Areas of Study

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; and 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.

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.

Course Study

Degree Requirements M.S. - with thesis
Bio Sci 402 Problems in Applied and Environmental Biology
Bio Sci 410 Graduate Seminar
Bio Sci 475 Techniques in Modern Biology
Bio Sci 490 Graduate Research

Degree Requirements M.S. - without thesis
Bio Sci 402 Problems in Applied and Environmental Biology
Bio Sci 410 Graduate Seminar

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.

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.

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.

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)

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

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.

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 CHE 410 graduate seminar

The master of science thesis program consists of a minimum of 30 semester hours, including 18-24 hours of coursework, in which CHE 383, CHE 420, CHE 433, and CHE 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 CHE 383, CHE 420, CHE 433, and CHE 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 CHE 383, CHE 433, and CHE 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 nano-particles; supercritical fluid technology.

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 themogravimetric analyzer; Perkin-Elmer, Parr 273, and EG&G potentiostat/galvanostats; