital image processing of landseed and/or aircraft scanner data for mineral resource studies and geological engineering applications. Prerequisite: Geo Eng 346. (Co-listed with Geo Eng 446).

GEOLOGY 450 Advanced Paleoclimatology and Paleoecology (LEC 3.0)
Advanced study of paleoclimatic and paleoecologic processes since the Archean, and the interpretation of Holocene climate changes, including human impacts. Extensive presentations and discussions of current ideas and techniques in paleoclimatic studies. Prerequisites: Geology 223 and 227.

GEOLOGY 470 Field and Laboratory Studies in Earth Science (LAB 3.0)
Hands-on laboratory and field experiences in the Earth Sciences. This course is designed to be taught in an intensive three week session during the summer on the S&T campus. Prerequisites: Geology 325 and 326 or equivalents, and at least one additional course in the MST Earth Science program.

GEOLOGY 478 Advanced Isotope Geochemistry (LAB 1.0 and LEC 2.0)
The use of radiogenic and stable isotopes in geology in the study of the evolution of Earth, crust, mantle, and the Solar System as well as applications to geothermometry, ore petrogenesis, paleontology, and the global climate system. Prerequisites: Geology 130, 223, 275.

GEOLOGY 480 Geotectonics (LEC 3.0)
A critical study of the origin, and differentiation of the earth, evolution of the crust, and plate tectonics. Geology of the continents and ocean basins. Regional tectonic analysis of precambrian shields, platforms, orogenic belts, and a review of internal energy sources. Emphasis is on North America. Prerequisite: Geology 220.

GEOLOGY 481 Geodynamics (LEC 3.0)
The applications of continuum physics to geological and petroleum engineering problems. Topics include plate tectonics, stress and strain in solids, elasticity and flexure, heat transfer, gravity, fluid mechanics, rock rheology, faulting, and flow in porous media. Prerequisites: Math 22 and Geology 220. (Co-listed with Pet Eng 481).
GEOLOGY 489 Ore Deposition (LAB 1.0 and LEC 2.0)
An advanced study of mineral deposits, time and space in deposition, theories of deposition and their effect on exploration. Discussions based on maps, logs, and samples from the world’s typical mineral deposits. Two all day field trips at student expense required. Prerequisite: Geology 294.

GEOLOGY 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation.

GEOLOGY 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

GEOLOGY 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Geophysics (GEOPHYS)

GEOPHYS 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

GEOPHYS 301 Special Topics (LAB 1.0 and LEC 2.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

GEOPHYS 320 Computational Geophysics (LAB 2.0 and LEC 1.0)
Scientific programming in a UNIX/Linux environment, with emphasis on solving geophysical problems such as linear and nonlinear inversion, spectral analysis, seismicity, seismic wave attenuation, shear-wave splitting, and seismic tomography. Prerequisite: Geophys 270.

GEOPHYS 321 Potential Field Theory (LEC 3.0)
The mathematics and physics of gravitational, magnetic, and electrical fields of the earth as derived from potential functions, with applications to practical problems. The theorems of Laplace, Poisson, Gauss, and Green and their applications to geophysics are presented. Prerequisite: Accompanied or preceded by Math 325.

GEOPHYS 336 Geophysical Field Methods (LAB 1.0 and LEC 2.0)
Imaging of selected subsurface features and engineering structures using various geophysical tools. Special emphasis is placed on ground penetrating radar and surface wave techniques. One field trip at student expense required. Prerequisite: Junior level standing or higher. (Co-listed with Geo Eng 336).

GEOPHYS 361 Transportation Applications of Geophysics (LEC 2.0 and LAB 1.0)
Overview of geophysical and non-destructive test methods that are commonly used to investigate transportation structures and their foundations. Emphasis is placed on bridge system substructure, bridge system superstructure, pavement, roadway subsidence, subsurface characterization and vibration measurements. Prerequisite: Junior level standing or higher. (Co-listed with Geo Eng 361 and Civ Eng 351).

GEOPHYS 377 Seismic Interpretation (LAB 1.0 and LEC 2.0)
An introduction to 2-D/3-D seismic structural interpretation, stratigraphic interpretation, reservoir identification and evaluation, and horizon and formation attributes. The students are expected to master interactive 2-D/3-D seismic interpretation software packages that are routinely used in the petroleum industry. Prerequisite: Geophys 270 or 385.

GEOPHYS 380 Seismic Stratigraphy (LEC 2.0 and LAB 1.0)
A study of the seismic expression of depositional models. Reflection patterns and reflection amplitudes are interpreted to determine bed thicknesses, fluid content, depositional environment, and lithology. Special data acquisition and processing techniques are examined. Prerequisites: Geophys 385, Geology 220, 223.

GEOPHYS 381 Global Tectonics (LEC 3.0)
An integrated view of the Earth’s structure and dynamics with an emphasis on information gained through geophysical methods. Topics include seismology, heat flow, gravity, rheological and compositional structure, plate motions and intermotions, and mantle driving mechanisms for plate tectonics. Prerequisite: Geology 220.

GEOPHYS 382 Environmental And Engineering Geophysics (LEC 2.0 and LAB 1.0)
An introduction to the theory and application of the gravity, magnetic, resistivity, self-potential, induced polarization and electromagnetic methods as applied to the solution of engineering and environmental problems. Prerequisite: Math 22. (Co-listed with Geo Eng 382).

GEOPHYS 383 Electrical Methods In Geophysics (LEC 2.0 and LAB 1.0)
The theory and instrumentation for measurements of the electrical properties of the earth. Includes passive and active techniques, the advantages and disadvantages of the various techniques, and geologic interpretations of electrical soundings. Several weekends are spent making a variety of electrical surveys of local features. Prerequisites: Math 325 and Geophys 285 or Geophys 382.

GEOPHYS 385 Exploration And Development Seismology (LEC 2.0 and LAB 1.0)
Principles of reflection seismology as applied to the delineation of geologic structures and the determination of stratigraphy and lithology. Emphasis on both the capabilities and limitations of the seismic method. The laboratory utilizes both modeled and actual seismic data. Prerequisite: Math 22.

GEOPHYS 386 Wave Propagation (LEC 3.0)
A study of Hamilton’s principle and energy theorems, fundamentals of plane wave theory, waves in stratified fluids, elastic waves in solids, electromagnetic and hydromagnetic radiation, and Allen’s functions and point sources. Prerequisites: Geophys 281, 321.

GEOPHYS 388 Geophysical Instrumentation (LAB 1.0)
Field and laboratory practice in the use of geophysical instrumentation. Techniques of geophysical data reduction and interpretation are also covered. May be taken more than once for credit with Geophys 383 and Geophys 384. Prerequisite: Concurrent registration in Geophys 382, 283 or 384.
GEOPHYS 389 Seismic Data Processing (LEC 2.0 and LAB 1.0)
Introduction to seismic data processing. Topics to be covered include statics corrections, filtering, velocity analysis, deconvolution, stacking and migration. Prerequisites: Geophys 270 or Geophys 385.

GEOPHYS 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

GEOPHYS 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

GEOPHYS 401 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

GEOPHYS 410 Seminar (RSD 0.0-6.0)
Discussion of current topics.

GEOPHYS 483 Advanced Electrical And Electromagnetic Methods In Geophysical Exp (LAB 1.0 and LEC 2.0)
Theory of the electrical geophysical methods as applied to subsurface investigations addressing geologic, engineering, groundwater and contaminant transport problems. Course content includes both passive and active methods and recent advances in the application of these methods. Course will include a field component illustrating application of techniques to local problems. Prerequisites: Geophys 382, Math 22.

GEOPHYS 485 Advanced Seismic Data Processing (LEC 2.0 and LAB 1.0)
Theory and application of seismic data processing. Topics to be covered include convolution, correlation, deconvolution, 2-D filtering, migration and inversion. Prerequisites: Geophys 385, 389, Stat 215.

GEOPHYS 486 The Theory Of Elastic Waves (LEC 2.0 and LAB 1.0)
A mathematical study of elastic waves in the layered earth. Prerequisite: Geophys 386.

GEOPHYS 487 Geophysical Inverse Theory (LEC 3.0)
A study of inverse theory applied to geophysical data, focusing on the relationship between data and model spaces and ways to estimate model parameters via global and local optimization techniques. Prerequisites: Geophys 286 or 384, Math 325, Stat 215.

GEOPHYS 488 Advanced Seismic Interpretation (LEC 3.0)
The integration of geologic information, well log data and seismic information for interpreting the earth’s subsurface using advanced 3-D seismic interpretation software packages. Reservoir identification and evaluation as well as horizon and formation attributes are included. Prerequisite: Geophys 270 or Geophys 385.

GEOPHYS 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

GEOPHYS 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

GEOPHYS 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Info Science & Technology (IS&T)

IS&T 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

IS&T 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

IS&T 321 Network Performance Design And Management (LEC 3.0)
This course provides analytical capabilities needed to effectively design, deploy, and manage computer networks and protocols. Prerequisites: IS&T 223, IS&T 233.

IS&T 335 Fundamentals of Mobile Technology for Business (LEC 3.0)
A broad overview of mobile technology use in business environments. Topics include the mobile industry; mobile network and wireless standards; mobile devices; mobile web design and app development; social and user experience issues; mobile marketing and commerce. Cannot take both IS&T 335 and IS&T 435. Prerequisites: IS&T 223 and IS&T 233.

IS&T 341 Advanced Electronic and Mobile Commerce (LEC 3.0)
Fundamental concepts of management and application to IT and support of commerce. Examines the use of IT in business processes and the management issues of integrating IT into organization processes to gain a competitive advantage. Includes a major end-of-semester project. Cannot receive credit for IS&T 241 and IS&T 341. Prerequisite: Knowledge of management information systems and Graduate standing.

IS&T 342 E-Commerce Architecture (LEC 3.0)
Course will cover the issues associated with computer architecture, as it relates specifically to e-commerce applications. Topics will include e-commerce systems and processes, specialized software, and databases. Prerequisite: IS&T 233 or IS&T 336.

IS&T 343 Database Applications in Business (LEC 3.0)
Design, development and implementation of application software typical to the modern business environment utilizing popular commercial database management systems such as Oracle and Access. Focus given to business case modeling, requirement analysis, database design, and implementation challenges. Project oriented. Prerequisite: IS&T 243.

IS&T 351 Technological Innovation Management and Leadership (LEC 3.0)
The course focuses on the knowledge and skills necessary for the development and implementation of effective strategies for the management of technology-based organizations. This involves: developing a general management perspective on technology and innovation, examining the problems of new product development, identifying distinctive technological competencies, licensing and marketing technologies, assessing the organizational and industrial context of technology. Prerequisite: Senior or Graduate Standing.
IS&T 352 Advanced Web Development (LEC 3.0)
Advanced Web development techniques to provide dynamic interaction; methods for extracting and delivering dynamic information to/from Web servers - a hands-on approach. Emphasis on interaction with servers; mobile software development; processing of graphics and web video. Project work is required. Prerequisites: IS&T 51 and IS&T 286.

IS&T 353 Modular Software Systems in Java (LEC 3.0)
Introduction to Software Life Cycle and characteristics of large modular software systems. Exploration of software support for such systems, using Java, including use of GUI interfaces, advanced I/O and String handling, Interfaces, Threads, and other modularity features. Program project included. Prerequisites: IS&T 151 and IS&T 231.

IS&T 354 Advanced Web and Digital Media Development (LEC 3.0)
This course covers advanced techniques and tools for the design and development of web-based media, including text, graphics, animation, audio, and video. This course is an advanced version of Web and Digital Media Development, with additional assignments. No credit for both IS&T 286 and IS&T 354. Prerequisite: Graduate standing.

IS&T 357 Network Economy (LEC 3.0)
Emerging Network/Internet economy, using traditional economic tools. Topics: production and reproduction cost of information, information as an "experience good," versions of products, switching cost, lock-in effects, market adoption dynamics, first-mover advantage, intellectual property rights. Prerequisite: Econ 121 or Econ 122. (Co-listed with Econ 357).

IS&T 361 Information Systems Project Management (LEC 3.0)
The course overviews general project management principles and then focuses on information system application development. Topics include requirements analysis, project scheduling, risk management, quality assurance, testing, and team coordination. Prerequisite: Strong programming knowledge and Senior standing.

IS&T 368 Law and Ethics in E-Commerce (LEC 3.0)
Provides the ethical framework to analyze the ethical, legal, and social issues that arise for citizens and computer professionals regarding the computerization of society. Topics include: free speech, privacy, intellectual property, product liability, and professional responsibility. (Co-listed with Philos 368).

IS&T 380 Introduction to Web and New Media Studies (LEC 3.0)
The course covers web culture, including topics such as social media, citizen journalism, crowd intelligence, privacy, and copyright. Students cannot receive credit for both this course and IS&T 480 (Advanced Web and New Media Studies). Prerequisite: Junior or Senior standing.

IS&T 385 Human Computer Interaction (LEC 3.0)
Introduction to the field of Human-Computer Interaction (HCI). Students examine issues and challenges related to the interaction between people and technology. The class explores the social and cognitive characteristics of people who use information systems. Students learn techniques for understanding user needs, interface prototyping, and interface evaluation. Prerequisite: Psych 50.

IS&T 386 Human-Computer Interaction Prototyping (LAB 1.5 and LEC 1.5)
This course covers methods and tools for creating low and high fidelity prototypes of IT systems as well as design concepts, including best practices and guidelines for different form factors (e.g., desktop vs. mobile). Prerequisites: IS&T 286 or web design experience; preceded or accompanied by IS&T 385.

IS&T 387 Human-Computer Interaction Evaluation (LAB 1.5 and LEC 1.5)
This course covers research and analysis methods and tools for evaluation of the impact of information technology systems on humans and organizations. The focus will be on practical evaluation with the goal of providing recommendations for improving system functionality and usability. Prerequisite: Preceded or accompanied by IS&T 385.

IS&T 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

IS&T 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

IS&T 401 Special Topics (LEC 0.0-6.0)
This is designed to give the department an opportunity to test a new course. Variable title.

IS&T 435 Mobile Technology for Business (LEC 3.0)
Overview of mobile technology use in business environments. Topics include: mobile industry; mobile network and wireless standards; mobile devices; mobile web design and app development; social and user experience issues; mobile marketing and commerce. Project required. Cannot take both IS&T 335 and IS&T 435. Prerequisites: IS&T 223 or equivalent, IS&T 233 or equivalent, Graduate standing.

IS&T 436 Foundations of Internet Computing (LEC 3.0)
The foundations of Internet Computing include computer networks and Web sites. Networks are covered thoroughly and research directions for networks are discussed. Web site design and research findings about site usability considerations are examined. Security of communications for computing, especially wireless communications, are explored. Prerequisite: IS&T MS entrance requirements, including solid programming knowledge.

IS&T 443 Information Retrieval and Analysis (LEC 3.0)
Covers the applications and theoretical foundations of organizing and analyzing information of textual resources. Topics include information storage and retrieval systems, web search engines, text mining, collaborative filtering, recommender systems. Students will also learn the techniques with the use of interactive tools such as SAS. Prerequisite: ERP 345 or statistics knowledge.

IS&T 444 Essentials of Data Warehouses (LEC 3.0)
This course presents the topic of data warehouses and the value to the organization. It takes the student from the database platform to structuring a data warehouse environment. Focus is placed on simplicity and addressing the user community needs. Prerequisite: IS&T 223 or equivalent relational database experience. (Co-listed with ERP 444).

IS&T 445 Database Marketing (LEC 3.0)
Intro to methods and concepts used in database marketing: 1) predictive modeling techniques (e.g., regression, decision trees, cluster analysis) and 2) standard processes for mapping business objectives to data mining goals to produce a deployable marketing model. Metrics like lifetime value of a customer and ROI will be covered. Several application areas covered. Prerequisite: Statistics understanding, programming understanding, familiarity with spreadsheets.
IS&T 448 Building the Data Warehouse (LEC 3.0)
Data modeling and processes needed to populate a data warehouse; tradeoffs among several models and tools; technical issues that are faced, such as security, schemas, Web access, other reporting techniques. Prerequisite: IS&T 444.

IS&T 461 Advanced Information Systems Project Management (LEC 3.0)
Project management principles, first from a general perspective, and then focused specifically on information system application development are explored. Topics include requirements analysis, project scheduling, risk management, quality assurance, testing, and team coordination. Report writing and research literature searches are required. Prerequisite: IS&T MS Entrance requirements, with strong programming knowledge.

IS&T 480 Advanced Web and New Media Studies (LEC 3.0)
The course covers web culture, including topics such as social media; citizen journalism, crowd intelligence, privacy, and copyright. This course is an advanced version of Intro to Web Studies, with additional assignments. Prerequisite: Graduate standing.

IS&T 487 Research Methods in Human-Computer Interaction (LAB 1.5 and LEC 1.5)
This course covers quantitative and qualitative research methods for exploring the interaction between people and information technologies. The course covers techniques and tools for carrying out literature reviews, forming research goals, designing research, conducting data analyses; and preparing manuscripts and live presentations. Prerequisite: IS&T 385.

IS&T 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

IS&T 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/ comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or facilities. In no case shall this be for less than three (3) semester hours for resident students.

IS&T 495 Continuous Registration (LEC 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Mathematics (MATH)

MATH 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MATH 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MATH 302 Intermediate Differential Equations (LEC 3.0)
Linear differential equations, vector-matrix systems, existence and uniqueness theory, nonlinear systems, phase-plane analysis, introduction to stability theory. Prerequisite: Math 204 or Math 229.

MATH 303 Methods of Applied Mathematics (LEC 3.0)
Methods to develop and analyze mathematical models. Topics include dimensional analysis and scaling, perturbation methods, and the construction of ordinary and partial differential equation models. Prerequisites: Math 204 or 229 with a grade of "C" or better, programming competency.

MATH 305 Modern Algebra I (LEC 3.0)
Equivalence relations and functions, basic properties of groups, subgroups, permutations, cosets and Lagrange's Theorem, isomorphisms and homomorphisms, factor groups. Prerequisite: Math 209 or graduate standing; preceded or accompanied by Math 208.

MATH 306 Modern Algebra II (LEC 3.0)
This course is a continuation of Math 305. Rings and fields are discussed. Euclidean domains, principal ideal domains, unique factorization domains, vector spaces, finite fields and field extensions are studied. Prerequisite: Math 305.

MATH 307 Combinatorics And Graph Theory (LEC 3.0)
Covers some basics of enumeration and graph theory. Topics are selected from the following: permutations combinations, the inclusion/ exclusion principle, generating functions, recurrence relations, trees, networks, graph connectivity and graph coloring. Prerequisite: Comp Sci 128 or Math 209.

MATH 308 Linear Algebra II (LEC 3.0)
Eigenvalue problems, Cayley-Hamilton theorem, Jordan normal form, linear functionals, bilinear forms, quadratic forms, orthogonal and unitary transformations, selected applications of linear algebra. Prerequisite: Math 208.

MATH 309 Advanced Calculus I (LEC 3.0)
Completeness of the set of real numbers, sequences and series of real numbers, limits, continuity and differentiability, uniform convergence, Taylor series, Heine-Borel theorem, Riemann integral, fundamental theorem of calculus, Cauchy-Riemann integral. Prerequisite: Math 22 and Math 209, or a 300-level mathematics course, or graduate standing.

MATH 310 Undergraduate Seminar (SEM 1.0-3.0)
Discussion of advanced or current topics. (Course cannot be used for graduate credit).

MATH 311 Advanced Calculus II (LEC 3.0)
Euclidean n-space, differentiation and integration of scalar functions of several variables, maxima and minima theory, change of variables, differentiation and integration of vector functions of several variables, Divergence theorem, Stokes' theorem. Prerequisite: Math 309.

MATH 315 Introduction To Real Analysis (LEC 3.0)
Riemann-Stieltjes integration, sequences and series of functions, uniform approximation, the Banach Space C(a,b), Lebesgue measure and integration, the space LP(a,b), Fourier series. Prerequisite: Math 309.

MATH 322 Vector And Tensor Analysis (LEC 3.0)
Vector algebra, vector differential and integral calculus, line and surface integrals, theorems of Stokes and Gauss, tensor algebra and tensor analysis, applications to problems in kinematics, elasticity theory, fluid mechanics, electromagnetic theory, relativity theory. Prerequisite: Math 22; Math 203 or Math 208.

MATH 325 Partial Differential Equations (LEC 3.0)
Linear equations, heat equation, eigenfunction expansions, Green's formula, inhomogeneous problems, Fourier series, wave equation. Prerequisite: Math 204 with a grade of "C" or better.
MATH 330 Topics In Geometry (LEC 3.0)
A survey of non-Euclidean geometries, finite geometries, affine and projective planes, metric postulates for the Euclidean plane, and selected topics. Prerequisite: Math 208.

MATH 337 Financial Mathematics (LEC 3.0)
The course objective is to provide an understanding of the fundamental concepts of financial mathematics. Topics include pricing, assets-liability management, capital budgeting, valuing cash flow, bonds, futures, swaps, options. Preparation for the financial mathematics actuarial exam will be provided. Prerequisites: Math 15 or Math 21, Econ 221 or Econ 222 or Econ 250 or Econ 321, Stat 211 or Stat 213 or Stat 215 or Stat 217 or Stat 343. (Co-listed with Econ 337).

MATH 340 Mathematical Analysis For Secondary Teachers (LEC 3.0)
Designed to help teachers gain a deeper understanding of the fundamental idea in analysis, that of a limit. A discovery method is used which includes both individual and group work. Students will present their results in written and oral format. Prerequisite: Math 22 or equivalent.

MATH 341 Mathematical Analysis For Secondary Teachers Practicum (LEC 1.0)
An instructional unit based on the discovery method used in Math 340 will be designed by each student. These units will be class tested. The unit and results of class testing will be presented both in written and oral format. Prerequisite: Math 340.

MATH 351 Introduction To Complex Variables (LEC 3.0)
The basic tools of complex variables are studied. These include the Cauchy-Riemann equations, complex contour integration, the Cauchy-Goursat theorem, conformal mappings, the calculus of residues and applications to boundary value problems. Prerequisite: Math 204.

MATH 354 Mathematical Logic I (LEC 3.0)
A mathematical introduction to logic with some applications. Functional and relational languages, satisfaction, soundness and completeness theorems, compactness theorems. Examples from Mathematics, Philosophy, Computer Science, and/or Computer Engineering. Prerequisite: Philos 15 with junior standing or Math 305 or Comp Sci 253 or Comp Eng 111. (Co-listed with Comp Eng 354, Comp Sci 354 and Philos 354).

MATH 361 Problem Solving In Pure Mathematics (LEC 1.0)
Problems from pure mathematics, including analysis, algebra, number theory, set theory, finite mathematics, probability and statistics. Emphasis on identifying or inventing ways to solve problems based on the student's entire mathematics background. Prerequisites: Corequisite Math 309 and Senior standing.

MATH 371 Problem Solving In Applied Mathematics (LEC 1.0)
Problems from applied mathematics which are open-ended, and do not always have a unique correct solution. Emphasis on developing mathematical models and writing solution narratives, including clarity, analysis, and design. Prerequisites: Math 209 and Senior standing.

MATH 381 Great Theorems In Mathematics (LEC 1.0)
A study of some of the great theorems which have shaped the development of mathematics and human civilization. History, the changing nature of mathematics, and the mathematical content of the theorems themselves, will all be addressed. Sources as close to the originals as possible will be used. Prerequisites: Math 209 and Senior standing.

MATH 383 Operational Calculus (LEC 3.0)
The Laplace transformation, properties of the transformation, various applications to ordinary and partial differential equations, systems with step and Dirac functions as driving forces, various non-elementary functions and their transforms, problems in heat conduction and wave motion, Fourier transforms and their operational properties. Prerequisite: Math 204.

MATH 385 Introduction To Topology (LEC 3.0)
Metric spaces; general topological spaces; connectedness, compactness, separation properties, functions and continuity. Prerequisite: Math 309.

MATH 390 Undergraduate Research (IND 0.0-6.0)
This course is designed for the undergraduate student who wishes to engage in research. It is not to be used for graduate credit nor for more than six credit hours of undergraduate credit. The subject and credit are to be arranged with the instructor. Prerequisite: Consent of instructor.

MATH 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MATH 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MATH 402 Mathematical Physics I (LEC 3.0)

MATH 403 Mathematical Physics II (LEC 3.0)
Green's functions in three dimensions, integral equations, complex variable theory and contour integration, group theory with applications to quantum mechanics, solid state and molecular physics. Prerequisite: Math 402 or Physics 402. (Co-listed with Physics 403).

MATH 405 Finite Fields And Applications (LEC 3.0)
After reviewing basic group theory and introducing basic properties of commutative rings, the main focus of the course will be on topics such as structure of finite fields, polynomials over finite fields, and applications such as coding theory and cryptography. Prerequisite: Math 305.

MATH 406 Introduction to Ring Theory (LEC 3.0)
Properties of rings with an emphasis on commutative rings. Ideals, factor rings, ring homomorphisms, polynomial rings; factorization, divisibility, and irreducibility. Introduction to extension fields and Galois theory. Applications may be chosen based on the interests of the students. Prerequisite: Math 305.

MATH 407 Group Theory (LEC 3.0)
Groups, subgroups, and factor groups; homomorphisms, isomorphisms, and associated theorems; abelian groups; Sylow theorems and p-groups; permutation groups; free groups and generators; representation theory; cohomology theory. Prerequisite: Math 306.

MATH 408 Applied Matrix Theory (LEC 3.0)
A second course in matrix theory directed toward applications. Linear spaces, linear operators, equivalence and similarity, spectral theorem, canonical forms, congruence, inertia theorem, quadratic forms, singular value decomposition and other factorizations, generalized inverses. Applications to optimization, differential equations, stability. Prerequisites: Math 203, 208, or 302.
MATH 435 Calculus Of Variations I
Continuation of Math/Econ 337. Topics include martingales and measures, stopping times, discrete and continuous time finance, Brownian motion, Ito calculus, stochastic differential equations, Black-Scholes-Merton formula, numerical procedures. Prerequisite: Math 337 or Econ 337. (Co-listed with Econ 437).

MATH 440 Geometric Structures
Selected topics in non-Euclidean, solid, projective, and fractal geometry. Prerequisite: Math 330.

MATH 441 Geometric Structures Practicum
An instructional unit based on material learned in Math 440 will be designed by each student. These units will be class tested. The unit and results of class testing will be presented both in written and oral format. Prerequisite: Math 440.

MATH 451 Functions Of A Complex Variable I
Complex plane, complex function theory, elementary Riemann surfaces, conformal mapping, complex integration, infinite complex series and sequences, calculus of residues with applications. Prerequisite: Math 311.

MATH 452 Functions Of A Complex Variable II
Argument principle and consequences; harmonic functions and Dirichlet’s problem; infinite products; entire, meromorphic and rational functions; analytic continuation; symmetry principle; conformal mapping; functions of several complex variables. Prerequisite: Preceded by Math 451.

MATH 461 Harmonic Analysis I
Fourier series, norm and pointwise convergence of Fourier series, the conjugate and maximal functions, analytic functions in the unit disk and Hardy spaces, interpolation of linear operators and the Hausdorff-Young-Riesz Theorem, Sidon sets. Prerequisites: Math 315 and Math 351.

MATH 462 Harmonic Analysis II
Fourier integrals, almost-periodic functions on the real line, Banach algebras, Wiener’s Tauberian Theorem and the prime number theorem, the Paley-Wiener Theorems, band-limited functions and Shannon’s Theorem, the continuous wavelet transform, discrete wavelet transforms and frames, orthonormal bases of wavelets and multi-resolution analysis. Prerequisite: Must be preceded by Math 461.

MATH 465 Mathematical Programming
An introduction to linear optimization and its engineering applications; problem modeling, search-based optimization, the simplex method for solving linear problems, multi-objective optimization, discrete problem modeling, search-based optimization, the simplex method

MATH 475 Theory Of Partial Differential Equations
Classical wave, potential, and heat equations; classification into elliptic, parabolic, and hyperbolic types; existence and uniqueness proofs. Prerequisite: Math 309.

MATH 485 Topology I
Topological spaces, uniform and quasi-uniform spaces, product and quotient spaces, separation properties and connected spaces, compactness. Prerequisite: Math 385.
MATH 486 Topology II (LEC 3.0)
Metrizability conditions, the theory of convergence using both filters and nets, completions and compactifications, and papers from the recent literature. Prerequisite: Math 485.

MATH 490 Research (IND 0.0-15)
Investigation of an advanced nature leading to the preparation of a thesis or dissertation.

MATH 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

MATH 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Mechanical Engineering (MECH ENG)

MECH ENG 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MECH ENG 301 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MECH ENG 302 Synthesis Of Mechanisms (LEC 3.0)
Synthesis of planar mechanisms for function generation, path generation, and motion generation. Emphasis is on analytical methods for synthesis. Prerequisite: Mech Eng 213.

MECH ENG 304 Compliant Mechanism Design (LEC 3.0)
Introduction to compliant mechanisms; review of rigid-body mechanism analysis and synthesis methods; synthesis of planar mechanisms with force/energy constraints using graphical and analytical methods; pseudo-rigid-body models; force-deflection relationships; compliant mechanism synthesis methods; and special topics, e.g. bistable mechanisms, constant-force mechanisms, parallel mechanisms, and chain algorithm in design. Emphasis will be on applying the assimilated knowledge through a project on compliant mechanisms design. Prerequisites: Mech Eng 213, Civ Eng 110.

MECH ENG 305 Lubrication (LEC 3.0)
Development of basic principles of bearing analysis including manufacture and properties of lubricants, hydrodynamics and hydrostatic lubrication, journal and thrust bearings, ball and roller bearings, boundary considerations, and bearing materials. Prerequisite: Mech Eng 231.

MECH ENG 306 Material Processing By High-Pressure Water Jet (LEC 3.0)
Methods of generating high pressure water jets; standard equipment, existing techniques, and basic calculations. Application of water jets to materials cutting and mineral processing. Safety rules. The course will be supported by laboratory demonstrations. Prerequisite: Mech Eng 231 or undergraduate fluids course. (Co-listed with Min Eng 306).

MECH ENG 307 Vibrations I (LEC 3.0)
Equations of motion, free and forced vibration of single degree of freedom systems and multidegree of freedom systems. Natural frequencies, resonance, modes of vibration and energy dissipation are studied. The vibration of continuous systems is introduced. Prerequisites: Mech Eng 211 and 213, or Aero Eng 213 and Math 204. (Co-listed with Aero Eng 307).

MECH ENG 308 Rapid Product Design And Optimization (LEC 3.0)
Product Life cycle design; Finding design solutions using optimization technique; Rapid product realization using rapid prototyping and virtual prototyping techniques. Prerequisite: Mech Eng 208.

MECH ENG 309 Engineering Acoustics I (LEC 3.0)
Introduction to acoustical theory and measurement with emphasis on mechanical and aerospace engineering applications. Plane and spherical wave propagation, resonators and filters, absorption, room acoustics, human response to noise, noise legislation, noise control. Use of common instrumentation in several projects. Prerequisites: Mech Eng 211 and 213, or Aero Eng 213 and Math 204. (Co-listed with Aero Eng 309).

MECH ENG 311 Introduction To Continuum Mechanics (LEC 3.0)
Introductory cartesian tensor analysis to aid in the development of the theory of a continuum. Kinematics of deformation, stress tensor, equations of motion, equations of mass and energy balance. Examples from specific material theories in solid and fluid mechanics. Prerequisites: Civ Eng 110, Math 204.

MECH ENG 312 Introduction to Finite Element Analysis (LEC 3.0)
Variational formulation of the governing equations. Finite element model, interpolation functions, numerical integration, assembly of elements and solution procedures. Applications to solid mechanics, fluid mechanics and heat transfer problems. Two-dimensional problems. Computer implementation and use of commercial finite element codes. Prerequisite: Mech Eng 208 or Aero Eng 253 or consent of instructor for majors that do not require either of these courses. (Co-listed with Aero Eng 352).

MECH ENG 313 Intermediate Dynamics Of Mechanical And Aerospace Systems (LEC 3.0)
Principles of dynamics are applied to problems in the design of mechanical and aerospace systems; basic concepts in kinematics and dynamics; dynamics of systems of particles; dynamics of rigid bodies, three-dimensional effects in machine elements; dynamic stability, theory and applications; methods of analytical dynamics. Prerequisite: Mech Eng 213 or Aero Eng 213. (Co-listed with Aero Eng 313).

MECH ENG 314 Applications Of Numerical Methods To Mechanics Problems (LEC 3.0)
Numerical solutions of statics, vibrations, and stability problems. Direct stiffness formulations are developed and user-oriented computer codes are used to solve practical structures problems. Computer graphics techniques are utilized to prepare data and display results. Prerequisites: Civ Eng 110; Mech Eng 160 or Aero Eng 160.
MECH ENG 315 Concurrent Engineering I (LEC 3.0)
Students will be introduced to the concurrent engineering approach to product development. They will learn to set up quantitative requirements and then use a quantitative rating process to identify the critical requirements relating to the desired product. The interaction between design, manufacturing, assembly, cost, and supportability will be covered. The students will form teams and practice the concurrent engineering process for simple products. Prerequisites: Mech Eng 213 or Aero Eng 231, and Civ Eng 110. (Co-listed with Aero Eng 315).

MECH ENG 316 Concurrent Engineering II (LAB 3.0)
Students will form groups and then using the electronic data based approach apply the concurrent engineering process to develop products. Areas to be covered are the customer, design, manufacturing, assembly, cost and supportability. Prerequisite: Mech Eng 315 or Mech Eng 316. (Co-listed with Aero Eng 316).

MECH ENG 319 Advanced Thermodynamics (LEC 3.0)
After a short review of classical thermodynamics, the elements of chemical reactions, chemical equilibrium, statistical thermodynamics, and the basic concepts of kinetic theory are presented. Prerequisite: Mech Eng 219. (Co-listed with Aero Eng 319).

MECH ENG 320 Advanced Mechanics of Materials (LEC 3.0)
Comprehensive insight into mechanics of materials. Topics to include: theories of failure, torsion of noncircular sections, shear flow and shear center, unsymmetric bending, bending of curved members, beams on elastic foundation and pressurization of thick walled cylinders. Prerequisites: Civ Eng 110, Math 204. (Co-listed with Aero Eng 320).

MECH ENG 322 Introduction To Solid Mechanics (LEC 3.0)
Review of basic concepts in continuum mechanics. Finite elasticity; some universal solutions for isotropic materials, application of special mechanical models. Linear elasticity: compatibility, stress functions, superposition, special examples such as extension, torsion, bending, and plane problems. Elements of plasticity. Prerequisite: Eng Mech 311. (Co-listed with Aero Eng 322).

MECH ENG 323 Transport Phenomena In Manufacturing Processes (LEC 3.0)
A study of the important role that transport phenomena (heat and mass transfer and fluid flow) play during various manufacturing processes including metal casting, joining and welding extrusion, forging, crystal growth, chemical deposition, and thermal spray deposition. Prerequisites: Mech Eng 225 and 231.

MECH ENG 325 Intermediate Heat Transfer (LEC 3.0)
Analytical study of conduction; theory of thermal radiation and applications; energy and momentum equations in convective heat transfer and review of empirical relations. Current topics are included. Prerequisite: Mech Eng 225. (Co-listed with Aero Eng 325).

MECH ENG 327 Combustion Processes (LEC 3.0)
Application of chemical, thermodynamic, and gas dynamic principles to the combustion of solid, liquid, and gaseous fuels. Includes stoichiometry, thermochemistry, reaction mechanism, reaction velocity, temperature levels, and combustion waves. Prerequisite: Mech Eng 221. (Co-listed with Aero Eng 327).

MECH ENG 329 Smart Materials And Sensors (LAB 1.0 and LEC 2.0)
Smart structures with fiber reinforced polymer (FRP) composites and advanced sensors. Multi-disciplinary topics include characterization, performance, and fabrication of composite structures; fiber optic, resistance, and piezoelectric systems for strain sensing; and applications of smart composite structures. Laboratory and team activities involve manufacturing, measurement systems, instrumented structures, and performance tests on a large-scale smart composite bridge. Prerequisites: Senior standing and Math 204. (Co-listed with Aero Eng 329, Elec Eng 329 and Civ Eng 318).

MECH ENG 330 Applied Computational Methods (LEC 3.0)
Detailed study of computational methods for efficient solution of selected fluids, structures, thermodynamics, and controls problems in aerospace and mechanical engineering. Besides basic numerical techniques, topics covered include gradient-based optimization and uncertainty quantification. Prerequisite: Comp Sci 53 or 73 or 78; Math 204. (Co-listed with Aero Eng 330).

MECH ENG 331 Intermediate Thermofluid Mechanics (LEC 3.0)
Derivation of Navier-Stokes equations, analytical solutions of viscous flows; flow in pipes, flow networks; intermediate treatment of boundary layer theory; micro-fluidics and MEMS; introduction to numerical methods for solving fluid flows; and, preliminary treatise on turbulence. Prerequisite: Mech Eng 231 or Aero Eng 231. (Co-listed with Aero Eng 331).

MECH ENG 333 Internal Combustion Engines (LEC 3.0)
A course dealing primarily with spark ignition and compression ignition engines. Topics include: thermodynamics, air and fuel metering, emissions and their control, performance, fuels, and matching engine and load. Significant lecture material drawn from current publications. Prerequisite: Mech Eng 221.

MECH ENG 334 Stability Of Engineering Structures (LEC 3.0)
Solution of stability problems with applications to columns, plates and shell structures. Torsional and lateral buckling of columns. Buckling under high temperatures. Effect of imperfections introduced by a technological process on stability. Design issues related to stability requirements. Prerequisites: Civ Eng 110; Math 204; and IDE 150 or Mech Eng 160 or Aero Eng 160. (Co-listed with Aero Eng 334).

MECH ENG 335 Applied Energy Conversion (LEC 3.0)
The study of the principles of energy conversion. Specific applications include fuel cells and other direct energy conversion devices used in plug-in hybrid electric vehicles. Prerequisite: Mech Eng 221.

MECH ENG 336 Fracture Mechanics (LEC 3.0)
Linear elastic and plastic mathematical models for stresses around cracks; concepts of stress intensity; strain energy release rates; correlation of models with experiment; determination of plane stress and plane strain parameters; application to design. Prerequisite: Civ Eng 110. (Co-listed with Aero Eng 336).

MECH ENG 338 Fatigue Analysis (LEC 3.0)
The mechanism of fatigue, fatigue strength of metals, fracture mechanics, influence of stress conditions on fatigue strength, stress concentrations, surface treatment effects, corrosion fatigue and fretting corrosion, fatigue of joints, components and structures, design to prevent fatigue. Prerequisite: Civ Eng 110. (Co-listed with Aero Eng 344).
**MECH ENG 339 Computational Fluid Dynamics** (LEC 3.0)
Introduction to the numerical solution of the Navier-Stokes equations, by
differentiation methods, in both stream function-vorticity and primitive
variable formulations. Course format emphasizes student development of
complete computer programs utilizing a variety of solution methods.
Prerequisites: Comp Sci 53 or 73 or 74; one course in fluid mechanics.
(LEc 3.0 and Aero Eng 339).

**MECH ENG 342 Experimental Stress Analysis II** (LAB 1.0 and LEC 2.0)
Acquaints the student with some techniques of experimental stress
analysis. Topics include principal stresses, strain to stress conversion,
transmission and reflection photoelastic methods, Moiré fringe methods,
and analogies. Prerequisites: Civ Eng 110, Mech Eng 321. (Co-listed with
Eng Mech 342, Aero Eng 342).

**MECH ENG 344 Interdisciplinary Problems In Manufacturing
Automation** (LEC 2.0 and LAB 1.0)
The course will cover material necessary to design a product and
the fixtures required to manufacture the product. Participants will
gain experience with CAD/CAM software while carrying out an actual
manufacturing design project. (Co-listed with Chem Eng 384, Eng Mgt
344).

**MECH ENG 349 Robotic Manipulators And Mechanisms** (LEC 2.0 and
LAB 1.0)
Overview of industrial applications, manipulator systems and geometry.
Manipulator kinematics; hand location, velocity and acceleration. Basic
formulation of manipulator dynamics and control. Introduction to machine
vision. Projects include robot programming, vision-aided inspection
and guidance, and system integration. Prerequisites: Comp Sci 73, Mech Eng
213. (Co-listed with Aero Eng 349).

**MECH ENG 353 Computer Numerical Control Of Manufacturing
Processes** (LAB 1.0 and LEC 2.0)
Fundamental theory and application of computer numerical controlled
machine tools from the viewpoint of design principles, machine structural
elements, control systems, and programming. Projects include manual
and computer assisted part programming and machining. Prerequisite:
Mech Eng 253.

**MECH ENG 354 Variational Formulations Of Mechanics Problems**
(LEC 3.0)
Introduction and study of variational problems in classical dynamics and
solid mechanics emphasizing the concepts of virtual work, minimum
potential energy, and complementary energy; Variational inequalities.
Prerequisites: Civ Eng 110; Math 204; and IDE 150 or Mech Eng 160 or
Aero Eng 160. (Co-listed with Eng Mech 354).

**MECH ENG 355 Manufacturing Equipment Automation** (LAB 1.0 and
LEC 2.0)
Manufacturing automation at the equipment level. Topics include
sensors, actuators, and computer interfacing for manufacturing
equipment, dynamic modeling and control of manufacturing equipment,
interpolation, coordinated motion control, kinematic and geometric error
modeling, and runout. Prerequisite: Mech Eng 279.

**MECH ENG 356 Design For Manufacture** (LEC 3.0)
Course covers the approach of concurrent product and process design.
Topics include: principle of DFM, New product design process, process
capabilities and limitations, Taguchi method, tolerancing and system
design, design for assembly and AI techniques for DFM. Prerequisites:

**MECH ENG 357 Integrated Product And Process Design** (LEC 3.0)
Emphasize design policies of concurrent engineering and teamwork,
and documenting of design process knowledge. Integration of various
product realization activities covering important aspects of a product life
cycle such as "customer" needs analysis, concept generation, concept
selection, product modeling, process development, DFX strategies, and
end-of-product life options. Prerequisite: Eng Mgt 253 or Mech Eng 253.
(Co-listed with Eng Mgt 354).

**MECH ENG 358 Integrated Product Development** (LAB 2.0 and LEC
1.0)
Students in design teams will simulate the industrial concurrent
engineering development process. Areas covered will be design,
manufacturing, assembly, process quality, cost, supply chain
management, and product support. Students will produce a final
engineering product at the end of the project. Prerequisite: Eng Mgt 354
or Mech Eng 357 or Mech Eng 253 or Mech Eng 308. (Co-listed with Eng
Mgt 358).

**MECH ENG 360 Probabilistic Engineering Design** (LEC 3.0)
The course deals with uncertainties in engineering analysis and design
at three levels - uncertainty modeling, uncertainty analysis, and design
under uncertainty. It covers physics-based reliability analysis and
reliability-based design, robustness assessment and robust design, their
integration with design simulations, and their engineering applications.
Prerequisite: Mech Eng 208 or Aero Eng 261. (Co-listed with Aero Eng
360).

**MECH ENG 361 Engineering Design Methodology** (LEC 3.0)
This course examines structured engineering design theory and
methodologies for conceptual design and redesign of products. Topical
coverage includes customer needs gathering, functional modeling,
engineering specifications creation (OFD), concept generation, selection
and design embodiment. Team work/hands-on projects emphasized.
Prerequisite: At least Senior standing in engineering. (Co-listed with IDE
220).

**MECH ENG 363 Principles And Practice Of Computer Aided Design**
(LEC 2.0 and LAB 1.0)
This course introduces the fundamentals of computer-aided design with
emphasis on mathematical representations of curves and surfaces,
modeling of solids, and graphic displays. Students will also practice with
commercial CAD/CAM packages to gain experiences and to help grasp
fundamentals. Prerequisites: Comp Sci 53 or 73 or 74; Mech Eng 161; at
least Junior standing.

**MECH ENG 364 Introduction to Decision Analysis** (LEC 3.0)
This course is an introduction to decision analysis, a decision-making
method under uncertainty. The course topics include probability
theory, influence diagram, decision tree, subjective probability,
sensitivity analysis, value of information, risk attitude, and utility models.
Prerequisite: Stat 211 or Stat 213 or Stat 215 or Stat 217.

**MECH ENG 366 Solar Energy Technology** (LEC 3.0)
Introduction to the nature of solar radiation and associated thermal
energy transfers. Methods of collecting and storing solar energy. Analysis
and design of systems for utilizing solar energy, including heating and
cooling. Prerequisite: Mech Eng 225, or consent of instructor for non-
Mech Eng majors.

**MECH ENG 367 Heat Pump And Refrigeration Systems** (LEC 3.0)
The various methods used in the thermal design and analysis of
both refrigeration and heat pumps systems are investigated. Various
methods of producing heating and cooling are examined including
vapor compression, absorption, air cycle, steam jet, and thermoelectric
systems. Prerequisites: Mech Eng 221, 225.
MECH ENG 370 Plasma Physics I (LEC 3.0)
Single particle orbits in electric and magnetic fields, moments of Boltzmann equation and introduction to fluid theory. Diffusion of plasma in electric and magnetic fields. Analysis of laboratory plasmas and magnetic confinement devices. Introduction to plasma kinetic theory. Prerequisite: Mech Eng 231 or Mech Eng 231 or Physics 221 or Nuc Eng 221 or Elec Eng 271. (Co-listed with Aero Eng 370, Nuc Eng 370, Physics 370).

MECH ENG 371 Environmental Controls (LEC 3.0)
Theory and applications of principles of heating, ventilating, and air conditioning equipment and systems; design problems. Physiological and psychological factors relating to environmental control. Prerequisites: Mech Eng 221 and accompanied or preceded by Mech Eng 225; or Mech Eng 227 and Civ Eng 230. (Co-listed with Arch Eng 371).

MECH ENG 375 Mechanical Systems For Environmental Control (LEC 3.0)
Analysis of refrigeration, heating, and air-distribution systems. Synthesis of environmental control systems. Prerequisites: Mech Eng 221 and 225; or Mech Eng 227 and Civ Eng 230.

MECH ENG 378 Mechatronics (LEC 2.0 and LAB 1.0)
This course will introduce students to the basics of mechatronics (i.e., the integration of mechanical, electrical, computer, and control systems). Students will learn the fundamentals of sensors and actuators for mechanical systems, computer interfacing, microcontrollers, real-time software, and control. Prerequisite: Mech Eng 279 or equivalent. (Co-listed with Aero Eng 378, Elec Eng 378 and Comp Eng 378).

MECH ENG 381 Mechanical And Aerospace Control Systems (LEC 3.0)
Synthesis of mechanical and aerospace systems to perform specific control functions. Response and stability are studied. Singular value analysis for stability margins is introduced. Prerequisite: Mech Eng 279 or Aero Eng 381. (Co-listed with Aero Eng 381).

MECH ENG 382 Introduction To Composite Materials & Structures (LEC 3.0)
Introduction to fiber-reinforced composite materials and structures with emphasis on analysis and design. Composite micromechanics, lamination theory and failure criteria. Design procedures for structures made of composite materials. An overview of fabrication and experimental characterization. Prerequisite: Civ Eng 110. (Co-listed with Aero Eng 311).

MECH ENG 383 Industrial Applications Of Composite Materials Technology (LEC 3.0)

MECH ENG 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

MECH ENG 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MECH ENG 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title. (Co-listed with Aero Eng 401).

MECH ENG 407 Advanced Vibrations (LEC 3.0)
Advanced treatment of discrete and continuous vibratory systems. Extensive use is made of matrix methods and operator notation. Special topics include: transmission matrices, relative coordinates, time dependent boundary conditions, approximate techniques for linear systems, nonlinear systems, and random excitations. Prerequisite: Mech Eng or Aero Eng 307. (Co-listed with Aero Eng 407).

MECH ENG 408 Advanced Finite Element Analysis (LEC 3.0)

MECH ENG 409 Engineering Acoustics II (LEC 3.0)

MECH ENG 410 Seminar (LEC 0.0-1.0)
Discussion of current topics. (Co-listed with Aero Eng 410).

MECH ENG 413 Advanced Dynamics Of Machinery (LEC 3.0)
Current problems in aerospace dynamics are treated using methods of analytical mechanics; gyroscopic phenomena; the calculus of variations; stability of systems, to include approximate techniques. Prerequisite: Mech Eng or Aero Eng 313. (Co-listed with Aero Eng 413).

MECH ENG 422 Applied Linear Elasticity (LEC 3.0)

MECH ENG 423 Viscous Fluid Flow (LEC 3.0)
Fundamentals of viscous fluids for incompressible and compressible flows governed by Navier-Stokes equations; exact, approximate, and numerical solutions for steady and unsteady laminar flows; boundary layer theory for incompressible and compressible flows; stability and transition. Prerequisite: Mech Eng 331 or Aero Eng 351 or Mech Eng 339 or Aero Eng 339 or equivalent. (Co-listed with Aero Eng 423).

MECH ENG 425 Heat Transfer By Conduction (LEC 3.0)
A study of conduction heat transfer in solids by analytical and other methods. Prerequisite: Mech Eng or Aero Eng 325. (Co-listed with Aero Eng 425).

MECH ENG 426 Micro-/Nano-Scale Thermophysics and Energy Transport (LEC 3.0)
Introduces advanced statistical thermodynamics, nonequilibrium thermodynamics, kinetic theory, and quantum theory to analyze thermophysics and energy transport for microscale and nanoscale systems. Covers the fundamental concepts of photons, electrons, and phonons in the forms of waves and particles. Includes applications to ultrafast laser processing. Prerequisite: Mech Eng 325.
MECH ENG 427 Heat Transfer By Convection (LEC 3.0)
An analytical study of convective heat transfer in laminar and turbulent flows; forced convection, natural convection, and mixed convection; combined heat and mass transfer; heat transfer with change of phase; instability of laminar flow; current topics in convection. Prerequisite: Mech Eng or Aero Eng 325. (Co-listed with Aero Eng 427).

MECH ENG 429 Heat Transfer By Radiation (LEC 3.0)
A study of the nature of thermal radiation; implications from electromagnetic theory; radiative characteristics of surfaces; enclosures; configuration factors; radiosity; specular and diffuse reflection; transfer in absorbing, emitting and scattering media; combined radiation conduction and convection; experimental methods. Prerequisite: Mech Eng or Aero Eng 325. (Co-listed with Aero Eng 429).

MECH ENG 430 Theory Of Plates (LEC 3.0)
General coverage of various approaches to plate problems and the application of these methods to practical problems. Special topics include applications to elastic foundations, buckling and energy methods in plate theory. Prerequisite: Math 325.

MECH ENG 431 Gas Dynamics I (LEC 3.0)
A critical analysis of the phenomena governing the flow of a compressible fluid; introduction to flow in two and three dimensions; Prandtl-Meyer expansions; small perturbations in subsonic and supersonic flows; method of characteristics. Prerequisite: Mech Eng or Aero Eng 331. (Co-listed with Aero Eng 431).

MECH ENG 432 Theory Of Shells (LEC 3.0)
General theory of stress analysis of shells based on topics in differential geometry and general elasticity theory. Theory is applicable to studies of the elastic behavior of flat plates and shells, buckling and post-duckling behavior of shells, and provides a basis for all shell theories which account for anisotropy, plasticity, creep, thermal strains, internal reinforcements, and transverse shearing deformations. Prerequisite: Math 325.

MECH ENG 435 Turbulent Flows - Theory, Measurements and Modeling (LEC 3.0)
Navier-Stokes equations; statistical description and mean-flow equations; behavior of free shear and wall bounded flows; the energy cascade; turbulence spectra and Kolmogorov hypothesis; measurement techniques: PIV, hot-wires, LDV; turbulence modeling for transport processes and closure schemes for RANS equations; evaluation of model constants, introduction to LES, DNS and hybrid-RANS. Prerequisite: Mech Eng 331 or Aero Eng 331 or Mech Eng 339 or Aero Eng 339 or equivalent. (Co-listed with Aero Eng 435).

MECH ENG 436 Advanced Fracture Mechanics (LEC 3.0)
Mathematical theories of equilibrium cracks and brittle fracture, mathematical analysis of elastic-plastic fracture mechanics, COD, R-curve and J-integral analysis. Prerequisite: Aero Eng 336 or Mech Eng 336.

MECH ENG 437 Physical Gas Dynamics I (LEC 3.0)
Features of high temperature gas flows including the development of the necessary background from kinetic theory, statistical mechanics, chemical thermodynamics and chemical kinetics. Equilibrium and non-equilibrium gas properties and gas flows are included. Prerequisite: Mech Eng or Aero Eng 331. (Co-listed with Aero Eng 437).

MECH ENG 441 Advanced Energy Conversion (LEC 3.0)
An analytical study of power producing systems with emphasis on new techniques and energy sources. All basic methods of energy conversion are covered from detailed physical descriptions to mathematical analysis. Included are advanced heat engines, nuclear power reactors, thermoelectric engines, magnetohydrodynamic devices, solar energy, fuel cells, and recent developments. Prerequisite: Mech Eng (or Aero Eng) 319, or Mech Eng (or Aero Eng) 325.

MECH ENG 447 Markov Decision Processes (LEC 3.0)
Introduction to Markov Decision Processes and Dynamic Programming. Application to Inventory Control and other optimization and control topics. Prerequisite: Graduate standing in background of probability or statistics. (Co-listed with Comp Eng 457, Aero Eng 457, Eng Mgt 457 and Comp Sci 457).

MECH ENG 453 Advanced Cnc Of Manufacturing Processes & Engineering Metrology (LAB 1.0 and LEC 2.0)
Advanced treatment of Computer Numerical Control (CNC) part programming and machine tool metrology. Topics include mathematical modeling and characterization of machine tools and Coordinate Measuring Machines (CMMs); Measurement and analysis of dimensional accuracy, surface finish, precision, and uncertainty; Machine tool error modeling and compensation; Virtual Numerical Control (VNC) Machine Tool modeling, programming, simulation and process verification/optimization. Projects include advanced CNC programming and simulation. Prerequisite: Mech Eng 353.

MECH ENG 455 Modeling And Control Of Manufacturing Processes (LEC 3.0)
This course covers control-oriented modeling, simulation, and control of manufacturing processes. Topics include digital control, control system hardware, servomechanisms, interpolation, coordinated motion control, regenerative chatter, and control of machining and non-traditional processes. Control algorithms are implemented on a machining center. Prerequisites: Mech Eng 355, Mech Eng 381.

MECH ENG 457 Laser Aided Manufacturing And Materials Processing (LEC 3.0)
Fundamental studies in laser aided manufacturing and materials processing including laser principles and optics, physics of laser-materials interaction, interface responses for rapid solidification, theories on non-equilibrium synthesis, modeling of transport phenomena, optical sensing techniques, current topics and considerations for lasers in manufacturing. Prerequisite: Mech Eng 325.

MECH ENG 458 Adaptive Critic Designs (LEC 3.0)
Review of Neurocontrol and Optimization, Introduction to Approximate Dynamic Programming (ADP), Reinforcement Learning (RL), Combined Concepts of ADP and RL - Heuristic Dynamic Programming (HDP), Dual Heuristic Programming (DHP), Global Dual Heuristic Programming (GDHP), and Case Studies. Prerequisite: Elec Eng 368 Neural Networks or equivalent (Computational Intelligence Comp Eng 301) (Co-listed with Comp Eng, Elec Eng, Aero Eng and Sys Eng 458).

MECH ENG 459 Advanced Topics In Design And Manufacturing (LEC 3.0)
Various topics in the area of design and manufacturing will be covered in this course: development of flexible manufacturing systems, CAD/CAM integration, rapid prototyping, etc. Prerequisite: Mech Eng 355.
MECH ENG 461 Modern Product Design (LEC 3.0)
Modern product development, design and prototyping are examined from a product architecture standpoint in this course. Functional modeling techniques are used to establish the architecture of a product and recently developed theories and techniques for design are covered. A prototyping project is required to provide immediate application of the theories. Prerequisite: Mech Eng/Aero Eng/Eng Mgt 350 or Mech Eng 308 or Mech Eng 356.

MECH ENG 463 Advanced Digital Design and Manufacturing (LEC 3.0)
This course covers freeform modeling, reverse engineering, numerical control path generation for material removal and addition, and virtual reality based digital design and manufacturing. Students learn theoretical and fundamental aspects of these topics from lectures and project exercises. Prerequisite: Mech Eng 308 or Mech Eng 363 or similar course.

MECH ENG 475 Advanced Environmental Control (LEC 3.0)
The study of environmental control systems including their sizing, control, and energy requirements. Use of major energy analysis programs for system evaluation. Prerequisite: Mech Eng 375.

MECH ENG 479 Analysis And Synthesis Of Mechanical And Aerospace Systems (LEC 3.0)
A unified treatment of modern system theory for the Mechanical and Aerospace Engineering Controls Analyst, including analysis and synthesis of linear and nonlinear systems, compensation and optimization of continuous and discrete systems, and theory of adaptivity. Prerequisite: Mech Eng 381 or Aero Eng 381. (Co-listed with Aero Eng 479).

MECH ENG 484 Analysis Of Laminated Composite Structures (LEC 3.0)
An overview of isotropic beams, plates, and shells. Bending, vibration, and buckling of laminated composite beams and plates: exact and approximate solutions. Development of composite shell theory and simplified solutions. Analysis of composite structures including transverse shear deformation and thermal effects. Prerequisite: Mech Eng 382 or Aero Eng 311. (Co-listed with Aero Eng 484).

MECH ENG 485 Mechanics Of Composite Materials (LEC 3.0)
Effective moduli of spherical, cylindrical, and lamellar systems. Micromechanics of fiber-matrix interfaces and unidirectional composites. Application of shear lag and other approximate theories to interfaces and composites including fiber pull-out, debonding and matrix cracking. Prerequisite: Mech Eng 382 or Aero Eng 311. (Co-listed with Aero Eng 485).

MECH ENG 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

MECH ENG 491 Internship (IND 0.0-15)
Students working toward a doctor of engineering degree will select, with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

MECH ENG 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

MECH ENG 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Metallurgical Engineering (MET ENG)

MET ENG 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MET ENG 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MET ENG 303 Metals Refining and Recycling of Materials (LEC 3.0)
Survey of selected modern processes for the production of metals, the treatment of wastes, and recycling of metal values. Processes are studied with respect to raw materials, chemical reactions, energy consumption, process intensity, yield and environmental impact. Prerequisite: Cer Eng 259.

MET ENG 305 Nondestructive Testing (LEC 3.0)
Principles and applications of various means of non-destructive testing of metallic materials. Radiological inspection methods, ultrasonic testing, magnetic methods, electrical and eddy current methods and others. Prerequisite: Physics 24 or 25. (Co-listed with Elec Eng 375).

MET ENG 306 Nondestructive Testing Laboratory (LAB 1.0)
Application of radiological and ultrasonic methods of nondestructive testing of metallic materials. A radiographic X-ray units and ultrasonic equipment are used in the inspection of a variety of materials and manufactured parts. Prerequisite: Accompanied or preceded by Met Eng 305.

MET ENG 307 Metals Casting (LEC 3.0)
An advanced course in the metals and methods used in modern metals casting processes. Application of metallurgical principles to the casting of metals. Design of castings and metals casting mold features using commercial casting process simulation software. Prerequisite: Met Eng 221 or Mech Eng 153.

MET ENG 308 Metals Casting Laboratory (LAB 1.0)
An advanced laboratory study of mold materials, metal flow, and cast metals. Emphasis is given to design of gating, risering, and ladle treatment techniques required for economical, highquality castings. Prerequisite: Accompanied or preceded by Met Eng 307.

MET ENG 310 Seminar (IND 0.0-3.0)
Discussion of current topics.
**MET ENG 311 Metals Joining** (LEC 2.0)
Metals joining processes such as welding and brazing. Effects of welding on materials. Treatment and properties of welded joints. Welding defects and quality control. Prerequisite: Met Eng 121 or 221.

**MET ENG 313 Scanning Electron Microscopy** (LAB 1.0 and LEC 2.0)
A course in the theory and application of scanning electron microscopy and x-ray microanalysis. Topics considered are electron optics, image formation and analysis; x-ray generation, detection and analysis; and characterization of fracture surfaces. Prerequisites: Met Eng 217 and 218 or course in optical microscopy - consent of instructor required.

**MET ENG 315 Metallurgical Process Design Principles** (LEC 2.0)
Application of mass, component and energy balances for metallurgical design. The fundamentals of engineering economic analysis will be examined and experimental design techniques will be introduced. Students will be prepared for the selection and planning of the subsequent design project. Prerequisite: Senior standing in Met Eng.

**MET ENG 316 Metalurgical Design Project** (LAB 2.0)
Student groups will undertake selected projects, which will represent a capstone design experience utilizing skills, understanding and data from previous courses. The faculty supervised open-ended design projects will involve a variety of tasks appropriate to the metallurgical engineer. Prerequisite: Met Eng 315.

**MET ENG 318 Principles for Microstructural Design** (LEC 2.0)
This course will introduce the basics of microstructural principles that can be used to design advanced materials. It will help students learn about the basic principles and microstructural design approaches. Prerequisites: At least junior standing, Met Eng 215; Met Eng 217 or equivalent.

**MET ENG 321 Metal Deformation Processes** (LEC 3.0)
An introduction to metal deformation concepts followed by a study of various forming processes from both the analytical and applied viewpoints. Processes to include: forging, wire drawing, extrusion, rolling, sheet metal forming, and others. Prerequisite: Met Eng 221.

**MET ENG 329 Material Selection, Fabrication, And Failure** (LEC 3.0)
Factors governing the selection of materials for specific needs, fabrication, heat treatment, surface treatment, and other aspects in the production of a satisfactory component. Failure analysis and remedies. Lecture plus assigned problems. Prerequisites: Met Eng 217, 218, 221.

**MET ENG 331 Steels And Their Treatment** (LEC 3.0)
Industrially important ferrous alloys are described and classified. The selection of proper heat treatments to facilitate fabrication and to yield required service properties in steels suitable for various applications is considered. Prerequisites: Met Eng 217 and Met Eng 218.

**MET ENG 332 Metals Treatment Laboratory** (LAB 1.0)
The students plan and perform experiments that illustrate heat treating processes and their effects on the properties and structure of commercial alloys. Prerequisite: Accompanied or preceded by Met Eng 331.

**MET ENG 333 Nonferrous Alloys** (LEC 3.0)
Structure and properties of nonferrous alloys (Al, Ti, Mg, Ni and Cu) are described. The role of processing and microstructure in the development of mechanical properties is emphasized. Prerequisites: Met Eng 217 or Met Eng 377.

**MET ENG 340 Biomaterials I** (LEC 3.0)
This course will introduce senior undergraduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. Prerequisite: Senior undergraduate standing. (Co-listed with Cer Eng 340, Bio Sci 340, Chem Eng 340).

**MET ENG 341 Nuclear Materials I** (LEC 3.0)
Fundamentals of materials selection for components in nuclear applications. Design and fabrication of UO2 fuel; reactor fuel element performance; mechanical properties of UO2; radiation damage and effects, including computer modeling; corrosion of materials in nuclear reactor systems. Prerequisites: Civ Eng 110; Nuc Eng 205; Nuc Eng 223; Met Eng 121.(Co-listed with Nuc Eng 341).

**MET ENG 343 Nuclear Materials II** (LEC 3.0)
Extricable metallurgy of uranium, thorium, and zirconium. Equation of state of UO2 and fuel chemistry. LMFB fuel and interaction of sodium and stainless steel. Materials for fusion and other advanced nuclear applications. Reprocessing of spent fuel and disposal. Prerequisite: Met Eng 341.

**MET ENG 350 Composites** (LEC 3.0)
An introduction to the structure, properties and fabrication of fiber and particulate composites. Prerequisites: Met Eng 215 & 211 or Cer Eng 102 & 242.

**MET ENG 352 International Engineering and Design** (LEC 3.0)
A multi-disciplinary engineering course focused on sustainable design and technology transfer to developing countries. Course includes elements of traditional capstone design classes. Experiential learning through competitions and/or field work is a major component of the class. Prerequisite: Senior standing, instructor approval. (Co-listed with Geo Eng 352 and Cer Eng 352).

**MET ENG 353 Mineral Processing II (Mechanics and Design)** (LAB 1.0 and LEC 2.0)
Mineral particle mechanics of comminution, sizing, classification, concentration, filtering and thickening. Mill and equipment selection and design including flowsheet, development and plant assessment. Prerequisite: Min Eng 241. (Co-listed with Min Eng 353).

**MET ENG 354 Electrical Systems and Controls for Materials** (LAB 1.0 and LEC 2.0)
This course will cover analysis of alternating and direct current circuits as experienced in the materials industry. Current, voltage, and power relationships in single and three-phase electrical power systems. Introduction to continuous and batch instrumentation including programmable logic controllers (PLCs) and computer interfacing for materials applications. Prerequisite: Physics 24.

**MET ENG 355 Process Metallurgy Applications** (LEC 3.0)
Application of thermodynamics to process metallurgy. Equilibrium calculations with stoichiometry and heat balance restrictions, phase transformations, and solution thermodynamics. Use of thermodynamic software to solve complex equilibria in metallurgical applications. Prerequisite: Cer Eng 259.

**MET ENG 356 Steelmaking** (LEC 3.0)
An introduction to the fundamentals and unit processes used to turn impure iron and scrap into steel. Includes desulfurization, BOF and electric furnace operations, ladle metallurgy, casting, and stainless steel manufacture. Prerequisite: Cer Eng 259.
MET ENG 359 Environmental Aspects Of Metals Manufacturing (LEC 3.0)
Introduction to environmental aspects of metal extraction, melting, casting, forming, and finishing. Subjects include history of environmental movement and regulations permitting, risk analysis, disposal and recycling of metal manufacturing residues, environmental ethics, environmental technologies and case studies. Prerequisite: Junior/Senior standing.

MET ENG 361 Alloying Principles (LEC 3.0)
Basis for alloy design and property control. Predictions of phase stability, alloy properties and metastable phase possibilities; interfaces in solids and their role in phase transformations. Prerequisites: Met Eng 217, 218.

MET ENG 363 Metal Coating Processes (LEC 3.0)
Introduction to the current technologies used to enhance metal performance, particularly corrosion resistance, by overlay coatings. Deposition processes are emphasized and the fundamentals of the behavior of the films in high technology and electronic materials applications is discussed. Prerequisite: Senior or Graduate Standing.

MET ENG 365 Microfabrication Materials And Processes (LEC 3.0)
An overview course on the materials and processes used to fabricate integrated circuits, microelectromechanical systems (MEMS), interconnect substrates and other microelectronic components from starting material to final product. The emphasis will be on the influence of structure and processing on the electrical, mechanical, thermal, and optical properties. Prerequisites: Chem 1 or equivalent; Senior or Graduate Standing.

MET ENG 367 Introduction to Particulate Materials (LEC 3.0)
Powder metallurgy and ceramic components, filters, catalysts, nanomaterials, vitamins and more depend strongly on particulate, or powder, characteristics and processing. Aspects of powder fabrication, characterization, safety, handling, component fabrication, secondary processing, and applications will be covered. Prerequisite: Met Eng 121.

MET ENG 375 Metallurgical Failure Analysis (LEC 3.0)
Application of the principles of manufacturing and mechanical metallurgy for the analysis of failed components. Analytical techniques such as Scanning Electron Microscopy, Optical Metallography, and High Resolution Photography are used to characterize microstructure and fractographic features. In addition, appropriate methods to gather data, assimilate it, and draw conclusions from the data such that it will stand up in a court of law will be addressed. Prerequisite: Senior or Graduate Student standing.

MET ENG 377 Principles Of Engineering Materials (LEC 3.0)
Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Aero Eng 377, Chem Eng 347, Physics 377, Cer Eng 377).

MET ENG 381 Corrosion And Its Prevention (LEC 3.0)
A study of the theories of corrosion and its application to corrosion and its prevention. Prerequisite: Chem 243 or Cer Eng 259. (Co-listed with Chem Eng 381).

MET ENG 385 Mechanical Metallurgy (LEC 3.0)
Elastic and plastic behavior of metallic single crystals and polycrystalline aggregates. Resulting changes in mechanical properties are considered. Included are applications to metal fabrication. Prerequisites: Met Eng 215, 216, Civ Eng 110.

MET ENG 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

MET ENG 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MET ENG 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MET ENG 403 High Temperature And Corrosion Resistant Alloys (LEC 3.0)
Fabrication and use of nickel, titanium, and refractory metal based alloys for use at high temperatures or in chemically corrosive environments. Properties and strengthening mechanisms of these alloys. Theory of high temperature oxidation and corrosion and design of alloys to prevent them. Prerequisites: Met Eng 217, 218.

MET ENG 404 Recent Advances In Extractive Metallurgy (LEC 2.0)
A survey of extractive processes recently developed in the light of modern requirements with respect to raw materials, product quality, environmental impact, energy consumption, capital cost and process control. Prerequisite: Met Eng 355.

MET ENG 414 Transmission Electron Microscopy (LEC 2.0 and LAB 1.0)
A course in the theory and application of transmission electron microscopy. Topics considered are electron optics, image formation, defect structures, specimen preparation, contrast theory and electron diffraction. Prerequisite: Met Eng 313.

MET ENG 421 Ferrous Metals Casting (LEC 3.0)
An advanced study of the metallurgy of cast irons and net shape cast steel alloys. Includes theories of nucleation and growth in gray, nodular, compacted graphite and malleable irons. The effects of deoxidation practice and inclusion shape control for cast steels are also included. The effects of alloying elements, processing variables and heat treatment.

MET ENG 429 Advanced Materials Selection And Fabrication (LEC 3.0)
Application of the principles of material selection and the factors governing fabrication, heat treatment, and surface treatment. Weekly assignments requiring library research and written reports. Lecture plus classroom discussion of assigned problems.

MET ENG 440 Biomaterials II (LEC 3.0)
This course will introduce graduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. A term paper and oral presentation are required. Prerequisite: Graduate Standing. (Co-listed with Cer Eng 440, Bio Sci 440, Chem Eng 440).

MET ENG 451 Refining Of Metals (IND 2.0-3.0)
Principles and applications of thermochemistry, phase equilibria, and kinetics as applied to the refining of metals and alloys. Theory of dilute solutions, interaction coefficients and reactions of metals with gases and slags. Analysis and design of refining processes. Optional third credit hour requires a term paper. Prerequisite: Met Eng 355 or Cer Eng 259.
**MET ENG 457 Transport Phenomena In Extractive Metallurgy** (LEC 3.0)
The application of chemical reaction engineering principles to metallurgical processes. Residence-time distribution in reactors and its effect on performance, topochemical gas-solid reactors, two-film theory of mass transfer applied to slag-metal and gas-metal reactions. Prerequisite: Met Eng 355 or equivalent.

**MET ENG 490 Research** (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

**MET ENG 493 Oral Examination** (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**MET ENG 495 Continuous Registration** (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

**Mining Engineering (MIN ENG)**

**MIN ENG 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**MIN ENG 301 Special Topics** (LAB 1.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**MIN ENG 302 Computer Aided Mine Design** (LEC 2.0 and LAB 1.0)
Project-based mine planning and design course. Engineering design process applied to computer-aided mine planning and design. Mine layouts, production planning, and materials scheduling optimization. Prerequisite: Min Eng 225 or graduate standing.

**MIN ENG 303 Aggregate Materials Sizing and Characterization** (LEC 2.0 and LAB 1.0)
Geological formation of aggregates; aggregate properties and their measurements; aggregates for specific end-user applications; specifications and standards; processing (crushing, screening, classification, and washing); plant design and flow sheet analysis; quality control and assurance. Prerequisite: Min Eng 241.

**MIN ENG 304 Advanced Aggregate and Quarrying** (LEC 3.0)
Advanced coverage of topics on the stone and aggregate industry, including surface and underground operations, plant equipment, economics, marketing, transportation, and environmental topics. The course will include at least one field trip and a design project. Prerequisite: Min Eng 215, co-requisite: Civ Eng 216.

**MIN ENG 306 Material Processing By High-Pressure Water Jet** (LEC 3.0)
Methods of generating high pressure water jets; standard equipment, existing techniques and basic calculations. Applications of water jets to materials cutting and mineral processing. Safety rules. The course will be supported by laboratory demonstrations. (Co-listed with Mech Eng 306).

**MIN ENG 307 Principles Of Explosives Engineering** (LEC 2.0 and LAB 1.0)
Theory and application of explosives in the mining industry; explosives, initiating systems, characteristics of explosive reactions and rock breakage, fundamentals of blast design, drilling and blasting, regulatory and safety considerations. Prerequisites: Min Eng 151; accompanied or preceded by Civ Eng 215 or Geology 220 or Geology 125; Successful background check. (Co-listed with Exp Eng 307).

**MIN ENG 311 Mine Plant Management** (LEC 2.0)
Optimization of mine plant and equipment performance. Availability, utilization and reliability of equipment; matching equipment and plant to mine site specific conditions; maintenance planning, scheduling and control; parts and materials supply systems; mine information and management systems. Basics of mine automation and robotics. Prerequisite: Senior standing or consent of instructor.

**MIN ENG 312 Ore Reserve Analysis And Geostatistics** (LEC 2.0 and LAB 1.0)
An introduction to principles of geostatistics. theory of spatially correlated random variables, variance and co-variances and their application on the evaluation of mineral resources, ore reserve estimation, strategic exploration, and production planning. Real case studies from mining industry will be presented. Prerequisites: Math 204, Stat 213.

**MIN ENG 315 Advanced Mine Health and Safety** (LEC 3.0)
A detailed study of health and safety principles, practices, analyses, regulations, issues and technology in the mining industry. Prerequisite: Min Eng 151.

**MIN ENG 317 Mine Power And Drainage** (LEC 2.0 and LAB 1.0)

**MIN ENG 318 Mine Atmosphere Control** (LAB 1.0 and LEC 2.0)
Fundamentals of mine ventilation, including the principles of airflow, control of gases, dust, and temperature, methane drainage, mine fans, network theory, computer network simulation, and economics of airflow, with emphasis on analysis, systems design and practical application. Prerequisite: Civ Eng 230.

**MIN ENG 322 Mine Management** (LEC 2.0)
Theory and practice of mine management, including basic managerial functions, management theories, communication skills, motivation, leadership, organization, maintenance management, managerial decision making, cost control, labor relations, government relations, ethics, with emphasis in presentation skills. Prerequisite: Completion of 100 credits in Mining Engineering curriculum.
**MIN ENG 324 Underground Mining Methods And Equipment (LEC 3.0)**

**MIN ENG 326 Surface Mining Methods And Equipment (LEC 3.0)**
Principles of planning, constructing, and operating economically viable surface mines. Cost effective mining methods: placer mining, strip mining, open pit mining, quarrying. Selection of equipment for surface mining operations. Optimization of mine performance. Field trip required. Prerequisites: Min Eng 215; Min Eng 225; Min Eng 270; coreq. Min Eng 331.

**MIN ENG 331 Rock Mechanics (LAB 1.0 and LEC 2.0)**
Applications of the fundamental principles of mechanics to engineering problems of equilibrium, strength and stiffness of rock materials. Review of in-situ stresses, laboratory and field instrumentation, rock and rockmass properties, pillar design, roof span design, rock reinforcement, surface subsidence, slope stability, and violent failures. Field trip required. Prerequisites: IDE 140, or Civ Eng 50 and IDE 150; and Geology 220.

**MIN ENG 332 Soils and Overburden Materials for Mining Engineering (LEC 2.0)**
Physical and mechanical properties of soils and overburden materials. Soils and overburden characterization for reclamation and mine closure and overburden blasting. Soil failure modes and slope stability for surface mine layouts, waste dumps, tailings and earth dams, and foundations for heavy mining machinery. Prerequisites: IDE 140, or Civ Eng 50 and IDE 150.

**MIN ENG 342 Environmental And Natural Resource Economics (LEC 3.0)**
Optimum use of replenishable and non-replenishable resources, public goods and common resources, externalities, private vs. public costs, and quality of the environment; emphasis on public policy related to environmental and natural resource economics. Prerequisite: Econ 221. (Co-listed with Econ 340).

**MIN ENG 343 Coal Mine Development And Production (LEC 3.0)**
An in-depth study of all aspects of coal mining, including an overview of coal industry, reserves and geology, planning and development of coal mines, surface and underground mechanized methods of face preparation, equipment, coal extraction, handling and preparation as practiced in the United States. Prerequisite: Accompanied or preceded by Min Eng 217.

**MIN ENG 344 Coal Preparation (LEC 2.0 and LAB 1.0)**
Coal properties, sampling, testing, breaking, sizing, cleaning and dewatering. Disposal of refuse. Prerequisites: Min Eng 241 and senior standing.

**MIN ENG 345 Strata Control (LEC 3.0)**
A detailed review of artificial ground support, both above and below ground, including slope stabilization techniques and shaft and tunnel liner design. The use of shotcrete, roofbolts, and solid liners and the principles of underground longwall and room and pillar mine support. Longwall and hydraulic mining practice is covered. Prerequisite: Min Eng 331.

**MIN ENG 350 Blasting Design And Technology (LAB 1.0 and LEC 2.0)**
Advanced theory and application of explosives in excavation; detailed underground blast design; specialized blasting including blast casting, construction and pre-splitting. Introduction to blasting research. Examination of field applications. Prerequisites: Min Eng 307. Student must be at least 21 years of age. Successful background check. (Co-listed with Exp Eng 350).

**MIN ENG 352 Mineral Processing I (Flotation and Hydrometallurgy) (LAB 1.0 and LEC 2.0)**
Forth flotation including mineral surfaces, double layer theory, zeta potential, hydrophobicity, adsorption, collectors, frothers, modulation, kinetics, and sulphide and acid flotation systems. Hydrometallurgy including leaching, ion exchange and liquid/liquid extraction. Prerequisite: Min Eng 241.

**MIN ENG 353 Mineral Processing II (Mechanics and Design) (LAB 1.0 and LEC 2.0)**
Mineral particle mechanics of comminution, sizing, classification, concentration, filtering and thickening. Mill and equipment selection and design including flowsheet, development and plant assessment. Prerequisite: Min Eng 241. (Co-listed with Met Eng 353).

**MIN ENG 355 Energy Economics (LEC 3.0)**
Market structure. World resource development. Supply and demand analysis on energy production and consumption within domestic and global settings. Prerequisite: Econ 221. (Co-listed with Econ 355).

**MIN ENG 376 Environmental Aspects Of Mining (LEC 3.0)**
Permitting: the legal environment of reclamation and environmental impact assessment; post-mining land-use selection and mine planning for optimum reclamation of all mines: metal, nonmetal, and coal; unit operations of reclamation: drainage, backfill, soil replacement, revegetation, maintenance, etc. Prerequisites: Geo Eng 50; Min Eng 324 and 326 or prereq./coreq. Civ Eng 215. (Co-listed with Geo Eng 376).

**MIN ENG 383 Tunneling & Underground Construction Techniques (LEC 2.0 and LAB 1.0)**
Cover both mechanical excavation and conventional excavation techniques to underground tunneling and construction. The emphasis will be on equipment selection and prediction of performance expected of the equipment. Ground control systems will be covered as technology emerges. Excavation methods and support of large caverns, often found in civil structures, will also be discussed. A limited focus will be on underground construction specifications and underground advance rate and cost estimation techniques. Prerequisites: Min Eng 331, Min Eng 324 or Civ Eng 215, Civ Eng 216 or Geo Eng 371.

**MIN ENG 390 Undergraduate Research (IND 0.0-6.0)**
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

**MIN ENG 392 Mine Design Project I (LAB 1.0)**
Formation of mine design project teams and acquisition of project data from industry. Geostatistical methods for ore reserves estimation. Develop complete project schedule and milestones for executing the project tasks in Min Eng 393 (Mine Design Project II). Set up database for Min Eng 393 and interact with selected mine design software packages.
MIN ENG 393 Mine Design Project II (LAB 3.0 and LEC 1.0)
Capstone project with written and oral presentations. Includes mine design and optimization, production plan, equipment and flowsheet design based on geology, resources/reserves, geotechnics, hydrology and hydro-geology. Project also incorporates markets, environmental and permitting, mine-mill organization, support facilities, economic and risk analyses. Prerequisite: Min Eng 392 and completion of 110 hours in the Mining Engineering Curriculum.

MIN ENG 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MIN ENG 401 Special Topics (LEC 2.0 and LAB 1.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MIN ENG 402 Environmental Controls For Blasting (LAB 1.0 and LEC 2.0)
Advanced blast mechanics; overbreak control including comprehensive coverage of perimeter and smoothwall specialist blasting techniques and geotechnical factors affecting blast vibration, limits analysis monitoring and control; air blast control including limits, monitoring and atmospheric and topographic effects. Prerequisites: Min Eng 307, Successful background check. (Co-listed with Exp Eng 402).

MIN ENG 403 Optimization Applications In Mining I (LEC 3.0)
Mining applications of deterministic optimization techniques are covered, including linear, integer, mixed-integer, dynamic, unconstrained and constrained nonlinear, and heuristic programming. Prerequisite: Graduate standing or consent.

MIN ENG 404 Advanced Mining Systems (LEC 3.0)
Principles of design for the development and production of hard rock mineral deposits that require integrated surface and underground mining methods. Cost considerations leading to optimization. Terminal feasibility report required. Prerequisites: Min Eng 224, 226 and 393.

MIN ENG 407 Theory Of High Explosives (LEC 3.0)
Study of the application of chemical thermodynamics and the hydrodynamic theory to determine the properties of high explosives; application of detonation theory to steady-state detonations in real explosives; application of the above to the blasting action of explosives. Prerequisite: Successful background check and Graduate Standing. (Co-listed with Exp Eng 407).

MIN ENG 409 Mining Property Feasibility Studies And Evaluation Procedure (LAB 1.0 and LEC 2.0)
A systematic phased approach is presented, designed to increase the level of confidence and accuracy of estimates, moving from exploration through to a "bankable" study. Liability, ethics, resource/reserves, political/social/investment risk, economic parameters, and due diligence are discussed. Prerequisite: Min Eng 270 or Geology 284 or Civ Eng 241 or Eng Mgt 208 or Min Eng 376 or Geophy 382.

MIN ENG 410 Seminar (RSD 1.0)
Discussion of current topics.

MIN ENG 411 Research Methods (LEC 3.0)
Foundations, dimensions, and methods for designing and investigating research problems in Mining Engineering. Focus on fundamental and applied research, research methods, literature review, experimental design and experimentation, dissertation composition, concepts of originality and intellectual property. Prerequisite: Graduate standing.

MIN ENG 412 Mine Management II (LEC 3.0)
The course covers advanced concepts in managing mine operations. Topics to be covered include TQM, statistical process control, benchmarking, KPI, standards and standardization, ISO 9000: Quality Control, ISO 14000: Environmental systems, OHSAS 18000. Management systems, SA8000, Social Accountability and others. Prerequisite: Consent of instructor.

MIN ENG 415 Advanced Mine Health And Safety Design (LEC 3.0)
Principles of design of mining operations with emphasis on the health and safety of the worker. Prerequisite: Graduate standing.

MIN ENG 416 Advanced Mineral Engineering Design II (LEC 1.0 and LAB 2.0)
Incorporation of principles developed in Mining 415 in advanced design projects for mineral plants and systems, with emphasis on environmental protection, health, and safety. Prerequisite: Min Eng 415.

MIN ENG 418 Mine Atmospheric Control II (LEC 3.0)
Climatic measurements and temperature recalculations, emergency plans for fan failures and mine fires, mine air contaminants, mine noises, mine dust, refrigeration and cooling plant layout, radiation control. Prerequisite: Min Eng 318.

MIN ENG 422 Advanced Rock Mechanics (LEC 3.0)
Advanced topics in static and dynamic rock mechanics; elasticity theory, failure theories and fracture mechanics applied to rock; stress wave propagation and dynamic elastic constants; rock mass classification methods for support design; pillar design in coal and metal mines; introduction to numerical models. Prerequisite: Min Eng 331 or Civ Eng 215.

MIN ENG 433 Rock Mechanics IV (LEC 3.0)
Advanced topics in dynamic rock mechanics. Stress wave propagation in the earth, dynamic elastic constants in isotropic and anisotropic rock, Hopkinson bar impact analysis, spallation and radial fracturing caused by stress pulses, shock wave generation in rock by explosions, shock wave propagation and effects. Prerequisite: Min Eng 331 or Civ Eng 215.

MIN ENG 490 Research (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

MIN ENG 491 Internship (IND 0.0-15)
Students working toward a doctor of engineering degree will select, with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

MIN ENG 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/ comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

MIN ENG 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.
Materials Science & Eng (MS&E)

MS&E 301 Special Topics (LAB 0.0 and LEC 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MS&E 325 Materials Selection in Mechanical Design (LEC 3.0)
This course will introduce the basics of materials selection in mechanical design. It will also introduce the benefits of computational materials and process selection. The students will also learn to use a commercially available materials selection software. This course will be offered as Distance Ed. Prerequisite: Met Eng 121.

MS&E 341 Tissue Engineering I (LEC 3.0)
The course will introduce senior undergraduate students to the principles and clinical applications of tissue engineering including the use of biomaterials scaffolds, living cells and signaling factors to develop implantable parts for the restoration, maintenance, or replacement of biological tissues and organs. Prerequisite: Senior standing. (Co-listed with Bio Sci 341).

MS&E 348 Energy Materials (LEC 3.0)
The objectives of the course are to understand how the rational design and improvement of chemical and physical properties of materials can lead to energy alternatives that can compete with existing technologies. Discussions on the present and future energy needs from a view point of multidisciplinary scientific and technological approaches. Prerequisite: Senior standing.

MS&E 351 Advanced Phase Equilibria (LEC 3.0)
Advanced aspects of unary, binary and ternary organic, phase equilibria. Includes practical examples of the applications of phase diagrams to solve engineering problems. Prerequisite: Graduate standing.

MS&E 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MS&E 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MS&E 410 Seminar (RSD 0.0-6.0)
(Variable) Discussion of current topics.

MS&E 421 Bonding, Crystallography, and Structure-Property Relationships (LEC 3.0)
Principles of electronic structure and chemical bonding in solids and their relationships to electrical, mechanical, thermal, and optical properties. An exploration of reciprocal lattices and tensor properties of crystals; consideration of the impact of crystal symmetry on anisotropy. The influence of defects and grain boundary phenomena on material behavior. Prerequisite: Graduate standing, or undergraduate standing with instructor and advisor approval.

MS&E 422 Thermodynamics and Phase Equilibria (LEC 3.0)
Classical thermodynamic treatment of materials and material processing based on the 1st and 2nd Laws of Thermodynamics and phase equilibria considerations. The course will cover equilibria in gaseous systems, gas-solid reactions including passive and active oxidation, solution thermodynamics, phase equilibria in solution systems, and electrochemistry. Prerequisite: Graduate standing, or undergraduate standing with instructor and advisor approval.

MS&E 423 Kinetic Theory for Materials (LEC 3.0)
Phenomenological and atomistic theories of diffusion in materials including discussion of short circuit diffusion and ionic diffusion in an electric field. Fundamentals of phase transformation in materials; chemical fluctuation, nucleation and growth theory; kinetic models for evaluating and predicting diffusion controlled transformation kinetics. Prerequisite: Graduate standing, or undergraduate standing with instructor and advisor approval.

MS&E 441 Tissue Engineering II (LEC 3.0)
The course will introduce graduate students to the principles and clinical applications of tissue engineering including the use of biomaterials, scaffolds, living cells and signaling factors to develop implantable parts for the restoration, maintenance, or replacement of biological tissues and organs. A related topic term paper and oral presentation are expected. Prerequisite: Graduate standing. (Co-listed with Bio Sci 441).

MS&E 443 Nanomaterials (LEC 3.0)
Introduction of the fundamentals of nanomaterials and recent developments on nanomaterials. Topics include physical and chemical properties, synthesis, processing, and applications of nanomaterials. Example nanomaterials include nanoparticles, nanotubes, and nanowires. Students will need to complete a project related to nanomaterials. Prerequisite: Graduate Standing. (Co-listed with Chem Eng 443).

MS&E 448 Advanced Energy Materials (LEC 3.0)
The objectives of the graduate level course are to review the recent developments on advanced energy materials and systems in addition to basic understanding how chemical and physical properties of materials can lead to energy alternatives. Prerequisite: Graduate standing.

MS&E 490 Research (IND 0.0-15)
(Variable) Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

MS&E 491 Internship (IND 0.0-15)
(Variable) Students working toward a doctor of engineering degree will select with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

MS&E 493 Oral Examination (IND 0.0)
(Variable) After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D students may be processed during intersession. Off-campus M.S. students must be enrolled in an oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

MS&E 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Nuclear Engineering (NUC ENG)

NUC ENG 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.
**NUC ENG 301 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**NUC ENG 303 Reactor Physics I** (LEC 3.0)
Study of neutron interactions, fission, chain reactions, neutron diffusion and neutron slowing down; criticality of a bare thermal homogeneous reactor. Prerequisite: Nuc Eng 205.

**NUC ENG 304 Reactor Laboratory I** (LAB 1.0 and LEC 1.0)
Acquaints the student with neutron flux measurement, reactor operation, control rod calibration, reactor power measurement and neutron activation experiments. Experiments with the thermal column and neutron beam port are also demonstrated. Prerequisites: Nuc Eng 204, 205.

**NUC ENG 306 Reactor Operation II** (LAB 1.0)
The operation of the training reactor. The program is similar to that required for the NRC Reactor Operator's license. Students from other disciplines will also benefit from the course. Prerequisite: Nuc Eng 105, 206.

**NUC ENG 307 Nuclear Fuel Cycle** (LEC 3.0)
Nuclear fuel reserves and resources; milling, conversion, and enrichment; fuel fabrication; in-and-out-of core fuel management; transportation, storage, and disposal of nuclear fuel; low level and high level waste management, economics of the nuclear fuel cycle. Prerequisite: Nuc Eng 205.

**NUC ENG 308 Reactor Laboratory II** (LEC 1.0 and LAB 1.0)
A continuation of Nuclear Engineering 304 with experiments of a more advanced nature. Prerequisite: Nuc Eng 304.

**NUC ENG 309 Licensing Of Nuclear Power Plants** (LEC 2.0)
The pertinent sections of the Code of Federal Regulations, the Nuclear Regulatory Commission’s Regulatory Guides and Staff Position Papers, and other regulatory requirements are reviewed. Safety analysis reports and environmental reports for specific plants are studied.

**NUC ENG 310 Seminar** (RSD 0.0-6.0)
Discussion of current topics. Prerequisite: Senior standing.

**NUC ENG 311 Reactor Physics II** (LEC 3.0)
Analytic and computer based methods of solving problems of reactor physics. Prerequisites: Nuc Eng 303, Comp Sci 228.

**NUC ENG 312 Nuclear Radiation Measurements and Spectroscopy** (LAB 1.0 and LEC 2.0)
Contemporary radiation detection theory and experiments with high resolution gamma-ray spectroscopy, solid state detectors, neutron detection and conventional gas filled detectors. Neutron activation analysis of unknown material, statistical aspects of nuclear measurements. Prerequisite: Nuc Eng 205.

**NUC ENG 315 Space Nuclear Power And Propulsion** (LEC 3.0)
A study of the design, operation and application of radioisotope power generators and nuclear reactors for space power and propulsion systems used on both manned and unmanned missions. Prerequisites: Nuc Eng 303 and Nuc Eng 319.

**NUC ENG 317 Two-phase Flow in Energy Systems - I** (LEC 3.0)
It is an introductory course for both undergraduate or graduate students who are interested in the application of two-phase flow in energy systems. It will acquaint students with governing equations for both single-phase and two-phase fluid flow, state-of-the-art analytical methods and various two-phase flow phenomena related to energy systems. Prerequisite: Nuc Eng 221 or Chem Eng 231 or Mech Eng 231.

**NUC ENG 319 Nuclear Power Plant Systems** (LEC 3.0)
A study of current nuclear power plant concepts and the environmental economics and safety considerations affecting their design. Includes such topics as: thermodynamics, thermal hydraulics, and mechanical and electrical aspects of nuclear power facilities. Prerequisites: Nuc Eng 205 and accompanied or preceded by Nuc Eng 223.

**NUC ENG 322 Nuclear System Design I** (LEC 1.0)
A preliminary design of a nuclear system (e.g. a fission or fusion nuclear reactor plant, a space power system, a radioactive waste disposal system). Prerequisites: Nuc Eng 223, 303, 319, preceded or accompanied by Nuc Eng 341.

**NUC ENG 323 Nuclear System Design II** (LEC 3.0)
A complete design of a nuclear system (e.g. a fission or fusion nuclear reactor plant, a space power system, a radioactive waste disposal system). Prerequisite: Nuc Eng 322.

**NUC ENG 327 Radiological Engineering** (LEC 3.0)

**NUC ENG 333 Applied Health Physics** (LEC 3.0)
Radiation sources; external and internal dosimetry; biological effects of radiation; radiation protection principles; regulatory guides; radioactive and nuclear materials management. Prerequisite: Nuc Eng 203 or Physics 107.

**NUC ENG 335 Radiation Protection Engineering** (LEC 3.0)

**NUC ENG 341 Nuclear Materials I** (LEC 3.0)
Fundamentals of materials selection for components in nuclear applications, design and fabrication of UO2 fuel; reactor fuel element performance; mechanical properties of UO2; radiation damage and effects, including computer modeling; corrosion of materials in nuclear reactor systems. Prerequisites: Civ Eng 110; Nuc Eng 205; Nuc Eng 223; Met Eng 121. (Co-listed with Met Eng 341).

**NUC ENG 345 Radioactive Waste Management And Remediation** (LEC 3.0)
Sources and classes of radioactive waste, long-term decay, spent fuel storage, transport, disposal options, regulatory control, materials issues, site selection and geologic characterization, containment, design and monitoring requirements, domestic and foreign waste disposal programs, economic and environmental issues, history of disposal actions, and conduct of remedial actions and clean up. Prerequisite: Math 204. (Co-listed with Geology 345).

**NUC ENG 351 Reactor Kinetics** (LEC 3.0)
Derivation and solutions to elementary kinetics models. Application of the point kinetics model in fast, thermal reactor dynamics, internal and external feedback mechanism. Rigorous derivation and solutions of the space dependent kinetics model fission product and fuel isotope changes during reactor operation. Prerequisite: Nuc Eng 205.
**NUC ENG 361 Fusion Fundamentals** (LEC 3.0)
Introduction to the plasma state, single particle motion, kinetic theory, plasma waves, fusion, power generation, radiation mechanisms, inertial confinement and fusion devices, including conceptual fusion power plant designs. Prerequisite: Preceded or accompanied by Math 204.

**NUC ENG 370 Plasma Physics I** (LEC 3.0)
Single particle orbits in electric and magnetic fields, moments of Boltzmann equation and introduction to fluid theory. Diffusion of plasma in electric and magnetic fields. Analysis of laboratory plasmas and magnetic confinement devices. Introduction to plasma kinetic theory. Prerequisite: Aero Eng 231 or Mech Eng 231 or Physics 221 or Nuc Eng 221 or Elec Eng 271. (Co-listed with Aero Eng 370, Mech Eng 370, Physics 370).

**NUC ENG 381 Probabilistic Risk Assessment I** (LEC 3.0)
A study of the techniques for qualitative and quantitative assessment of reliability, safety and risk associated with complex systems such as those encountered in the nuclear power industry. Emphasis is placed on fault tree analysis. Prerequisite: Nuc Eng 205.

**NUC ENG 390 Undergraduate Research** (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

**NUC ENG 400 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**NUC ENG 401 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**NUC ENG 403 Advanced Reactor Physics** (LEC 3.0)
Transport and diffusion theory; multigroup approximation; criticality calculations; cross-section processing; buildup and depletion calculations; delayed neutrons and reactor kinetics; lattice physics calculations; full core calculations; analysis and measurement of reactivity coefficients. Prerequisite: Math 325.

**NUC ENG 405 Linear Transport Theory** (LEC 3.0)
Monoenergetic Boltzmann equation for neutral particles by the method of singular eigen-functions and polynomial expansions. Prerequisites: Nuc Eng 303, Math 358.

**NUC ENG 407 Advanced Nuclear Thermal Hydraulics** (LEC 3.0)
Integrated treatment of thermodynamics and advanced mass, momentum and energy transport in solids and fluids; velocity and temperature distributions in laminar and turbulent flow; flow and thermal analysis with applications to nuclear engineering systems. Prerequisite: Nuc Eng 303.

**NUC ENG 410 Seminar** (RSD 0.0-6.0)
Discussion of current topics.

**NUC ENG 411 Computational Methods In Nuclear Engineering** (LEC 3.0)
Numerical solution of the neutron diffusion and transport equations utilizing the computer. The Sn and Pn methods are studied in detail. Prerequisites: Nuc Eng 305 and Comp Sci 218.

**NUC ENG 421 Advanced Nuclear Reactor Design** (LEC 3.0)
Complete design of a nuclear power reactor, including analysis of reactor physics and engineering; layout and design of primary and secondary cooling systems, pressure vessel and thermal shields, control systems; introduction to the economics of nuclear power. Prerequisites: Nuc Eng 311 and 321.

**NUC ENG 423 Nuclear Reactor Safety** (LEC 3.0)
Study of safety criteria; reactor characteristics pertinent to safety; reactor transient behavior; loss of coolant accident analysis; emergency core cooling; fuel behavior during accident conditions; reactor risk analysis; current reactor safety issues. Prerequisites: Nuc Eng 303 and 321.

**NUC ENG 425 Plasma Physics** (LEC 3.0)
Fundamentals of kinetic, theory, fluid equations, MHD equations, and applications: wave propagation, shielding effect, diffusion, stability, and charged particle trajectories. Prerequisite: Nuc Eng 361 for Nuc Eng; Physics 411 for Physics.

**NUC ENG 431 Radiation Shielding** (LEC 3.0)
Radiation sources; interactions of radiation with matter; dosimetry and radiation protection guidelines. The particle transport equation and methods of solving it; the Monte Carlo Method; special computational methods for neutron and gamma attenuation. Computer codes used in shielding. Shielding materials, shield design. Prerequisite: Nuc Eng 303.

**NUC ENG 441 Effects Of Radiation On Solids** (LEC 3.0)
The theories of the interaction of nuclear radiation with matter. Experimental approaches to radiation studies, including the sources and dosimetry. Nature and properties of crystal imperfections. The influence of radiation on physical, mechanical and surface properties of metals and alloys. Radiation effects on materials other than those incorporated in nuclear reactors. The annealing of defects. Prerequisite: Met Eng 341.

**NUC ENG 481 Probabilistic Risk Assessment II** (LEC 3.0)
A continuation of Nuc Eng 381 with emphasis on reliability, importance, availability and frequency of occurrence. Advanced topics of phased mission analysis and dynamic fault tree analysis will be considered. The use of fault tree results with respect to risk calculations will be studied. Prerequisite: Nuc Eng 381.

**NUC ENG 490 Research** (IND 0.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

**NUC ENG 491 Internship** (IND 0.0-15)
Students working toward a doctor of engineering degree will select with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

**NUC ENG 493 Oral Examination** (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**NUC ENG 495 Continuous Registration** (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

**Petroleum Engineering (PET ENG)**
PET ENG 300 Special Problems (IND 1.0-3.0)
Problems or readings on specific subjects or projects in the department.
Consent of instructor required.

PET ENG 301 Special Topics (LEC 1.0-3.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

PET ENG 302 Offshore Petroleum Technology (LEC 3.0)
An introduction to the development of oil and gas fields offshore, including offshore leasing, drilling, well completions, production facilities, pipelines, and servicing. Subsea systems, and deepwater developments are also included. This course is suitable for mechanical, electrical and civil engineering students interested in ultimately working offshore.

PET ENG 303 Environmental Petroleum Applications (LEC 3.0)
This course is a study of environmental protection and regulatory compliance in the oil and gas industry. The impact of various environmental laws on drilling and production operations will be covered. Oilfield and related wastes and their handling are described. Federal, state and local regulatory agencies are introduced, and their role in permitting and compliance monitoring is presented. Legal and ethical responsibilities are discussed. Prerequisite: Chem 1.

PET ENG 308 Applied Reservoir Simulation (LEC 3.0)
Simulation of actual reservoir problems using both field and individual well models to determine well spacing, production effects of secondary and enhanced recovery processes, future rate predictions and recovery, coning effects, relative permeability adjustments and other history matching techniques. Prerequisite: Pet Eng 241.

PET ENG 310 Seminar (RSD 1.0)
Discussion of current topics. (Course cannot be used for graduate credit). Prerequisite: Senior standing in Pet Eng. (Co-listed with Geology 310, Geo Eng 310).

PET ENG 313 Drilling and Well Design (LAB 1.0 and LEC 2.0)
This course covers drilling fluids, including mixing and analysis of rheological properties; pressure loss calculations; casing design; well cementing; pore pressure and geomechanical considerations in drilling; completion equipment; and completion design. Prerequisite: Preceded or accompanied by Civ Eng 230.

PET ENG 314 Advanced Drilling Technology (LEC 3.0)
In-depth study of directional well planning and drilling. The course covers the bottom hole assemblies and operational techniques used in drill directional drilling as well as the limiting factors and hole problems related to horizontal wells. Prerequisite: Pet Eng 313.

PET ENG 316 Well Performance and Production Systems (LEC 2.0 and LAB 1.0)
Introduction to the producing wellbore system; inflow performance relationships; effect of formation damage on well flow; nodal systems analysis; perforating methods and their effect on inflow; stimulation treatments to enhance well performance. Introduction to well completions, diagnostics and well servicing. Overview of production systems. Prerequisite: Preceded or accompanied by Pet Eng 241.

PET ENG 318 Well Stimulation (LEC 3.0)
This course reviews fundamentals of hydraulic fracturing and builds on the basic theory through the use of STIMPLAN software and hands on industry examples. The course teaches the methods used to plan, execute and evaluate hydraulic fracturing treatments. Students may not earn credit for both Pet Eng 318 and Pet Eng 418. Prerequisites: Pet Eng 241 and Pet Eng 232.

PET ENG 320 Fundamentals Of Petroleum Reservoir Simulation (LEC 3.0)

PET ENG 323 Artificial Lift (LEC 3.0)
This course is a study of artificial lift methods used to produce liquids (oil/water) from wellsbores. Methods covered include sucker rod (piston) pumps, electric submersible pumps, gas lift, hydraulic lift and plunger lift. Prerequisite: Pet Eng 316.

PET ENG 325 Well Completion Design (LEC 3.0)
An overview of the hardware, fluids and processes employed in completing oil and gas wells. Examination of types of well completions and considerations in their design. Introduction to downhole mechanics and tubing movement and stress calculations. Prerequisite: Pet Eng 241.

PET ENG 329 Applied Petroleum Reservoir Engineering (LEC 3.0)
Quantitative study of oil production by natural forces, gas cap, water influx, solution gas, etc.; material balance equations, study of gas, non-retrograde gas condensate, and black oil reservoirs. Predictive calculations of oil recovery from different reservoir types. Prerequisites: Pet Eng 241 and 242.

PET ENG 333 Reservoir Characterization (LEC 3.0)
The integration and extrapolation of Geologic, Geophysical, and Petroleum Engineering data for flow model construction. Prerequisites: Pet Eng 241, Pet Eng 232; Geology 332 or Geology 340.

PET ENG 335 Secondary Recovery Of Petroleum (LEC 3.0)

PET ENG 338 Finite Element Analysis with Applications in Petroleum Engineering (LAB 1.0 and LEC 3.0)
This course introduces finite element analysis (FEA) methods and applications of FEA in subsurface engineering. The course is intended to provide a fundamental understanding of FEA software and experience in creating meshes for petroleum reservoirs or other subsurface features. Prerequisites: Pet Eng 241, Geology 220, and Math 204.

PET ENG 341 Well Test Analysis (LEC 2.0 and LAB 1.0)
Causes of low well productivity; analysis of pressure buildup tests, drawdown tests, multi-rate tests, injection well fall off tests, and open flow potential tests; design of well testing procedures. Prerequisite: Pet Eng 241.

PET ENG 347 Petroleum Engineering Design (LEC 3.0)
Senior capstone design project(s) based on industry data. Application of reservoir engineering; drilling and production engineering principles to evaluate and solve an industry problem such as a new field development, evaluation of an existing reservoir asset, or analysis of field re-development. Prerequisites: Pet Eng 241, Pet Eng 316, and senior standing.
**PET ENG 357 Petroleum Economics and Asset Valuation** (LEC 3.0)
Uncertainty in the estimation of oil and gas reserves; tangible and intangible investment costs; depreciation; evaluation of producing properties; federal income tax considerations; chance factor and risk determination. Petroleum economic evaluation software is introduced. Prerequisites: Pet Eng 241, Econ 121 or Econ 122.

**PET ENG 360 Natural Gas Engineering** (LEC 3.0)
Gas reserves estimation, deliverability, and future production performance prediction. Deliverability testing of gas wells including isochronal, flow after flow, drawdown and buildup. Gasfield development and underground storage. Gas production metering gauging and transmission. Prerequisite: Preceded or accompanied by Pet Eng 241.

**PET ENG 366 Mechanical Earth Modeling** (LEC 3.0)
This course introduces the work process necessary to create the Mechanical Earth Model's principle components, formation in-situ stress and strength. 1-D modelign methods are reviewed and extended to 3-D; and the integration of MEM with well design is shown. An MEM model will be created and compared to actual field results. Prerequisites: Pet Eng 232 and Geology 220.

**PET ENG 400 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects of projects in the department. Consent of instructor required.

**PET ENG 401 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**PET ENG 408 Advanced Applied Reservoir Simulation** (LEC 3.0)
Advanced simulation of actual reservoir problems using both field and individual well models to determine well spacing, production effects of secondary and enhanced recovery processes, future rate predictions and recovery, coning effects, relative permeability adjustments and other history matching techniques. Prerequisite: Pet Eng 320.

**PET ENG 410 Seminar** (RSD 0.0-6.0)
Discussion of current topics.

**PET ENG 415 Drilling Optimization** (LEC 3.0)
Optimization of the drilling process based on geomechanical model of the subsurface. Topics include drilling hydraulics, drilling bits, selection of operational parameters and analysis of drilling time and cost. Prerequisite: Pet Eng 313.

**PET ENG 417 A Survey Of Improved Recovery Processes** (LEC 3.0)
An overview of current advanced recovery methods including secondary and tertiary processes. An explanation of the primary energy mechanism and requirements of these methods and an analysis of laboratory results and their subsequent field applications. Prerequisite: Pet Eng 335.

**PET ENG 418 Advanced Well Stimulation** (LEC 3.0)
This course builds on the basic theory and fundamentals of hydraulic fracturing through the use of STIMPLAN software and hands on industry examples. The course teaches the methods used to plan, execute and evaluate hydraulic fracturing treatments. An advanced exercise and a research assignment are required. Students may not earn credit for both Pet Eng 318 and Pet Eng 418. Prerequisites: Pet Eng 241 and Pet Eng 232.

**PET ENG 437 Advanced Reservoir Engineering I** (LEC 3.0)
Advanced study of producing mechanisms. Prerequisites: Pet Eng 308 and Pet Eng 341.

**PET ENG 438 Advanced Reservoir Engineering II** (LEC 3.0)
Flow through porous media: derivations and solutions for steady, semi-steady, and transient flow of single and multiple phase flow through porous media. Prerequisite: Pet Eng 241.

**PET ENG 441 Advanced Well Test Analysis** (LAB 1.0 and LEC 2.0)
Pressure transient analysis equations, well test analysis for fractured wells, horizontal wells, injection wells, and other special situations. Introduction to rate transient analysis. Prerequisites: Pet Eng 241 and Pet Eng 341.

**PET ENG 481 Geodynamics** (LEC 3.0)
The applications of continuum physics to geological and petroleum engineering problems. Topics include plate tectonics, stress and strain in solids, elasticity and flexure, heat transfer, gravity, fluid mechanics, rock rheology, faulting, and flow in porous media. Prerequisites: Math 22 and Geology 220. (Co-listed with Geology 481).

**PET ENG 490 Research** (IND 0.0-12)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

**PET ENG 491 Internship** (IND 0.0-15)
Students working toward a doctor of engineering degree will select, with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

**PET ENG 493 Oral Examination** (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/ written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**PET ENG 495 Continuous Registration** (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

**Physics (PHYSICS)**

**PHYSICS 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**PHYSICS 301 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**PHYSICS 302 Physics For Elementary School Teachers** (LEC 2.0 and LAB 1.0)
A nonmathematical review of the fundamental ideas of physics, including mechanics, matter, energy, sound, electricity, magnetism, astronomy, and light. Emphasis is placed on the development of hands-on activities. (For elementary school teachers or Master of Science for Teachers candidates only.).
**PHYSICS 303 Physics For Secondary School Teachers** (LEC 3.0)
A review of the fundamental ideas of physics, including mechanics, matter, energy, sound, electricity, magnetism, and light with an emphasis on how mathematics can be used to help understand the underlying concepts. (For secondary teachers or Masters of Science Teachers candidates only.) Prerequisites: Math 22 and admission to the MST program.

**PHYSICS 304 Science Education and Quantitative Literacy for Middle School Teachers** (LEC 3.0)
An integrated science-mathematics course for middle school teachers. Course covers selected science/mathematics topics/skills specified in Missouri standards for grades 5-7. Inquiry based methods of teaching these topics in an integrated manner will be emphasized. Prerequisite: Current enrollment in a Teacher Education Program or a full or part-time teacher in a K-12 school. (Co-listed with Stat 304).

**PHYSICS 305 Astrophysics** (LEC 3.0)
The structure, physical characteristics and evolution of stars, binary systems, nebulae and galaxies. Prerequisite: Physics 107.

**PHYSICS 306 Physics, Energy, and the Environment** (LEC 3.0)
Applications of physics to the environment, including energy, its conservation and transformation, environmental consequences of energy use; world energy resources; atmospheric physics; sources of air, water, and land pollution, and the role physics plays in controlling those resources. May not be used as a 300-level elective for a B.S. in Physics. Prerequisite: Admissions to the MST program.

**PHYSICS 307 Modern Physics II** (LEC 3.0)
A continuation of Physics 207. An introduction to nuclear and particle physics. Topics include nuclear models, decays, and reactions, and elementary particles and fundamental forces. Prerequisites: Math 204 or 229, and either Physics 107 with consent of instructor or Physics 207.

**PHYSICS 308 Physical Mechanics** (LEC 3.0)
This course covers topics of rigid body motion in three dimensions, moving coordinate frames, two body collisions, conservation laws, small oscillations, generalized coordinates, and Lagrange's and Hamilton's equations. Prerequisite: Physics 208.

**PHYSICS 309 Astrophysical Concepts** (LEC 3.0)
A comprehensive course in modern astrophysics. Topics include: Earth and sky, planetary science, stellar structure and evolution, galaxies, and structure and evolution of the universe. The course includes hands-on computer simulation and telescope use. (For secondary teachers or Master of Science for Teachers candidates.) Prerequisite: Math 22 or admission to the MST program.

**PHYSICS 311 Thermal Physics** (LEC 3.0)
A study of the equilibrium states of matter as governed by the first and second laws of thermodynamics. Emphasis is placed on the microscopic approach with an introduction to statistical mechanics. Topics include the kinetic theory of (uniform) gases, phase equilibria in pure systems, and an introduction to quantum statistics. Prerequisite: Physics 107 or 207.

**PHYSICS 313 Introduction To General Relativity** (LEC 3.0)
An introduction to the theory of general relativity. Topics covered include the formalism of general relativity, Einstein's gravitational field equations, the Schwarzschild solution, black holes, and cosmological models of the universe. Prerequisite: Physics 208.

**PHYSICS 321 Electricity And Magnetism II** (LEC 3.0)
A continuation of Physics 221. Topics covered include the magnetostatic field, the magnetic vector potential, the magnetostatic field in matter, electrodynamics, and electromagnetic waves. Prerequisite: Physics 221.

**PHYSICS 322 Advanced Physics Laboratory I** (LAB 3.0)
A laboratory study of the principles of basic experiments in all major branches of physics. The experiments stress design of apparatus, and procedures and analysis in projects involving electronic, optical, mechanical, and vacuum techniques. Prerequisite: Physics 212.

**PHYSICS 323 Classical Optics** (LEC 3.0)
Physical optics and advanced topics in geometrical optics. Topics include ray propagation, electromagnetic propagation, mirrors, lenses, interference, diffraction, polarization, imaging systems, and guided waves. Prerequisites: Math 22 and Physics 24 or 25. (Co-listed with Elec Eng 323).

**PHYSICS 324 Fourier Optics** (LEC 3.0)
Applications of Fourier analysis and linear system theory to optics. Topics include scalar diffraction theory, Fourier transforming properties of lenses, optical information processing, and imaging systems. Prerequisites: Elec Eng 261 & 275 or Physics 208 & 321. (Co-listed with Elec Eng 324).

**PHYSICS 326 Fiber And Integrated Optics** (LEC 3.0)
Introduction to optical waveguides and their applications to communication and sensing. Topics include dielectric waveguide theory, optical fiber characteristics, integrated optic circuits, coupled-mode theory, optical communication systems, and photonic sensors. Prerequisite: Elec Eng 275 or Physics 321. (Co-listed with Elec Eng 326).

**PHYSICS 332 Advanced Physics Laboratory II** (LAB 3.0)
A senior laboratory involving experimental design. The student must specify his objectives, assemble apparatus, take measurements, analyze the results, form conclusions, write a report, and deliver an oral presentation of the results. Prerequisite: Physics 212.

**PHYSICS 351 Computational Physics** (LAB 1.0 and LEC 3.0)
An introduction to modern computer simulations for solving physics problems. The course will be project-oriented with examples including planetary motion, chaotic dynamics, quantum scattering, structure of atoms and clusters, molecular dynamics, and Monte-Carlo simulations. Prerequisites: Physics 107 or Physics 207; Math 204; programming experience.

**PHYSICS 355 Chaos, Fractals, and Nonlinear Dynamics** (LEC 3.0)
An introduction into nonlinear dynamics, deterministic chaos, and fractals. Topics covered include phase plane analysis, iterated maps, routes to chaos, Lyapunov exponents, strange attractors and pattern formation with applications to chaotic vibrations, population dynamics, chemical oscillations and lasers. Prerequisites: Math 204; Physics 24 or Physics 25.

**PHYSICS 357 Subatomic Physics** (LEC 3.0)
An introduction to elementary particles. Topics include particle properties, nuclear forces, particle interactions, the Standard Model for quarks and leptons, fundamental forces in gauge field theory models, and the role of elementary particle interactions in cosmology. Prerequisite: Physics 307.

**PHYSICS 361 Introduction To Quantum Mechanics** (LEC 3.0)
The fundamental concepts, postulates and methods of quantum mechanics and their applications to physical systems. Topics include solutions of the Schrodinger equation for simple systems and operator methods. Prerequisites: Physics 107 or 207, 208.
PHYSICS 370 Plasma Physics I (LEC 3.0)
Single particle orbits in electric and magnetic fields, moments of Boltzmann equation and introduction to fluid theory. Diffusion of plasma in electric and magnetic fields. Analysis of laboratory plasmas and magnetic confinement devices. Introduction to plasma kinetic theory. Prerequisite: Aero Eng 231 or Mech Eng 231 or Physics 221 or Nuc Eng 221 or Elec Eng 271. (Co-listed with Aero Eng 370, Mech Eng 370, Nuc Eng 370).

PHYSICS 371 Laser Physics (LEC 3.0)
The generation of coherent radiation by lasers and the interaction of laser radiation with matter. Topics include stimulated emission, population inversion, optical cavities, optical gain, properties of laser media and other applications. Prerequisite: Physics 107 or 207.

PHYSICS 377 Principles Of Engineering Materials (LEC 3.0)
Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Aero Eng 377, Chem Eng 347, Met Eng 377, Cer Eng 377).

PHYSICS 381 Elementary Solid State Physics (LEC 3.0)
An introductory study of the structure and physical Properties of crystalline solids. Included are topics in crystal structure, x-ray diffraction, crystal binding, thermal properties of solids, free electron theory and elementary energy band theory. Prerequisites: Math 204 and Physics 107 or 207.

PHYSICS 390 Undergraduate Research (IND 0.0-6.0)
This course is designed for the undergraduate student who wishes to engage in research. It is not to be used for graduate credit nor for more than six credit hours of undergraduate credit. The subject and credit are to be arranged with the instructor.

PHYSICS 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department Consent of instructor required.

PHYSICS 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

PHYSICS 402 Mathematical Physics I (LEC 3.0)
Vector spaces, generalized coordinate transformations, vector analysis, tensors, partial differential equations in physics and boundary value problems, orthogonal functions and solutions to ordinary differential equations, hypergeometric, confluent hypergeometric, Legendre, Laguerre, and Bessel functions, Hermite polynomials, Green’s functions in one dimension. (Co-listed with Math 402).

PHYSICS 403 Mathematical Physics II (LEC 3.0)
Green’s functions in three dimensions, integral equations, complex variable theory and contour integration, group theory with applications to quantum mechanics, solid state and molecular physics. Prerequisite: Math 402 or Physics 402. (Co-listed with Math 403).

PHYSICS 404 Advanced Physics Laboratory Teaching Methods (LEC 3.0)
Objectives, methods and problems related to teaching of introductory physics, with an emphasis on laboratory instruction, the development of educational laboratory experiments and techniques, student learning styles, student assessment, student work groups, computer-based data acquisition, and communication techniques. Prerequisite: Graduate standing.

PHYSICS 409 Classical Mechanics I (LEC 3.0)
Methods of Newton, Lagrange, and Hamilton applied to the motion of particles and rigid bodies. Introduction to canonical transformations and Poisson brackets. Classical scattering and small oscillations. Prerequisites: Math 204, Physics 309.

PHYSICS 410 Seminar (RSD 0.0-6.0)
Discussion of current topics.

PHYSICS 411 Electrodynamics I (LEC 3.0)
A rigorous development of the fundamentals of electromagnetic fields and waves. Electrostatics, magnetostatics, Maxwell’s equations—Green’s function, boundary value problems, multipoles, conservation laws. Prerequisites: Elec Eng 273 and Math 325; Physics 321.

PHYSICS 413 Statistical Mechanics (LEC 3.0)
A study of statistical ensembles; Maxwell-Boltzmann, Fermi-Dirac and Einstein-Bose distribution laws, application to some simple physical systems. Prerequisites: Physics 309, 361.

PHYSICS 423 Electrodynamics II (LEC 3.0)
A continuation of Physics 411. Applications of time-dependent Maxwell’s equations to such topics as plasmas, wave guides, cavities, radiation; fields of simple systems and multipoles. Relativity; covariant formulation of Maxwell’s equations and conservation laws, fields of uniformly moving and accelerated charges. Prerequisite: Physics 411.

PHYSICS 451 Advanced Computational Physics (LEC 3.0 and LAB 1.0)
An introduction to modern computer simulations for solving physics problems. The course will be project-oriented with examples including planetary motion, chaotic dynamics, quantum scattering, structure of atoms and clusters, molecular dynamics, and Monte-Carlo simulations. Graduate students will be required to do extra work upon consultation with their advisor. Prerequisite: Graduate Standing.

PHYSICS 456 Advanced Chaos, Fractals, and Nonlinear Dynamics (LEC 3.0)
An introduction into nonlinear dynamics, deterministic chaos, and fractals. Topics include phase plane analysis, routes to chaos, and pattern formation with applications in physics, chemistry and biology. Graduate students will be required to do extra work upon consultation with their advisor. Prerequisites: Math 204; Physics 24 or Physics 25; Graduate standing.

PHYSICS 457 Advanced Subatomic Physics (LEC 3.0)
An introduction to elementary particles. Topics include particle properties, nuclear forces, particle interactions, the Standard Model for quarks and leptons, fundamental forces in gauge field theory models, and the role of elementary particle interactions in cosmology. Graduate Students will be required to do extra work upon consultation with their advisor. Prerequisite: Physics 307.

PHYSICS 461 Quantum Mechanics I (LEC 3.0)
Basic formalism applied to selected problems. Schroedinger equation and one dimensional problems, Dirac notation, matrix mechanics, harmonic oscillator, angular momentum, hydrogen atom, variational methods, introduction to spin. Prerequisite: Physics 361 or equivalent.

PHYSICS 463 Quantum Mechanics II (LEC 3.0)
Perturbation theory, treatment of spin, angular momentum addition, Wigner-Eckart theorem; scattering theory including partial wave analysis, born approximation, and formal scattering theory; identical particles, introduction to second quantization, and structure of complex atoms. Prerequisite: Physics 461.
PHYSICS 467 Quantum Statistical Mechanics (LEC 3.0)
Techniques for calculation of the partition function with examples drawn from interacting Fermi gas, interacting Bose gas, superconductors, and similar sources. Prerequisites: Physics 413 and 463.

PHYSICS 471 Atomic And Molecular Structure (LEC 3.0)
Applications of quantum mechanics to the structure of atoms and molecules; perturbation and variational calculations, self-consistent field, multiplets, angular momenta, Thomas-Fermi model, diatomic molecules, spectral intensities. Prerequisite: Physics 461.

PHYSICS 473 Atomic Collisions (LEC 3.0)
Basic quantum mechanical concepts involved in atomic scattering theory. Topics include the Born approximation elastic collisions, and inelastic collisions. Other specific topics will be chosen from the general areas of electron, ion, and atom collisions with atoms and molecules. Prerequisite: Physics 471 or 463.

PHYSICS 481 Condensed Matter Physics (LEC 3.0)
A course in the physics of hard and soft matter including solids, liquids, and complex materials. Topics: atomic structure, mechanical properties, phonons, electronic structure, energy band theory, electronic correlations, transport properties, magnetism, superconductivity. Prerequisite: Physics 461.

PHYSICS 490 Research (IND 3.0)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

PHYSICS 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

PHYSICS 494 Coop Registration (IND 0.0-1.0)
Doctoral candidates participating in a cooperative program with another UM campus must enroll for one hour of credit for their first semester in the program and zero hours of credit for successive registration periods until degree is completed. Failure to do so may invalidate candidacy. Billing is automatic as is registration upon payment.

PHYSICS 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Statistics (STAT)

STAT 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

STAT 301 Special Topics (LEC 3.0 and LAB 1.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

STAT 304 Science Education and Quantitative Literacy for Middle School Teachers (LEC 3.0)
An integrated science-mathematics course for middle school teachers. Course covers selected science/mathematics topics/skills specified in Missouri standards for grades 5-7. Inquiry based methods of teaching these topics in an integrated manner will be emphasized. Prerequisite: Current enrollment in a Teacher Education Program or a full or part-time teacher in a K-12 school. (Co-listed with Physics 304).

STAT 305 Making Sense Of Data For Elementary School Teachers (LEC 3.0)
An activity based course that is intended to provide elementary school teachers with the skills necessary to implement the Probability & Statistics strand of the American Statistical Association of the National Council of Teachers of Mathematics (NCTM) joint. Prerequisite: Graduate Standing.

STAT 306 Making Sense Of Data For Middle School Teachers (LEC 3.0)
An activity based course that is intended to provide middle school teachers with the skills necessary to implement the Probability & Statistics strand of the American Statistical Association of the National Council of Teachers of Mathematics (NCTM) joint.

STAT 307 Making Sense Of Data For High School Teachers (LEC 3.0)
An activity based course that is intended to provide high school teachers with the skills necessary to implement the Probability & Statistics strand of the American Statistical Association of the National Council of Teachers of Mathematics (NCTM) joint.

STAT 314 Applied Time Series Analysis (LEC 3.0)
Introduction to time series modeling of empirical data observed over time. Topics include stationary processes, autocovariance functions, moving average, autoregressive, ARIMA, and GARCH models, spectral analysis, confidence intervals, forecasting, and forecast error. Prerequisites: One of Stat 213, 215, 217, 343 and one of Math 203, 208, or 308.

STAT 320 Statistical Methods (LEC 3.0)
A continuation of Stat 215 with emphasis on statistical methods. Topics would include further work on regression analysis, control charts, acceptance sampling, nonparametric statistics, goodness of fit tests, reliability and life-testing, analysis of experimental designs. Prerequisite: Stat 215.

STAT 325 Introduction to Biostatistics (LEC 3.0 and LAB 1.0)
Introduction to common biostatistical methods for designing research studies, collecting and analyzing data, with application to problems originating from the biological, environmental, and health sciences. Topics include randomization, means comparisons, ANOVA, regression, and analysis of count data. Prerequisite: Math 4 or equivalent.

STAT 343 Probability And Statistics (LEC 3.0)
Introduction to the theory of probability and its applications, sample spaces, random variables, binomial, Poisson, normal distributions, derived distributions, and moment generating functions. Prerequisite: Math 22.

STAT 344 Mathematical Statistics (LEC 3.0)
A continuation of Stat 343 with introduction to the theories of point estimation, hypothesis testing, and interval estimation. Includes sufficiency, completeness, likelihood and how they apply to the exponential family. Prerequisite: Stat 343.
STAT 346 Regression Analysis (LEC 3.0)
Simple linear regression, multiple regression, regression diagnostics, multicolinearity, measures of influence and leverage, model selection techniques, polynomial models, regression with autocorrelated errors, introduction to non-linear regression. Prerequisites: Math 22 and one of Stat 211, 213, 215, 217, or 343. (Co-listed with Comp Sci 366).

STAT 353 Statistical Data Analysis (LEC 3.0)
Introduction to methods for analyzing statistical data from experiments and surveys. Analysis of variance, correlation, introduction to regression techniques, contingency tables, non-parametric techniques and introduction to modern statistical software. Prerequisites: Math 22 and one of Stat 115, 213, 215 and 217.

STAT 355 Statistical Models in Actuarial Science (LEC 3.0)
This course covers the statistical foundation of actuarial models and their applications. Topics include survival and severity models, Kaplan-Meier and Nelson-Aalen estimators, aggregate and credibility models for insurance losses, discrete time Markov chains, ruin theory, and simulation. Prerequisite: Stat 343 and either Stat 344 or a 200-level Stat course. (Co-listed with Econ 360).

STAT 356 Statistical Models for Life Contingencies (LEC 3.0)
The basic statistical theory of actuarial models for life uncertainties such as time of death. Multiple life and multiple decrement models, statistical models for life and contingent insurance; last survivor, disability, withdrawal, retirement and reserving models for life insurance. Prerequisite: Stat 343.

STAT 360 Statistical Data Analysis Using SAS (LAB 1.0 and LEC 2.0)
This course will introduce the student to selected data analytic tools implemented in the Statistical Analysis System (SAS) and appropriate and effective use of these tools. Focus would be on both the use of SAS data analytic tools and the theoretical and methodological rationale that form the basis of such analyses. Prerequisite: One of Stat 213 or 215 or 217 or 343; and one of Stat 346 or 353 or 443 or 444 or 445.

STAT 390 Undergraduate Research (IND 0.0-6.0)
This course is designed for the undergraduate student who wishes to engage in research. It is not to be used for graduate credit nor for more than six credit hours of undergraduate credit. The subject and credit are to be arranged with the instructor. Prerequisite: Consent of instructor.

STAT 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects in the department. Consent of instructor required.

STAT 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

STAT 414 Statistical Time Series Analysis (LEC 3.0)
A formal introduction to the fundamentals of statistical modeling and analysis of discrete time series. Topics include autoregressive and moving average processes, ARIMA models, second order stationarity, vector processes, autocorrelation function, Fourier representation, estimation of nd prediction of time series. Prerequisites: Stat 343 and Math 203 or 208.

STAT 438 Stochastic Optimization (LEC 3.0)
Introduction to stochastic modeling theory and application. Topics include probability theory, Markov processes, renewal theory, and queuing theory. Additional topics include stochastic dynamic programming and stochastic programming. Prerequisite: Eng Mgt 365. (Co-listed with Eng Mgt 438).

STAT 439 Clustering Algorithms (LEC 3.0)
An introduction to cluster analysis and clustering algorithms rooted in computational intelligence, computer science and statistics. Clustering in sequential data, massive data and high dimensional data. Students will be evaluated by individual or group research projects and research presentations. Prerequisite: At least one graduate course in statistics, data mining, algorithms, computational intelligence, or neural networks, consistent with student’s degree program. (Co-listed with Comp Eng 439, Elec Eng 439, Sys Eng 439 and Comp Sci 449).

STAT 441 Stochastic Processes (LEC 3.0)
Development and application of Poison and nonhomogeneous Poison processes; renewal processes; Markov chains and processes including birth and death processes; and normal processes, including Brownian motion. Prerequisites: Stat 343 and Math 204 or 229.

STAT 443 Nonparametric Statistical Methods (LEC 3.0)
A course covering distribution free statistical methods. Topics include: order statistics, tests of hypotheses for one-sample and two-sample problems, analyses of variance, goodness-of-fit tests, runs test, independence and regression problems. Point and interval estimation, ALE. Prerequisite: Stat 344.

STAT 444 Design And Analysis Of Experiments (LEC 3.0)
Experimental designs and their statistical analysis. Includes completely randomized designs, complete and incomplete blocking designs, factorial and fractional factorial experiments, multiple comparisons, response surface analysis. Prerequisites: One of Stat 353, Eng Mg 387 and one of Stat 211, 213, 215, 217, 343; or Stat 343 and one of Stat 211, 213, 215, 217.

STAT 445 Multivariate Statistical Methods (LEC 3.0)
Analysis of data consisting of simultaneous measurements on many variables. Multivariate normal distribution, multivariate analysis of variance, canonical correlation, principal components, classification and clustering techniques. Prerequisites: Stat 344 and Math 203.

STAT 446 Intermediate Probability (LEC 3.0)
Probability spaces, random variables, distribution functions, expectations, independence, convergence theorems, characteristic functions, moment generating functions, and central limit theorem. Prerequisites: Stat 344 and Math 315.

STAT 453 Linear Statistical Models I (LEC 3.0)
Includes a development of the theory of the distribution of quadratic forms, and the estimation of parameters and testing hypotheses in linear statistical models. Prerequisites: Math 208 and Stat 343 and either Stat 353 or 344.

STAT 454 Linear Statistical Models II (LEC 3.0)
Includes the theory of polynomial models, regression models, experimental design models, incomplete block models, nonlinear models, with emphasis on optimum properties of point and interval estimation and the power of tests. Prerequisite: Stat 453.

STAT 457 Advanced Mathematical Statistics I (LEC 3.0)

STAT 458 Advanced Mathematical Statistics II (LEC 3.0)
A continuation of Stat 457 with the emphasis on hypothesis testing. Prerequisite: Stat 457.
SYS ENG 300 Special Problems (IND 1.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

SYS ENG 301 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

SYS ENG 348 Wireless Networks (LAB 1.0 and LEC 2.0)
Introduction to wireless communications and networking. Topics include transmission fundamentals, wireless channel, coding techniques and error control, satellite and cellular networks, cordless systems, mobile IP and management, multiple access techniques and wireless protocols, wireless LAN, IEEE 802.11, and ad hoc and sensor networks. Prerequisites: Hardware competency, Elec Eng 243 or Comp Eng 213 and graduate standing. (Co-listed with Comp Eng 348 and Elec Eng 348).

SYS ENG 367 Computational Intelligence (LEC 3.0)
Introduction to Computational Intelligence (CI), Biological and Artificial Neuron, Neural Networks, Evolutionary Computing, Swarm Intelligence, Artificial Immune Systems, Fuzzy Systems, and Hybrid Systems. CI application case studies covered include digital systems, control, power systems, forecasting, and time-series predictions. Prerequisite: Comp Sci 153 or programming competency. (Co-listed with Elec Eng 367 and Comp Eng 358).

SYS ENG 368 System Engineering and Analysis I (LEC 3.0)
The concepts of Systems Engineering are introduced through a project. Students work in virtual teams. The topics covered are architecture development, basic system architectural design techniques, functional decomposition, design and technical review objectives, and initial specifications. Prerequisite: Graduate or senior standing.

SYS ENG 378 Introduction To Neural Networks & Applications (LEC 3.0)
Introduction to artificial neural network architectures, adaline, madaline, back propagation, BAM, and Hopfield memory, counterpropagation networks, self organizing maps, adaptive resonance theory, are the topics covered. Students experiment with the use of artificial neural networks in engineering through semester projects. Prerequisites: Math 204 or 229; graduate standing. (Co-listed with Elec Eng 368).

SYS ENG 400 Special Problems (IND 1.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

SYS ENG 401 Special Topics (LEC 1.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

SYS ENG 404 Advanced Topics in Data Mining (LEC 3.0)
Advanced topics of current interest in the field of data mining. This course involves reading seminal and state-of-the-art papers as well as conducting topical research projects including design, implementation, experimentation, analysis, and written and oral reporting components. Prerequisite: A "C" or better grade in Comp Sci 301 Introduction to Data Mining . (Co-listed with Comp Sci 444 and Comp Eng 404).

SYS ENG 408 Financial Risk Management (LEC 3.0)
Techniques and methods for managing financial risk, including portfolio theory, Monte Carlo methods, ARIMA, time series forecasting, Value-at-Risk, stress testing, extreme value theory, GARCH and volatility estimation, random variables and probability distributions, real options, decision trees, utility theory, statistical decision techniques, and game theory. Prerequisite: Eng Mgt 137 or 308. (Co-listed with Eng Mgt 408).

SYS ENG 410 Seminar (RSD 0.0-6.0)
Discussion of current topics.

SYS ENG 411 Systems Engineering Capstone (LEC 3.0)
The topics covered are Systems Engineering Management Plan (SEMP), Systems Engineering processes, process re-engineering, standards, and systems engineering case studies. Students will apply the skills and theory that they mastered in previous five core courses to the analysis of assigned cases. Prerequisites: Sys Eng 412 and 469.

SYS ENG 412 Complex Engineering Systems Project Management (LEC 3.0)
The course topics include issues specific to distributed project management, team development, resource management, constraint planning, development of Integrated Master Schedule and Integrated Master Plan, monitoring technical performance, schedule, cost, and risk. Prerequisite: Sys Eng 468.

SYS ENG 413 Economic Analysis for Systems Engineering (LEC 3.0)
Methods of economic evaluation for engineering projects involving complex systems. Economic impacts on choosing system alternatives, life cycle costing, economic decisions involving risk and uncertainty, and engineering cost estimation for projects in government, defense, and commercial industries. Prerequisite: Sys Eng 368.

SYS ENG 419 Network Centric Systems (LEC 3.0)
Network-centric systems comprises a diverse category of complex systems with the primary purpose is providing network-type services. Network-centric systems are also known as collaborative systems. This course address the intersection between network engineering and the needs of systems architecting and engineering. Prerequisite: Sys Eng 469 or graduate standing. (Co-listed with Comp Eng 419).
SYS ENG 427 Function-Based Risk Analysis (LEC 3.0)
Risk analysis of products and systems will be explored using product functionality as the starting point. Traditional probabilistic risk assessment techniques will be covered along with recent approaches that use historical data to produce automatic risk assessments. Prerequisite: Graduate standing.

SYS ENG 433 Distributed Systems Modeling (LEC 3.0)
This course will discuss issues related to distributed systems architecture, modeling, analysis and representation, with specific focus on discrete-part manufacturing domain. Distributed modeling techniques and other model decomposition methods using simulation modeling and scalability issues will also be addressed.

SYS ENG 435 Model Based Systems Engineering (LEC 3.0)
This course covers the use of models to represent systems and the underlying system elements, components, etc. Topics also include SysML, executable systems architectures, model repositories, integration of models and information, and use of MBSE in distributed systems. Prerequisite: Sys Eng 433.

SYS ENG 439 Clustering Algorithms (LEC 3.0)
An introduction to cluster analysis and clustering algorithms rooted in computational intelligence, computer science and statistics. Clustering in sequential data, massive data and high dimensional data. Students will be evaluated by individual or group research projects and research presentations. Prerequisite: At least one graduate course in statistics, data mining, algorithms, computational intelligence, or neural networks, consistent with student’s degree program. (Co-listed with Comp Eng 439, Elec Eng 439, Comp Sci 449 and Stat 439).

SYS ENG 443 Wireless Ad hoc and Sensor Networks (LEC 3.0)
Introduction to ad hoc and sensor networks, IEEE standards, heterogeneity, quality of service, wireless channel issues, energy awareness, power and topology control, routing, scheduling, rate adaptation, self-organization, admission and flow control, energy harvesting, security and trust levels, hardware and applications. Prerequisite: Comp Eng 348 or Comp Eng 349 or equivalent. (Co-listed with Comp Eng 443 and Elec Eng 443).

SYS ENG 449 Network-Centric Systems Reliability and Security (LEC 3.0)
This course presents reliability and fault tolerance for network-centric systems, including models, metrics, and analysis techniques. This course also concentrates on security, including technical tools and methods for audit and assessment as well as management and policy issues. Prerequisite: Sys Eng/Comp Eng 419 or Comp Eng 349. (Co-listed with Comp Eng 449).

SYS ENG 458 Adaptive Critic Designs (LEC 3.0)
Review of Neurocontrol and Optimization, Introduction to Approximate Dynamic Programming (ADP), Reinforcement Learning (RL), Combined Concepts of ADP and RL - Heuristic Dynamic Programming (HDP), Dual Heuristic Programming (DHP), Global Dual Heuristic Programming (GDHP), and Case Studies. Prerequisite: Elec Eng 368 Neural Networks or equivalent (Computational Intelligence Comp Eng 301) (Co-listed with Comp Eng, Elec Eng, Mech Eng and Aero Eng 458).

SYS ENG 468 Systems Engineering Analysis II (LEC 3.0)
This course uses customized case studies based on team projects from prior courses. Topics covered include physical and functional analysis, analysis and traceability of requirements and specifications, verification and validation, optimization, simulation, and trade studies. Prerequisite: Sys Eng 368.

SYS ENG 469 Systems Architecting (LEC 3.0)
The objective of the course is to provide the basic tools and concepts of architecting complex engineering systems. Systems thinking, ambiguity in system architecting, search as an architecting process, SysML and DoDAF Architecting Framework, System of Systems and Network-Centric Architectures. Prerequisite: Sys Eng 468.

SYS ENG 470 Software Intensive Systems Architecting (LEC 3.0)
Basic tools and concepts of architecting complex software intensive systems are introduced. The following topics are covered under four main sections; namely Architecting Process, Architecting Heuristics, Architecting Patterns and Frameworks, and Architecture Assessment. Prerequisite: Graduate Standing.

SYS ENG 478 Advanced Neural Networks (LEC 3.0)
Advanced artificial neural network architectures, namely: Radial-Basis Function Networks, Support Vector Machines, Committee Machines, Principal Components Analysis, Information-Theoretic Models, Stochastic Machines, Neurodynamic Programming, Temporal Processing are the topics covered. Prerequisite: Sys Eng 378 or equivalent neural network course.

SYS ENG 479 Smart Engineering System Design (LEC 3.0)
This course covers the emerging approaches for designing of smart engineering systems architectures for complex systems through evolutionary acquisition, namely; adaptive architecture generation for family of systems, complexity theory, evolutionary programming, fuzzy logic, collaborative behavior, artificial life, and chaos. Prerequisite: Sys Eng 378 or graduate standing.

SYS ENG 480 Investment (LEC 3.0)
An introduction to the theory and practice of investment, including financial markets and instruments, security trading, mutual funds, investment banking, interest rates, risk premiums, the capital asset pricing model, arbitrage pricing theory, market efficiency, bonds and the fixed income market, equity valuation, fundamental and technical analysis. Prerequisite: Eng Mgt 137 or 308. (Co-listed with Eng Mgt 480).

SYS ENG 481 Financial Engineering (LEC 3.0)
An introduction to financial engineering, with an emphasis on financial derivatives, including the future markets, the pricing of forwards and futures, forward rate agreements, interest and exchange rate futures, swaps, the options markets, option strategies, the binomial and Black-Scholes models for option valuation, the option Greeks, and volatility smiles. Prerequisites: Eng Mgt 137 or 308. (Co-listed with Eng Mgt 481).

SYS ENG 482 Financial Engineering II (LEC 3.0)
This course introduces advanced topics in financial engineering, which includes introduction to Wiener processes, martingales and Ito’s lemma; basic numerical methods for options pricing, exotic options; interest rate models; stochastic volatility models and jump-diffusion models; and value-at-risk. Prerequisite: Eng Mgt/Sys Eng 481. (Co-listed with Eng Mgt 482).

SYS ENG 490 Research (IND 1.0-15)
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required. Prerequisite: Graduate standing.
SYS ENG 493 Oral Examination (IND 0.0)
After completion of all other program requirements, oral examination for on-campus MS/PhD students may be processed during intersession. Off-campus MS students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive exam (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

SYS ENG 495 Continuous Registration (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation, and are away from campus must continue to enroll for at least one credit hour each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

Technical Communication (TCH COM)

TCH COM 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

TCH COM 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

TCH COM 302 Research Methods in Technical Communication (LEC 3.0)
Students learn essential research methods in technical communication, including audience analysis, interviewing techniques, working with subject matter experts, and experimental research design. Prerequisites: TCH COM 65 AND TCH COM 240 or English 65 and English 240.

TCH COM 310 Seminar (RSD 0.0-6.0)
Discussion of current topics. Prerequisite: TCH COM 65 and TCH COM 240.

TCH COM 311 International Dimensions of Technical Communication (LEC 3.0)
Examines complexity of communication of technical information worldwide. Includes topics such as graphics, icons, symbols; user interface design; intercultural communication. Students may not earn credit for both TCH COM 311 and TCH COM 411. Prerequisite: TCH COM 65 or English 65, or equivalent.

TCH COM 325 Help Authoring (LEC 3.0)
Students will acquire the technological and rhetorical skills necessary for creating effective online help systems, including context-sensitive help for computer applications. Prerequisite: One semester of college writing or technical writing.

TCH COM 331 Technical Editing (LEC 3.0)
The principles and practices of technical editing, including usability, audience analysis, contextual editing, the conventions of scientific and technical communication, and the role of the editor in document development and publication. Students will also learn standard practices of copy editing and the use of style guides. Prerequisite: TCH COM 65 or English 65, or equivalent.

TCH COM 333 Proposal Writing (LEC 3.0)
Familiarizes students with many aspects of writing proposals for various purposes in academic, professional, and public spheres. Offers students opportunities to write documents to promote their academic, professional, or personal goals or those of their organization(s). Prerequisite: One semester of college composition or technical writing.

TCH COM 334 Usability Studies (LEC 3.0)
Students in this course will study and apply methods used by technical communicators to evaluate usability. Students will study methods used to evaluate human interaction with communication tools and how to make those products more suitable for human use. Prerequisite: One semester of college writing or technical writing.

TCH COM 340 Theory of Visual Technical Communication (LEC 3.0)
A study of the relationships between visual and conceptual elements of technical communication. Prerequisites: TCH COM 65 and TCH COM 240 or English 65 and English 240.

TCH COM 361 History of Technical Communication (LEC 3.0)
Introduction to the roles of the technical communicator and the technologies of communication from ancient cultures to the present. Prerequisite: TCH COM 65 or English 65, or equivalent.

TCH COM 380 Internship (IND 0.0-6.0)
Internship will involve students applying critical thinking skills and discipline specific knowledge in a work setting based on a project designed by the advisor and employee. Activities will vary depending on the student’s background and the setting. Prerequisites: Senior status; must have completed 24 hours in the major core curriculum.

TCH COM 385 Theory and Practice of Technical Communication (LEC 3.0)
This capstone course enables the student to work on individual and group projects that put into play the theories and practices of technical communication. Students are expected to develop professional portfolios. Prerequisites: Senior Status and TCH COM 65 and TCH COM 240 or English 65 and English 240.

TCH COM 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

TCH COM 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

TCH COM 402 Foundations of Technical Communication (LEC 3.0)
Introduction to themes and issues, methods, and genres that define technical communication.

TCH COM 403 Theoretical Approaches to Technical Communication (LEC 3.0)
Examines representative theories and research in written, oral, and visual modes of technical communication. Includes such issues as ethics, document design, rhetorical methods, and people-machine communication.

TCH COM 404 Teaching of Technical Communication (LEC 3.0)
Provides a theoretical and pedagogical foundation for teaching workshops and undergraduate courses in technical communication. Includes both traditional and electronic settings.

TCH COM 409 Web-Based Communication (LEC 3.0)
Covers such topics as advanced writing and editing for the web; the creation of rhetorically effective websites; the use of blogs, wikis, and other web genres to communicate technical information.
**TCH COM 410 Seminar** (RSD 0.0-6.0)
Discussion of current topics.

**TCH COM 411 Advanced International Technical Communication**  
LEC 3.0
Advanced study of international technical communication. Includes topics such as graphics, icons, symbols; user interface design; intercultural communication. Requires field work at student's expense. Students may not earn credit for both TCH COM 311 and TCH COM 411. Prerequisite: Graduate Standing.

**TCH COM 420 Advanced Theories of Visual Technical Communication**  
LEC 3.0
An in-depth investigation and analysis of historical and contemporary visual theories and their impact on technical communication, including visual rhetoric, semiotics, and design and critical theories.

**TCH COM 433 Advanced Proposal Writing**  
LEC 3.0
Familiarizes graduate students with many aspects of writing proposals for various purposes in academic, professional, and public spheres. Offers opportunities to write documents to promote their academic, professional, or personal goals or those of their organization(s). Prerequisite: Graduate standing.

**TCH COM 440 Advanced Layout and Design**  
LEC 3.0
Advanced theory and practice of layout and design for print and electronic media. Students who have taken TCH COM 240 may not take this course for credit. Prerequisite: Graduate standing.

**TCH COM 450 Information Management in Technical Communication**  
LEC 3.0
Study of and practice in directing projects related to such areas as multimedia, web sites, strategic planning, newsletters. Includes writing planning documents, selecting team members, synchronizing assignments, testing prototypes, and issuing a final report.

**TCH COM 490 Research**  
IND 0.0-15
Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

**TCH COM 493 Oral Examination**  
IND 0.0
After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D. students may be processed during intersession. Off-campus M.S. students must be enrolled in oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.
Non-Degree Graduate Course List

The following disciplines (aerospace studies, ArchE, art, econ., educ., English, ERP, finance, French, German, history, marketing, music, phil., pol sci, pre-med,psych., Russian, Spanish, sp&ms, and theatre) do not offer a graduate degree. The Depts. of Economics & Finance, English and History & Political Science have entered into cooperative agreements with the corresponding departments of the University of Missouri-St. Louis to offer a Master of Arts in Economics and in English. The agreements permit students to take a maximum of 12 semester hours on the Missouri S&T campus. Some of the upper division courses may be used, where pertinent, for credit toward other graduate degrees. Be sure to check the use of these courses with your major professor before you add these courses to your schedule.

Art (ART)

**ART 300 Special Problems (IND 0.0-6.0)**
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**ART 301 Special Topics (IND 0.0-6.0)**
This course is designed to give the department an opportunity to test a new course. Variable title.

Economics (ECON)

**ECON 300 Special Problems (IND 0.0-6.0)**
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**ECON 301 Special Topics (LEC 0.0-6.0)**
This course is designed to give the department an opportunity to test a new course. Variable title.

**ECON 302 Internship (IND 0.0-6.0)**
Internship will involve students applying critical thinking skills and discipline-specific knowledge in a work setting based on a project designed by the advisor and employee. Activities will vary depending on the student's background and the setting. Prerequisite: Senior status; must have completed 24 hours in major.

**ECON 305 Micro and Macro Economics Essentials (LEC 1.5)**
This course is an introduction to the essentials of micro and macro economics for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit in this course cannot be applied to any major or minor in Business, IS&T, or Economics. Prerequisite: Senior or Junior standing and 3.0 GPA required.

**ECON 311 Econometrics (LEC 3.0)**
Applied statistical analysis of economic phenomena, including identification, least squares bias, and autocorrelation with emphasis on recent estimation procedures. Prerequisites: Stat 115 & 116, Econ 221 and 222.

**ECON 315 Mathematical Economics (LEC 3.0)**
Marginal analysis, calculus, and linear algebraic systems are applied in selected advanced topics in economics such as price theory, general equilibrium theory, input-output analysis, activity analysis, and game theory. Prerequisite: Econ 221, 222, and Math 8.

**ECON 320 Money And Banking (LEC 3.0)**
Study of the origin, principles, and functions of money, emphasizing the role of banks in the effectuation of monetary policies geared to achieve various economic and political goals. Prerequisite: Econ 222.

**ECON 322 International Trade (LEC 3.0)**
Analysis of gains from trade; the effects of factor mobility; effects of trade restrictions on trade flow and income distribution; arguments for restricting trade; and effects of trade on economic development, employment and human capital development. Prerequisite: Econ 222.

**ECON 323 International Finance (LEC 3.0)**
Examination of the international monetary system, the Balance of Payments, the foreign exchange market, futures and options markets; foreign exchange and other risk management for firms, financing from a global perspective and direct foreign investment. Prerequisite: Econ 222.

**ECON 330 Public Finance (LEC 3.0)**
Study of government expenditures and sources of revenue. Particular emphasis is given to governmental decision making--how these decisions affect the economy and the behavior of individuals, firms, and families within the economy; and how these decisions may be evaluated. Prerequisite: Econ 221.

**ECON 332 International Trade (LEC 3.0)**
This interdisciplinary course applies an entrepreneurial mindset to the environmental and social opportunities and challenges facing the global community. Topics are examined from multiple perspectives: nonprofit, hybrid, and for-profit organizations. Credit cannot be earned for both Econ 344 and 444. Prerequisite: Econ 342.
**ECON 351 Economic Development** (LEC 3.0)
Theoretical analysis of the problem of economic development of the "poor" countries, where two-thirds of the world's population lives. Treatment of basic problem areas leading to a synthesis of theoretical approaches for the achievement of development. Prerequisite: Econ 221 or 222.

**ECON 355 Energy Economics** (LEC 3.0)
Market structure. World resource development. Supply and demand analysis on energy production and consumption within domestic and global settings. Prerequisite: Econ 221. (Co-listed with Min Eng 355).

**ECON 357 Network Economy** (LEC 3.0)
Emerging Network/Internet economy, using traditional economic tools. Topics: production and reproduction cost of information, information as an "experience good," versions of products, switching cost, lock-in effects, market adoption dynamics, first-mover advantage, intellectual property rights. Prerequisite: Econ 121 or Econ 122. (Co-listed with IS&T 357).

**ECON 360 Statistical Models in Actuarial Science** (LEC 3.0)
This course covers the statistical foundation of actuarial models and their applications. Topics include survival and severity models, Kaplan-Meier and Nelson-Aalen estimators, aggregate and credibility models for insurance losses, discrete time Markov chains, ruin theory, and simulation. Prerequisite: Stat 343 and either Stat 344 or a 200-level Stat course. (Co-listed with Stat 355).

**ECON 375 Labor Economics** (LEC 3.0)
Labor as a factor of production, collective bargaining, trade unionism, labor legislation, from the viewpoint of public policy. Prerequisite: Econ 221 or Econ 222.

**ECON 389 Problems In Economic Policy** (LEC 3.0)
Advanced course designed for students majoring within the department. Appraisal and analysis of major problems of economic policy. Research and reports. Topics covered vary from year to year. Offered jointly by members of the department. Prerequisite: Seniors with 24 or more hours in Econ.

**ECON 401 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course.

**ECON 405 Advanced Micro and Macro Economics Essentials** (LEC 1.5)
An introduction to the essentials of micro and macro economics for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit in this course cannot be applied to any major or minor in Business, IS&T, or Economics. Additional case or report required. Prerequisite: Bachelor Degree.

**ECON 415 Advanced Mathematical Economics** (LEC 3.0)
Marginal analysis, calculus, and linear algebraic systems are applied in selected advanced topics in economics such as price theory, general equilibrium theory, input-output analysis, activity analysis, and game theory. This course is an advanced version of Econ 315, and will include additional research and project assignments. Credit cannot be obtained for both Econ 315 and Econ 415. Prerequisites: Econ 221, 222 and Math 8, Math 203.

**ECON 421 Advanced Finance** (LEC 3.0)
This course provides a rigorous and consistent presentation of the theory of financial decisions. Capital markets are analyzed under assumptions of risk aversion and uncertainty. Models of modern portfolio theory are discussed including the CAPM and the Modigliani-Miller analysis. This course is an advanced version of Econ 321, and will include additional research and project assignments. Credit cannot be obtained for both Econ 321 and Econ 421. Prerequisite: Econ 221 or Econ 222.

**ECON 422 Advanced International Trade** (LEC 3.0)
Analysis of gains from trade; the effects of factor mobility; effects of trade restrictions on trade flow and income distribution; arguments for restricting trade; and effects of trade on economic development, employment and human capital development. This course is an advanced version of Econ 322, and will include additional research and project assignments. Credit cannot be obtained for both Econ 322 and Econ 422. Prerequisite: Econ 221.

**ECON 423 Advanced International Finance** (LEC 3.0)
Examination of the international monetary system, the Balance of Payments, the foreign exchange market, futures and options markets; foreign exchange and other risk management for firms, financing from a global perspective and direct foreign investment. This course is an advanced version of Econ 323, and will include additional research and project assignments. Credit cannot be obtained for both Econ 323 and Econ 423. Prerequisite: Econ 222.

**ECON 435 Advanced Cost-Benefit Analysis** (LEC 3.0)
Investigates the rationale for cost-benefit analysis within a free enterprise setting. Discussion of market efficiency and failure; determination of social costs and benefits; applications of cost-benefit analysis; and, problems remaining in theory and practice. This course is an advanced version of Econ 335, and will include additional research and project assignments. Credit cannot be obtained for both Econ 335 and Econ 435. Prerequisite: Econ 221.

**ECON 437 Financial Mathematics II** (LEC 3.0)
Continuation of Math/Econ 337. Topics include martingales and measures, stopping times, discrete and continuous time finance, Brownian motion, Ito calculus, stochastic differential equations, Black-Scholes-Merton formula, numerical procedures. Prerequisite: Math 337 or Econ 337. (Co-listed with Math 437).

**ECON 440 Advanced Environmental And Natural Resource Economics** (LEC 3.0)
Optimum use of replenishable and non-replenishable resources, public goods and common resources, externalities, private vs. public costs, and quality of the environment; emphasis on public policy related to environmental and natural resource economics. This course is an advanced version of Econ 340, and will include additional research and project assignments. Credit cannot be obtained for both Econ 340 and Econ 440. Prerequisite: Econ 221.

**ECON 444 Global Economic- and Social-preneurship and Innovation** (LEC 3.0)
This interdisciplinary course applies an entrepreneurial mindset to the environmental and social opportunities and challenges facing the global community. Topics are examined from multiple perspectives: nonprofit, hybrid, and for-profit organizations. Written case studies required. Credit cannot be earned for both Econ 344 and 444. Prerequisite: Econ 342.
ECON 445 Advanced Energy Economics (LEC 3.0)
Market structures. World resource development. Supply and demand analysis on energy production and consumption within domestic and global settings. This course is an advanced version of Econ 345, and will include additional research and project assignments. Credit cannot be obtained for both Econ 345 and Econ 445. Prerequisite: Econ 221.

ECON 475 Advanced Labor Economics (LEC 3.0)
Labor as a factor of production, collective bargaining, trade unionism, labor legislation, from the viewpoint of public policy. This course is an advanced version of Econ 375, and will include additional research and project assignments. Credit cannot be obtained for both Econ 375 and Econ 475. Prerequisite: Econ 221 or Econ 222.

Education (EDUC)

EDUC 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

EDUC 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

EDUC 305 Philosophy And Administration Of The Middle School (LEC 3.0)
This course will acquaint students with aspects of education that are unique to the middle school. Attention will be given to the philosophy underlying the middle school. Finally, leadership theories most appropriate to the middle school will be studied.

EDUC 315 Advanced Adolescent Development (LEC 3.0)
This course is an advanced examination of the intellectual and social development of the adolescent. Theories of adolescent development and their implications for the educative process are covered and debated.

EDUC 320 Professional Development (LEC 1.0)
This online course focuses on the responsibilities of the professional development committee, state requirements, and components of effective programs that positively impact student performance. Students will examine the relationships among the district’s Comprehensive School Improvement Plan, MSIP and the PD Plan. Prerequisite: Graduate standing.

EDUC 325 Novell Netware 4.1 / 4.11 (LEC 3.0)
A practical, hands-on course for Novell network administration including NDS planning, mapping and documentation; system power up/down; security, resource service management; user management from creation to user and workstation maintenance; application software installation and management, and Novell Server installation.

EDUC 335 Curriculum And Instruction Of The Middle School (LEC 3.0)
This course advances teachers’ understanding of middle school curriculum and instruction. It utilizes knowledge about the nature and needs of young adolescents in developing interdisciplinary learning units, and fosters applications appropriate to experienced teachers’ professional assignments. Prerequisite: Graduate standing.

EDUC 339 Current Issues In Educ: Performance Based Assessment, Beginning (LEC 1.0 and LAB 2.0)
This course is intended to provide an understanding of the principles of sound classroom assessment, the five different types of learning outcomes that need to be assessed and the choice of an assessment that best evaluates the achievement targets. Prerequisite: Practicing educator.

EDUC 340 Current Issues In Educ: Performance Based Assessment, Intermediate (LEC 3.0)
This course will provide participants with an understanding of performance-based assessments, how to construct performance tasks and how to construct scoring guides.

EDUC 341 Current Issues In Educ: Performance Based Assessment, Advanced (LAB 2.0 and LEC 1.0)
This course is intended to provide an understanding of balanced classroom assessment. Students will learn to create multiple types of assessment measures for the purpose of evaluating a wide variety of achievement targets. Prerequisite: Practicing educator.

EDUC 345 Introducing Educators To Computers (LEC 1.0)
A basic introduction to computers for K-12 educators. Includes identification and use of hardware components, as well as the fundamentals of using the operating system and basic computer software. Actual software taught will reflect current usage. Prerequisite: Post Bac/practicing teacher.

EDUC 350 Social Studies In The Elementary School (LEC 3.0)
Problems in preparation, teaching of social studies units with suitable materials, techniques for elementary teachers. Prerequisite: Instructor’s approval.

EDUC 354 Psychology Of The Exceptional Child (LEC 3.0)
Study of the psychology of children on both ends of the educational spectrum. The course presents the fundamentals of providing services as well as understanding the abilities and disabilities of children classified as exceptional. Includes coverage of various disabilities, and the implications of dealing with personal, family and classroom issues Prerequisite: Psych 50. (Co-listed with Psych 354).

EDUC 370 Teachers Academy: Effective Instructional Strategies (LEC 3.0)
Participants will develop an understanding of research-based instruction and the ability to implement the instructional strategies in their classrooms. In addition to effective instructional practices, the teachers’ academy will focus on leadership, empowerment, collaboration and renewal. Prerequisite: Graduate standing.

English (ENGLISH)

ENGLISH 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

ENGLISH 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

ENGLISH 302 Advanced Composition (LEC 3.0)
Instruction and practice in writing expository essays of substantial content and skill, with particular emphasis on the rhetorical applications of recent findings in language research. Papers required will include critical analyses of literary works, and library research. Prerequisite: English 60 or 160.
ENGLISH 303 Internship (LEC 0.0-6.0)
Internship will involve students applying critical thinking skills and discipline specific knowledge in a work setting based on a project designed by the advisor and employee. Activities will vary depending on the student's background and the setting. Prerequisite: Senior status; must have completed 24 hours in the major.

ENGLISH 305 History And Structure Of The English Language (LEC 3.0)
An introduction to the study of the English language and its history through Old English, Middle English, and Modern English. Prerequisite: English 20.

ENGLISH 306 A Linguistic Study Of Modern English (LEC 3.0)
A descriptive analysis of Modern English--its phonology, grammar, and vocabulary. Prerequisite: English 20.

ENGLISH 310 Seminar (RSD 3.0)
Discussion of current topics. Prerequisites: English 20 and a semester of college literature.

ENGLISH 311 Teaching And Supervising Writing (LEC 3.0)
Students will study contemporary and traditional approaches to writing instruction. The course will give students practice in applying composition theory and research to development of teaching methods, including course syllabi and assignments. Prerequisite: 6 hours of college level writing courses.

ENGLISH 312 Survey Of Old And Middle English Literature (LEC 3.0)
Survey of Old English poetry in translation and Middle English literature (excluding Chaucer) through Malory. Special emphasis on culture and language with some attention given to modern reinterpretation of medieval works. Prerequisites: English 20 and a semester of college literature.

ENGLISH 315 Chaucer (LEC 3.0)
A study of Chaucer as a narrative poet by an intensive examination of The Canterbury Tales and Troilus and Criseyde. Prerequisites: English 20 and a semester of college literature.

ENGLISH 330 Sixteenth Century English Literature (LEC 3.0)
A survey of the poetry and prose of England from 1500 to 1600. Prerequisites: English 20 and a semester of college literature.

ENGLISH 331 Seventeenth Century English Literature (LEC 3.0)
A study of major authors (excluding Milton) of prose and poetry in England from 1600 to 1660. Special attention will be paid to John Donne and the metaphysical poets, to Ben Jonson and the Cavalier poets, and to major prose writers such as Francis Bacon, Sir Thomas Browne, and others. Prerequisites: English 20 and a semester of college literature.

ENGLISH 337 The Plays Of William Shakespeare (LEC 3.0)
Selected comedies, tragedies, histories, and romances from early middle, and late periods of William Shakespeare's life. Prerequisites: English 20 and a semester of college literature.

ENGLISH 345 The Restoration & Eighteenth Century (LEC 3.0)
The history, development, and cultural contexts of British literature from 1660 to 1798. Prerequisites: English 20 and a semester of college literature.

ENGLISH 350 Texts And Contexts (LEC 3.0)
Examines the relationships between selected texts written or published in a given year and the context of events of that time. Also explores current critical approaches to such texts and contexts. Writing intensive and Computer intensive. Prerequisites: English 20 and a semester of college literature; junior standing.

ENGLISH 353 British Romantic Literature (LEC 3.0)
A study of the prose and poetry of the British Romantic period, 1775 to 1832. Prerequisite: English 20 and a semester of college literature.

ENGLISH 355 Victorian Literature (LEC 3.0)
A study of British prose and poetry from 1832 to 1900. Prerequisites: English 20 and a semester of college literature.

ENGLISH 361 The British Novel I (LEC 3.0)
The history, development, and cultural contexts of the British novel from the late seventeenth to the early nineteenth century. Prerequisite: English 20 and a semester college literature.

ENGLISH 362 The British Novel II (LEC 3.0)
A study of the development of the novel with major attention given to the Victorian and 20th century novelists. Prerequisites: English 20 and a semester of college literature.

ENGLISH 368 Early American Literature (LEC 3.0)
This course will follow the development of American literature from its Colonial beginnings (1614) to the rise of Romanticism (1836). The course will pay particular attention to how American writers used literature in defining and even creating the New World. Prerequisites: English 20 and a semester of college literature.

ENGLISH 370 American Poetry I (LEC 3.0)
A study of significant selected poets of, primarily, the 19th century, with special attention to theme, diction, and form, and to poetry as a compressed image of the human condition. Prerequisites: English 20 and a semester of college literature.

ENGLISH 371 The American Renaissance (LEC 3.0)
A study of American literature from Poe to Whitman. Prerequisites: English 20 and a semester of college literature.

ENGLISH 372 American Poetry II (LEC 3.0)
A study of significant selected poets of the 20th century, with special attention to theme, diction, and form, and poetry as a compressed image of the human condition. Prerequisites: English 20 and a semester of college literature.

ENGLISH 374 Southern Culture (LEC 3.0)
Introduction to major issues in the history and culture of the recent American South. Non-fiction, fiction, memoir, autobiography, journalism and film explore the social, economic, and political transformations of the region in the last half-century. Prerequisite: English 20 and one semester of literature.

ENGLISH 375 The American Novel I (LEC 3.0)
A study of selected, representative novels in chronological sequence from the beginning to the major realists. Prerequisites: English 20 and a semester of college literature.

ENGLISH 376 The American Novel II (LEC 3.0)
A study of selected, representative novels in chronological sequence from the major realists to the present. Prerequisites: English 20 and a semester of college literature.

ENGLISH 377 American Gothic (LEC 3.0)
This course follows the development of gothic/horror literature in the United States for its earliest expression in Phillip Freneau's 18th century works through Brockden Brown's late 18c. Gothic novels, to Hawthorne, Melville, and Poe's dark fiction, and finally to modern and contemporary works by Faulkner, O'Connor, Stephen King and others. Prerequisite: English 20 and a previous literature course.
ENGLISH 378 The American Experience (LEC 3.0)
Examines one or more of the subjects of the American experience such as race, gender, class, ethnicity, region, technology, religion, as it is expressed in the culture. Prerequisite: English 178.

ENGLISH 380 Contemporary American Literature (LEC 3.0)
Studies in American prose (fiction and non-fiction), drama, poetry, and screen plays published within the last fifteen years. Prerequisites: English 20 and a semester of college literature.

ENGLISH 382 Contemporary British Literature (LEC 3.0)
Studies in British prose (fiction and non-fiction), drama, poetry, and screen plays published within the last fifteen years. Prerequisites: English 20 and a semester of college literature.

ENGLISH 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor. Consent of instructor required.

ENGLISH 392 Advanced Writing For Science & Engineering (LEC 3.0)
Focus on writing applications specifically for students in scientific or engineering fields. Primary emphases will be on producing effective and readable professional writing. Prerequisites: English 160 and 260, or graduate standing.

ENGLISH 393 Advanced Writing For Science And Engineering II (LEC 2.0)
This course -- second in a series -- focuses on writing for publication, from the initial proposal and query to the final product. Students will work on the materials they have underway with their advisers and/or research colleagues. Prerequisites: English 160 and 260, or graduate standing.

ENGLISH 402 Readings In British Literature (LEC 3.0)
Directed readings and writing on selected topics and areas in British literature. Credit will only be given for one of English 402, 403, 404, or 405 toward the Coop MA with UMSL. Prerequisites: Graduate standing and consent of instructor.

ENGLISH 403 Readings In American Literature (LEC 3.0)
Directed readings and writing on selected topics and areas in American literature. Credit will only be given for one of English 402, 403, 404, or 405 toward the Coop MA with UMSL. Prerequisites: Graduate standing and consent of instructor.

ENGLISH 404 Readings In Literature And Theory (LEC 3.0)
Directed readings and writing on selected topics and areas in Literature and Theory. Credit will only be given for one of English 402, 403, 404, or 405 toward the Coop MA with UMSL. Prerequisites: Graduate standing and consent of instructor.

ENGLISH 405 Readings In Rhetoric And Composition (LEC 3.0)
Directed readings and writing on selected topics and areas in Rhetoric and Composition. Credit will only be given for one of English 402, 403, 404, or 405 toward the Coop MA with UMSL. Prerequisites: Graduate standing and consent of instructor.

Enterprise Resource Planning (ERP)

ERP 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

ERP 341 Enterprise Portal and Mobile Application Development (LEC 3.0)
This course provides conceptual foundation and hands on experience in web based applications development deployed through an Enterprise Portal and Mobile platform. SAP Netweaver Enterprise Portal and tools including Visual Composer, Web Dynpro, and Sybase Unwired Platform will be used for apps. Prerequisite: Programming knowledge and either ERP 246 or preceded or accompanied by ERP 346.

ERP 342 Customer Relationship Management in ERP Environment (LEC 3.0)
The course emphasizes identification (targeting), acquisition, retention, and development (expansion) of (profitable) customers, as well as effective and efficient management of customers, using information technology. SAP CRM, SAS BI tools, and Sybase mobile application development are used. Prerequisite: ERP 246 or preceded or accompanied by ERP 346.

ERP 345 Use of Business Intelligence (LEC 3.0)
This course introduces data-oriented techniques for business intelligence. Topics include Business Intelligence architecture, Business Analytics, and Enterprise Reporting. SAP Business Information Warehouse, Business Objects, or similar tools will be used to access and present data, generate reports, and perform analysis. Prerequisites: IS&T 223 or equivalent; ERP 246 or preceded or accompanied by ERP 346.

ERP 346 Enterprise Resource Planning Systems Design and Implementation (LEC 3.0)
This course provides a technical overview of Enterprise Resource Planning Systems and their impact on organizations. SAP is introduced to illustrate the concepts, fundamentals, framework, general information technology context, the technological infrastructure, and integration of business enterprise-wide applications. Prerequisite: IS&T 50.

ERP 347 Supply Chain Management Systems in an ERP Environment (LEC 3.0)
The course studies the need for supply chain integration and the challenges of managing complex interfaces using the systems approach for the planning, analysis, design, development, and evaluation of supply chain. SAP’s ERP ECC, SCM, BW, and Sybase Unwired Platform are used to deploy SCM apps. Prerequisite: ERP 246 or preceded or accompanied by ERP 346.

ERP 348 Performance Dashboard, Scorecard and Data Visualization (LEC 3.0)
This course will study different performance management systems including dashboards, management cockpit, scorecards, and strategy maps in an organization. SAP’s BW, Business Objects Xcelsius, Crystal Reports, Sybase Unwired Platform will be used to develop the applications.. Prerequisite: ERP 246 or preceded or accompanied by ERP 346.

ERP 349 ERP System Administration (LEC 3.0)
System administration and performance monitoring practices for an Enterprise Resource Planning (ERP) system will be studied. Students will install an instance of an ERP system and establish user management attributes and system security. Prerequisite: ERP 346.

ERP 401 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.
**Finance (FINANCE)**

**FINANCE 300 Special Problems** (IND 0.0-6.0)
Variable Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**FINANCE 301 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**FINANCE 305 Finance Essentials** (LEC 1.5)
This course is an introduction to the essentials of corporate finance for running a business. This course is designed for students planning to enter the MBA program. Credit in this course cannot be applied to any major or minor in Business, Information Sciences and Technology. Prerequisites: Senior or Junior Standing; 3.0 GPA required.

**FINANCE 350 Corporate Finance II** (LEC 3.0)
This course provides a rigorous and consistent presentation of the theory of financial decisions. Capital markets are analyzed under assumptions of risk aversion and uncertainty. Models of modern portfolio theory are discussed including the CAPM and the Modigliani-Miller analysis. Prerequisite: Finance 250 or Eng Mgt 147 or Eng Mgt 252.

**FINANCE 360 Investments I** (LEC 3.0)
Introduction to fundamental elements of investment analysis. Students learn financial tools and gain necessary knowledge to select among alternative financial assets. Real-world experience includes stock analysis, portfolio simulations, and interactions with professionals in the securities industry. Field trip required. Prerequisite: Finance 250 or Eng Mgt 147 or Eng Mgt 252.

**FINANCE 390 Undergraduate Research** (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed towards graduation credit. Subject and credit to be arranged with the instructor.

**FINANCE 400 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in finance. Prerequisite: Admission to the MBA program and permission of the instructor.

**FINANCE 401 Special Topics** (LEC 0.0-6.0)
This is designed to give the department an opportunity to test a new course. Variable title. Prerequisite: Admission to the MBA program.

**FINANCE 405 Graduate Finance Essentials** (LEC 1.5)
This course is an introduction to the essentials of corporate finance for running a business. This course is designed for students planning to enter the MBA program. Credit in this course cannot be applied to any major or minor in Business, Information Sciences and Technology. Additional case or report required. Prerequisite: Bachelor Degree.

**FINANCE 430 Advanced Mathematical Finance** (LEC 3.0)
Topics include exotic options, liquidity, volatility surfaces, discrete hedging, market jumps, calibrating to market, modeling yield curves and related products, convertible bonds, credit derivatives, various hybrid derivatives, applicable numerical methods. Prerequisite: Finance 250.

**FINANCE 490 Research** (IND 0.0-9.0)
Research investigation of an advanced nature leading to a major report suitable for publication in a journal or in a conference proceedings. Prerequisite: Permission of the instructor.

**French (FRENCH)**

**FRENCH 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**FRENCH 301 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**FRENCH 310 Seminar** (IND 0.0-6.0)
Discussion of current topics. Prerequisite: Senior standing.

**FRENCH 311 Advanced French Conversation** (LEC 2.0)
Advanced conversation and oral practice. Prerequisite: French 110.

**FRENCH 360 French Culture And Civilization** (LEC 3.0)
A survey of French culture and civilization of the past 2,000 years, including art, architecture, music, literature, geography and politics. Prerequisite: French 170.

**FRENCH 370 Survey Of French Literature I (Early Period)** (LEC 3.0)
The history and development of French literature from Les Chansons de Geste through the important philosophers of the 18th century to Beaumarchais. Assigned readings are in French, and lectures are largely in French. Prerequisite: French 170.
**FRENCH 375 Survey Of French Literature II (Modern Period)** (LEC 3.0)
19th and 20th century French literature. Prerequisite: French 170.

**German (GERMAN)**

**GERMAN 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**GERMAN 301 Special Topics** (IND 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**GERMAN 310 Seminar** (RSD 0.0-6.0)
Discussion of current topics. Prerequisite: Senior standing.

**History (HISTORY)**

**HISTORY 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**HISTORY 301 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**HISTORY 302 Internship** (IND 0.0-6.0)
Internship will involve students applying critical thinking skills and discipline specific knowledge in a work setting based on a project designed by the advisor and employee. Activities will vary depending on the student's background and the setting. Prerequisites: Senior status; must have completed 24 hours in major.

**HISTORY 310 Seminar** (IND 0.0-6.0)
Discussion of current topics. Prerequisite: Senior standing.

**HISTORY 312 Tudor And Stuart England** (LEC 3.0)
A study of England 1485 - 1689 covering the social, political, religious, and cultural developments. Prerequisite: History 111 or 220.

**HISTORY 316 The American Presidency** (LEC 3.0)
An in-depth examination of the causes, courses and results of the French Revolution and the Napoleonic Era (1789-1815). The impact of the age of the French Imperium upon European economic, diplomatic, intellectual, political and social development. Prerequisite: History 112.

**HISTORY 323 Medieval History I** (LEC 3.0)
The Early Middle Ages, 284 A.D.-753 A.D., transition from ancient to Medieval civilization. The fundamental differences between Roman and Medieval ideas, institutions and life. The triumph of Christianity, the conditions which made this triumph possible and its role in the development of Western Europe. Prerequisite: History 111.

**HISTORY 324 Medieval History II** (LEC 3.0)
Medieval Civilization, 11th-13th centuries. The transition from Medieval to Modern world, developments in the political, social and economic institutions of the Medieval world and their enduring effect on Western European Civilization, conflict of faith and reason during this period. Prerequisite: History 111.

**HISTORY 325 History Of Renaissance Thought** (LEC 3.0)
Concentrates on the political, religious, and social thought of the Renaissance. Particular emphasis on the revival of the classics, the spread of humanistic values, and reform efforts during the period with relationship to the material basis of society. Prerequisite: History 111 or 112.

**HISTORY 326 The Reformation** (LEC 3.0)
An examination of the backgrounds, events, ideas, and impact of the Reformation in Europe. Emphasis on the competing ideas of the reformers as well as on the Reformation's long-term social, cultural, and political impact. Prerequisite: History 111 or 112.

**HISTORY 327 Europe In The Age Of The French Revolution And Napoleon** (LEC 3.0)
An in-depth examination of the causes, courses and results of the French Revolution and the Napoleonic Era (1789-1815). The impact of the age of the French Imperium upon European economic, diplomatic, intellectual, political and social development. Prerequisite: History 112.

**HISTORY 328 Foundations Of Contemporary Europe 1815-1914** (LEC 3.0)
Europe after Napoleon, development of democracy and nationalism, revolutionary movements and leaders, unification of Italy and Germany, national developments of the major powers and the road to the First World War are the bases of this course. Prerequisite: History 112.

**HISTORY 329 Contemporary Europe** (LEC 3.0)
A study of England 1485 - 1689 covering the social, political, religious, and cultural developments. Prerequisite: History 111 or 220.

**HISTORY 330 European Migrations and Nationalism Formation** (LEC 3.0)
Analyzes migration patterns into, out of, and within Europe in context of global population movements from Roman Empire through the present. Students will learn to analyze and synthesize factors involved in these movements and correlations to personal and national identity formations. Prerequisite: History 112.

**HISTORY 331 Nazi Germany and the Holocaust** (LEC 3.0)
This course focuses on the rise of Nazism and its consequences for politics, society, and culture in Europe. The period's history will be examined from the perspective of perpetrators, victims, and bystanders with emphasis on the Holocaust and its legacy. Prerequisite: History 112.

**HISTORY 340 Religion And Witchcraft In Early America** (LEC 3.0)
An examination of the role of occult ideas and practices in the religious life of early Americans. Emphasis placed upon Puritan beliefs which contributed to seventeenth century effort to eradicate witchcraft. Prerequisite: History 175 or History 112.
HISTORY 341 Colonial America (LEC 3.0)
Political and social trends in America to 1754. Emphasis placed upon native American culture, Spain and France in America, population trends, family, religion, class structure, economic change, social conflict, and the development of individualism in early America. Prerequisite: History 175.

HISTORY 342 Revolutionary America, 1754-1789 (LEC 3.0)
An examination of the causes and consequences of the American Revolution. Emphasis placed upon the social conditions in America which contributed to both the Revolution and the writing of the 1787 Constitution. Prerequisite: History 175.

HISTORY 343 Age Of Jefferson And Jackson (LEC 3.0)
Economic, political, social and constitutional development of the early American republic; the Federalist and Jeffersonian periods, Jacksonian Democracy, rise of sectionalism. Emphasis placed on historical interpretation and historiography of the period. Prerequisite: History 175.

HISTORY 344 Civil War And Reconstruction (LEC 3.0)
Lecture, discussion and readings on the causes and consequences of the American Civil War. Focuses on the prewar North-South sectional rivalry: impact of the war on American society, government and politics. Reconstruction including the development of racial crisis in United States history. Prerequisite: History 175.

HISTORY 348 Recent United States History (LEC 3.0)
Examines America's modern age including the New Era, the New Deal, Internationalism, post-war affluence, the post-industrial era as well as the cultural, intellectual, social and technological features of American society from 1920 to the present. Prerequisite: History 176 or 347.

HISTORY 352 American Intellectual History II (LEC 3.0)
The ideas of intellectuals and the thought of popular culture, and possible relationships between the two. Among the climates of opinion studied are the Gilded Age, Darwinism, Progressivism, the Twenties, the Great Depression, the Affluent Fifties, the Counter-Culture Sixties. Prerequisite: History 176 or 351.

HISTORY 353 History Of The Old South (LEC 3.0)
Analysis of the southern region of the United States between 1607-1861 with emphasis on economic, social, political, intellectual, and racial themes. Prerequisite: History 175.

HISTORY 354 History Of The Modern South (LEC 3.0)
Analysis of the southern region of the United States between 1877 and the present with emphasis on economic, social, political, intellectual, and racial themes. Prerequisite: History 176.

HISTORY 357 History of the American West (LEC 3.0)
This course examines the American settlement of the Trans-Mississippi West. Areas to be considered include cattle, mining, exploring, women, and Native Americans. Traditional and contemporary views of the American West will be analyzed. Prerequisite: History 175 or History 176.

HISTORY 361 American Environmental History (LEC 3.0)
This class discusses the impact of human interactions with the physical environment and the natural world's influence on human civilizations with emphasis on the 19th and 20th centuries. Prerequisite: History 112 or History 175 or History 176.

HISTORY 370 History Of Baseball (LEC 3.0)
This course will survey and interpret the history of baseball from its earliest beginnings down to the present. Main focus will be on the evolution of the professional game in all of its facets. Prerequisite: History 175 or 176.

HISTORY 375 Architecture, Technology and Society; 1750 to Present (LEC 3.0)
This course investigates the relationships between architecture and technology and, as a consequence, architecture's impact on modern culture and society. A field trip to Chicago is an integral part of the course. Topics include: the industrial revolution, housing styles, new materials, Bauhaus and international style, and post-modern architecture. Prerequisites: History 111 or 112 or 175 or 176 or Pol Sci 90. Recommended: Junior or Senior Standing. Recommended for Arch Eng majors: Art 203 taken prior to course.

HISTORY 380 20th Century Americans In Combat (LEC 3.0)
Through lectures, films, readings, exams, film reviews and discussions, this course examines the American military and combat experience throughout much of the twentieth century. The ultimate goal of the course is for students to understand the realities of warfare and its effect on ordinary Americans as well as American society. Prerequisite: History 175 or 176 or 112.

HISTORY 381 The United States In World War II (LEC 3.0)
Through lectures, readings and film this course will explore the American experience in World War II. The course will particularly focus on the war's American major battles along with the war's effect on Americans in combat and on the home front. Prerequisite: History 175 or 176.

HISTORY 382 The United States in Vietnam (LEC 3.0)
Through lecture, film and readings, this course examines the American experience in the Vietnam War. The course covers the causes and consequences of the war as well as its effect on those who fought and on American society as a whole. There is a special emphasis on the realities of combat and the war's impact on individual Americans. Prerequisite: History 176.

HISTORY 383 U.S. Diplomatic History to World War II (LEC 3.0)
This course is a history of American foreign relations, broadly conceived, from the War for Independence to WWII. Among other things, it deals with the diplomacy of survival, of expansion and of economic and political hegemony. Prerequisites: History 175, 176 or Pol Sci 90. (Co-listed with Pol Sci 383).

HISTORY 384 American Diplomatic History Since World War II (LEC 3.0)
American Diplomatic History Since World War II will address the major issues in American foreign policy from WWII to the present. Its primary focus is on the Cold War and the post-Cold War problems the U.S. has faced. Prerequisite: History 176 or Pol Sci 90. (Co-listed with Pol Sci 384).

HISTORY 397 Senior Thesis (LEC 3.0)
History majors will complete an extended research paper under the supervision of a department faculty member. Prerequisite: History 299 and senior history majors only.

HISTORY 403 Readings In American History Since 1865 (IND 3.0-5.0)
Directed readings and writing on selected topics and areas in American History since 1865. Prerequisites: Graduate standing and consent of instructor.

HISTORY 404 Readings In European History To 1715 (IND 3.0-5.0)
Directed readings and writing on selected topics and areas in European History to 1715. Prerequisites: Graduate standing and consent of instructor.

HISTORY 405 Readings In European History Since 1715 (IND 3.0-5.0)
Directed readings and writing on selected topics and areas in European History since 1715. Prerequisites: Graduate standing and consent of instructor.
Military Science - Air Force (MIL AIR)

MIL AIR 350 Air Force Leadership Studies I (LAB 0.50 and LEC 2.5)
This course introduces students to the leadership and management skills required of an Air Force junior officer. Special topics include leadership ethics, the Air Force personnel and evaluation systems, and management fundamentals. Through the use of classroom tools that include case studies, Air Force leadership and management situations are examined and practical applications of studies concepts are exercised. The principles and theories of ethical behavior as well as the complete understanding of the individual responsibility and authority of an Air Force officer are stressed. This course includes a Leadership Lab that provides the students the opportunity to apply leadership and management principles.

MIL AIR 351 Air Force Leadership Studies II (LAB 0.50 and LEC 2.5)
This course is a continuation of Arosp St 350. Emphasis is placed on professional knowledge, communication skills, and ethical behavior. Varied Air Force-peculiar formats and situations are offered to apply learned listening, writing, and speaking skills. This course includes a Leadership Lab that provides the students the opportunity to apply leadership and management principles.

MIL AIR 380 National Security Affairs/Preparation For Active Duty I (LEC 2.5 and LAB 0.50)
This course examines national security policies, processes, and issues along with Air Force strategy and doctrine. Special topics include Air Force roles and missions, the roles of various federal government departments, military organizations and functions, and the concept of joint operations. Within this structure, continued emphasis is given to refining communication skills. This course includes a Leadership Laboratory that provides advanced leadership experiences, giving students the opportunity to apply leadership and management principles of this course.

MIL AIR 381 National Security Affairs/Preparation For Active Duty II (LAB 0.50 and LEC 2.5)
Continuation of Arosp St 380. This final course of the Air Force ROTC curriculum examines officership, advanced leadership ethics, military law, current Air Force issues, regional studies, core values, and preparation for active duty. This course includes a Leadership Laboratory that provides leadership experiences, giving students the opportunity to apply the leadership and management principles of this course.

Marketing (MKT)

MKT 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in marketing. Prerequisite: Consent of instructor required.

MKT 301 Special Topics (LEC 0.0-6.0)
This is designed to give the department and opportunity to test a new course. Variable title.

MKT 307 Marketing and Strategy Essentials (LEC 1.5)
This course is an introduction to the essentials of marketing and strategy for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit in this course cannot be applied to any major or minor in Business, IS&T, or Economics. Prerequisite: Bachelor Degree.

MKT 311 Marketing (LEC 3.0)
The course examines the distribution, product, price, and promotion policies that underlie the activities of marketing institutions and the managerial, economic, and societal implications of such policies.

MKT 321 Consumer Behavior (LEC 3.0)
Introduces and applies important concepts, principles, and theories to understand consumer decision-making processes in the purchase, usage and disposal of goods and services. Examines the influence of cultural, social, and psychological factors on consumer behavior. Prerequisite: MKT 311.

MKT 331 Digital Marketing and Promotions (LEC 3.0)
A managerial examination of integrated marketing communication (IMC) and creativity, with a focus on digital media and new marketing concepts. Specifically, we will look at innovative marketing techniques such as viral marketing, brand communities, experiential marketing and guerilla tactics. Prerequisite: Psych 50.

MKT 350 Customer Focus and Satisfaction (LEC 3.0)
Major emphasis is given to the concept of customer focus, with coverage of techniques for obtaining customer needs, measuring customer satisfaction, developing products and services to satisfy customers, and maximizing the benefits of customer feedback. A semester long HoQ project will be done. Prerequisites: MKT 311 or MKT 307 or Eng Mgt 251. (Co-listed with Bus 350).

MKT 380 Marketing Strategy (LEC 3.0)
Identification and analysis of strategic managerial marketing issues. Integration of marketing concepts through theoretical overview and practical analysis, including extensive use of simulation. Prerequisite: MKT 311 or MKT 407 or Eng Mgt 251.

MKT 390 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor. Prerequisite: Consent of instructor required.

MKT 400 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in marketing. Prerequisite: Consent of instructor required.

MKT 401 Special Topics (LEC 0.0-6.0)
This is designed to give the department an opportunity to test a new course. Variable title.

MKT 407 Graduate Marketing and Strategy Essentials (LEC 1.5)
This course is an introduction to the essentials of marketing and strategy for running a business. It’s designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit cannot be applied to any major or minor in Business, IS&T or Economics. Additional case study or report required. Prerequisite: Bachelor Degree.
**MKT 450 Advanced Customer Focus and Satisfaction** (LEC 3.0)
Major emphasis is given to the concept of customer focus, with coverage of techniques for obtaining customer needs, measuring customer satisfaction, developing products and services to satisfy customers, and maximizing the benefits of customer feedback. Individual focused research is included. Prerequisite: MKT 311 or MKT 307 or Eng Mgt 251. (Co-listed with Bus 450).

**MKT 480 Advanced Marketing Strategy** (LEC 3.0)
Identification and analysis of strategic managerial marketing issues. Integration of marketing concepts through theoretical overview and practical analysis, including extensive use of simulation. Independent work on marketing project. Prerequisite: MKT 310 or MKT 407 or Eng Mgt 251.

**MKT 490 Research** (IND 0.0-9.0)
Research investigation of an advanced nature leading to a major report suitable for publication in a journal or in a conference proceedings. Prerequisite: Consent of instructor required.

**Music (MUSIC)**

**MUSIC 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**MUSIC 301 Special Topics** (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**MUSIC 310 Symphonic Bands** (LAB 1.0)
An auditioned ensemble. Students perform music for wind ensemble and large bands. Music from 1400-present is performed in a concert setting. Prerequisite: Consent of instructor - audition only.

**Philosophy (PHILOS)**

**PHILOS 300 Special Problems** (IND 0.0-6.0)
Problems or readings on specific subjects of projects in the department. Consent of instructor required.

**PHILOS 301 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

**PHILOS 320 Minds And Machines** (LEC 3.0)
The course will be centered on the topic of artificial intelligence and the problems raised by contemporary attempts to simulate human thinking and perception in machines. Special emphasis will be placed on recent developments in psychology, physiology, cybernetics and computer technology. Prerequisite: Any introductory (below 100) level philosophy course.

**PHILOS 333 American Philosophy** (LEC 3.0)
A study of American philosophical development with emphasis upon the "Classical Age of American Philosophy", i.e., Pierce, James, Dewey, Royce, Santayana and Whitehead. Prerequisite: An introductory (below 100) level Philosophy course.

**PHILOS 335 Philosophy Of Religion** (LEC 3.0)
A consideration of the major presuppositions of western theism, such as the existence of god and the cognitive meaningfulness of religious language. Prerequisite: Any introductory (below 100) level philosophy course.

**PHILOS 340 Social Ethics** (LEC 3.0)
Discussion of ethical issues confronting society and the arguments offered for alternative laws and public policies. Topics might include: freedom of speech/action, government regulation, welfare, capital punishment, euthanasia, abortion, the environment, affirmative action, just wars, foreign aid, world hunger. Prerequisite: Any lower level ethics course.

**PHILOS 345 Philosophy Of Science** (LEC 3.0)
An examination of the fundamental methods and assumptions of the sciences, with emphasis on scientific reasoning and theories. Prerequisite: Any introductory (below 100) level philosophy course.

**PHILOS 350 Environmental Ethics** (LEC 3.0)
Study of the complex moral issues concerning our relationship to the environment and the ethical foundations of our environmental responsibilities. Discussion topics include: conservation, preservation, resource development, pollution, toxic substances, future generations, endangered species, regulation, zoning, takings, etc. Prerequisite: Any introductory (below 100) level philosophy course.

**PHILOS 354 Mathematical Logic I** (LEC 3.0)
A mathematical introduction to logic with some applications. Functional and relational languages, satisfaction, soundness and completeness theorems, compactness theorems. Examples from Mathematics, Philosophy, Computer Science, and/or Computer Engineering. Prerequisite: Philos 15 with junior standing or Math 305 or Comp Sci 253 or Comp Eng 111. (Co-listed with Comp Eng 354, Comp Sci 354 and Math 354).

**PHILOS 360 Foundations Of Political Conflict** (LEC 3.0)
This course is designed as a survey of the philosophical foundation of major political systems. For example, communism, fascism, democracy. Materials will be drawn from relevant historical and/or contemporary sources. Prerequisite: Any introductory (below 100) level Philosophy course.

**PHILOS 368 Law and Ethics in E-Commerce** (LEC 3.0)
Provides the ethical framework to analyze the ethical, legal, and social issues that arise for citizens and computer professionals regarding the computerization of society. Topics include: free speech, privacy, intellectual property, product liability, and professional responsibility. (Co-listed with IS&T 368).

**PHILOS 399 Topics In Philosophy** (LEC 3.0)
An intensive course designed for students with a special interest in philosophy. The content of the course may vary and the course may be repeated for additional credit. Prerequisite: An introductory (below 100) level Philosophy course.

**Political Science (POL SCI)**

**POL SCI 300 Special Problems And Readings** (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

**POL SCI 301 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.
POL SCI 302 Political Science Internship (IND 0.0-6.0)
Internship will involve students applying critical thinking skills and
discipline specific knowledge in a work setting based on a project
designed by the advisor and employee. Activities will vary depending on
the student’s background and the setting. Prerequisite: Pol Sci 90 or Pol
Sci 235.

POL SCI 310 Seminar (RSD 0.0-6.0)
Discussion of current topics Prerequisite: Senior standing.

POL SCI 315 Principles Of Public Policy (LEC 3.0)
This course presents a study of public policy in the United States.
Students analyze the policy process, the resulting policy choices and the
impact of the choices on the American people. Prerequisite: Pol Sci 90.

POL SCI 316 The American Presidency (LEC 3.0)
Historical development of the presidency; emphasis on the constitutional
powers and limits of the office and the political contextual variables which
influence presidential behavior. Prerequisite: Pol Sci 90. (Co-listed with History 316).

POL SCI 317 Public Policy Analysis (LEC 3.0)
An advanced study of major U.S. national policies. A wide range of public
policies, including education, economics, and health and welfare will be
studied. Students will be introduced to the methods of policy analysis.
Emphasis will be placed on the use of tools used by policy analysts to
determine program effectiveness and impact. Prerequisite: Pol Sci 90.

POL SCI 350 The Politics Of The Third World (LEC 3.0)
This course explores the processes and problems of the developing
nations of the world. It examines the internal political processes of third
world nations, as well as the position of the third world in international
affairs. Prerequisite: Pol Sci 90 or History 112 or 175 or 176.

POL SCI 383 U.S. Diplomatic History to World War II (LEC 3.0)
This course is a history of American foreign relations, broadly conceived,
from the War for Independence to WWII. Among other things, it deals
with the diplomacy of survival, of expansion and of economic and political
hegemony. Prerequisites: History 175, 176 or Pol Sci 90. (Co-listed with History 383).

POL SCI 384 American Diplomatic History Since World War II (LEC 3.0)
American Diplomatic History Since World War II will address the major
issues in American foreign policy from WWII to the present. Its primary
focus is on the Cold War and the post-Cold War problems the U.S. has
faced. Prerequisite: History 176 or Pol Sci 90. (Co-listed with History 384).

Pre-Medicine (PREMED)

PREMED 310 Communication Workshop for the Pre-Health Student
(RSD 1.0)
This course is for Pre-Medicine students or others interested in careers in
the health care industry or graduate studies. Students in this course will
learn and develop writing and speaking skills necessary for success in
health and science careers. Prerequisite: Junior Standing.

Psychology (PSYCH)

PSYCH 300 Special Problems And Readings In Psychology (IND
0.0-6.0)
Problems or readings on specific subjects or projects in the department.
Consent of instructor required.

PSYCH 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a
new course. Variable title.

PSYCH 302 Internship (IND 0.0-6.0)
Internship will involve students applying critical thinking skills and
discipline specific knowledge in a work setting based on a project
designed by the advisor and employee. Activities will vary depending on
the student’s background and the setting. Prerequisite: Junior or Senior
Psychology major; consent of instructor; must have completed 9 hours in
major.

PSYCH 305 Cognitive Psychology (LEC 3.0)
This course covers basic cognitive processes and their application.
Theory and research are presented on attention, perception, memory,
problem solving, decision making and language. Prerequisite: Psych 50.

PSYCH 307 Industrial Psychology (LEC 3.0)
An overview of the field of industrial psychology including topics such
as criterion development, job analysis, selection, training, performance
assessment, and some human factors concerns. Prerequisite: Psych 50.

PSYCH 308 Social Psychology (LEC 3.0)
An exploration of the phenomena involved in human social behavior and
the theories that explain them. Topics typically include social thinking,
attitudes and attitude change, conformity, persuasion, interpersonal
attraction, and more. Prerequisite: Psych 50.

PSYCH 310 Seminar (RSD 0.0-6.0)
Prerequisite: Senior Standing.

PSYCH 311 Human Factors (LEC 3.0)
An examination of human-machine systems and the characteristics of
people that affect system performance. Topics include applied research
methods, systems analysis, and the perceptual, cognitive, physical and
social strengths and limitations of human beings. The focus is
on user-centered design of technology, particularly in manufacturing
environments. Prerequisite: Psych 50. (Co-listed with Eng Mgt 311).

PSYCH 314 Human-Computer Interaction (LEC 3.0)
Research, theory, and practice from psychology and other social
science disciplines have implications for the effective design and use
of computers in organizations. This course introduces students to
the psychological issues in software engineering, technology in the
workplace, and organizational design. Prerequisite: Psych 50.

PSYCH 315 Environmental Psychology (LEC 3.0)
An examination of the psychological effects of various environmental
designs and ways to design environments effectively. Topics include:
environmental attitudes, perception, and cognition; environmental
influences, crowding, and the application of environmental design
principles to living, educational, work, and recreational settings.
Prerequisite: Psych 50.

PSYCH 316 Psychology of Leadership in Organizations (LEC 3.0)
Examination of conceptual and empirical research on determinants of
effective vs. ineffective leadership. Topics include leadership
measurement, traits, skills, leader-member exchange, charismatic and
transactional leadership, change management, team leadership, and
ethical leadership. Practical guidelines for developing leadership skills are
discussed. Prerequisite: General Psychology.

PSYCH 330 Neuroscience (LEC 3.0)
The neurophysiological bases of behavior and cognition are examined. Topics covered include neuroanatomy, neurotransmission,
neuropharmacology, brain systems, learning and memory, emotion,
attention and consciousness, and neurologic/psychological disorders.
Prerequisite: Psych 50.
**PSYCH 340 Sensation and Perception** (LEC 3.0)
An in-depth examination of the human senses, with special emphasis on vision and hearing. Topics include the anatomy and physiology of the eye and ear, neural transduction, the organization and interpretation of sensory signals by the brain, selective attention, and the neural basis of the perception of color, form, space, depth, motion, music, and language. Prerequisite: Psych 50.

**PSYCH 345 Evolutionary Psychology** (LEC 3.0)
Fundamental principles of evolution, and their applicability to human behavior and psychological processes are examined. Topics include interpersonal attraction, sperm competition, altruism, aggression, and creationism/intelligent design. Prerequisite: Psych 50.

**PSYCH 350 Psychology of Women** (LEC 3.0)
A history of the psychology of women with a focus on the latest research and theories in the field (e.g., research methods, gender theories, biological and social factors, communication and leadership styles, nature of interpersonal relationships, and health and mental issues). Prerequisite: Psych 50.

**PSYCH 354 Psychology Of The Exceptional Child** (LEC 3.0)
Study of the psychology of children on both ends of the educational spectrum. The course presents the fundamentals of providing services as well as understanding the abilities and disabilities of children classified as exceptional. Includes coverage of various disabilities, and the implications of dealing with personal, family and classroom issues. Prerequisite: Psych 50. (Co-listed with Educ 354).

**PSYCH 360 Personality Theory** (LEC 3.0)
An examination of the ways in which personality traits develop and the sources of differences among people in the traits they exhibit. The emphasis is on major theories of personality development, as well as recent research in the field. Prerequisite: Psych 50.

**PSYCH 362 Abnormal Psychology** (LEC 3.0)
An introductory study of various forms of personality and behavioral disorders. Consideration will be given to neurosis, psychosis, mental deficiency and other deviations, with emphasis on etiology and treatment. Prerequisite: Psych 50.

**PSYCH 364 Tests and Measurements** (LEC 3.0)
Theoretical and statistical basis of psychological testing and measurement; test development and validation; examination of standardized tests of intelligence, aptitude, interest, personality, attitudes, and psychopathology; use of test and test batteries for diagnostics and prediction of criteria. Prerequisite: Psych 50.

**PSYCH 368 Clinical Psychology** (LEC 3.0)
Comprehensive survey of the field of clinical psychology. Course will cover a variety of assessment and treatment procedures relevant to psychology and other professionals who treat human adjustment problems; techniques based on experimental outcome research and psychological testing will be emphasized. Prerequisites: Psych 50 and Psych 362.

**PSYCH 370 Advanced Social Psychology** (LEC 3.0)
An advanced study of the behavior of individuals in interaction within groups. Consideration will also be given to the experimental literature dealing with the formal properties of groups, conformity and deviation, intergroup relations, and attitude formation and attitude change. Prerequisite: Psych 308.

**PSYCH 372 Group Dynamics** (LEC 3.0)
A review of the concepts and theories related to group dynamics. Topics include group goals, communication within groups, group structure, norms, leadership, decision making, controversy, conflict resolution, power, diversity issues, and team development. Prerequisite: Psych 50.

**PSYCH 374 Organizational Psychology** (LEC 3.0)
Analysis, comprehension, and prediction of human behavior in organizational settings through the scientific study of individual processes, group processes, and organizational structure and function. Prerequisite: Psych 50.

**PSYCH 375 Health Psychology** (LEC 3.0)
This course examines Health Psychology. Topics include basic behavioral pharmacology (involving alcohol and other drugs), illusions of invulnerability to risk, stress and coping, and the science of persuading people to protect their health. Students learn how to construct a public service announcement towards a societal problem as part of the course. Prerequisite: Psych 50.

**PSYCH 377 Psychology in Media** (LEC 3.0)
Examples drawn from the media (e.g., television, movies, newspapers) will be used as the basis for discussing a wide variety of psychological phenomena, principles, and theories, and their applicability to everyday life. Prerequisite: Psych 50.

**PSYCH 378 Social Influence: Science and Practice** (LEC 3.0)
Principles and procedures that affect the process of social influence, with consideration given to attitudinal, compliance inducing, and perceptual influences. Prerequisite: General Psychology.

**PSYCH 380 Cross-Cultural Psychology** (LEC 3.0)
Study of the impact of ethnic and national culture on psychological processes and behaviors. Topics include the effects of individualism and collectivism on patterns of socialization, personality, motivation, emotion and cognition; cultural differences in diagnosis and treatment of mental and physical health; and group and organizational behavior. Prerequisite: Psych 50.

**PSYCH 390 Undergraduate Research** (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor. Prerequisite: Instructor consent.

**PSYCH 401 Special Topics** (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new graduate level course. Variable title.

**PSYCH 403 Psychometrics** (LEC 3.0)
An examination of statistical methods used to develop and refine measures of human performance, aptitudes, and personality. Topics include reliability and validity, data reduction, measuring inter-relationships among variables (e.g., factor analysis, multiple regression), and testing group differences. Prerequisites: Psych 50 and Psych 140.

**PSYCH 410 Seminar in Industrial / Organizational Psychology** (RSD 3.0)
Review of the most recent theoretical and applied research in advanced personnel and organizational psychology. Topics will include personnel selection, training and performance appraisal, job attitudes, motivation, work groups and teams, leadership, organizational culture, and organizational development. Prerequisite: Nine hours of psychology.
PSYCH 418 Leadership for Engineers (LEC 3.0)
Provides engineers with a background in leadership concepts and principles; enables students to develop practical skills in leading and managing through multiple personal assessment. Topics include leadership styles, managing commitments, conflict resolution, change management, emotional intelligence, team dynamics and business ethics. Prerequisite: Eng Mgt 313 or Psych 374. (Co-listed with Eng Mgt 418).

Russian (RUSSIAN)

RUSSIAN 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

RUSSIAN 301 Special Topics (LEC 2.0 and LAB 1.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

RUSSIAN 310 Seminar (IND 0.0-6.0)
Discussion of current topics. Prerequisite: Senior standing.

RUSSIAN 320 Russian Phonetics and Intonation (LAB 1.0 and LEC 2.0)
This course focuses on pronunciation improvement, development of basic transcription skills, comprehension of Russian speech at fast tempo, interactions of intonation and syntax. Lab work is required. Prerequisite: Russian 2.

RUSSIAN 330 Business Russian (LEC 2.0 and LAB 1.0)
The course addresses practical language skills and strategies for conducting business in Russian-speaking countries. Students will improve their knowledge of contemporary Russian culture and business etiquette. Readings, lectures, and discussions are in Russian. Lab work is required. Prerequisite: Russian 80.

RUSSIAN 360 Russian Civilization (LEC 3.0)
Introduction to Russian history and culture from the 9th to the 20th century exploring the interrelation between Russian society, its history and its cultural expression in painting, literature, music and architecture over the past thousand years. The periods covered include Kievan Russia, the birth of Christianity, the Mongol invasion, Ivan the Terrible, Peter the Great, Catherine the Great, and Imperial Russia. Prerequisite: Any 1xx level history course.

RUSSIAN 370 Survey Of Russian Literature I (Early Period) (LEC 3.0)
A study of the history and development of 16th, 17th, 18th, and 19th century Russian literature. Prerequisite: Russian 170.

RUSSIAN 375 Survey Of Russian Literature II (Modern Period) (LEC 3.0)
20th Century Russian Literature. Prerequisite: Russian 170.

Speech & Media Studies (SP&M S)

SP&M S 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

SP&M S 301 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

Spanish (SPANISH)

SPANISH 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

SPANISH 301 Special Topics (LAB 1.0 and LEC 2.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

SPANISH 302 Phonetics and Phonology of Spanish (LEC 3.0)
Theoretical and practical approach to the phonetics and phonology of Spanish from the dual perspective of the mental representation of the sound system and pronunciation within syllables, words and phrases. Practice in listening comprehension, and sound discrimination with transcription exercises. Prerequisite: Spanish 80.

SPANISH 310 Seminar (IND 1.0-3.0)
Discussion of current topics.

SPANISH 311 Advanced Spanish Conversation (LEC 2.0)
Advanced Spanish conversation and oral practice. Prerequisite: Spanish 110.

SPANISH 370 Survey Of Spanish Literature (LEC 3.0)
Survey of Spanish literature from Medieval to Modern Times, including the Renaissance, Siglo De Oro, Enlightenment, Romanticism, and the 20th century. Prerequisite: Spanish 170 or native ability.

SPANISH 377 Spanish-American Novel And Short Story (LEC 3.0)
A study of the development of narrative prose in Spanish America. Prerequisite: Spanish 170.

Theatre (THEATRE)

THEATRE 300 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

THEATRE 301 Special Topics (IND 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

THEATRE 341 Directing (LEC 3.0)
This course studies the theories, technique, and approaches of directing for the stage, culminating in the preparation, rehearsal, and presentation of directing scenes. Prerequisite: Theatre 141.
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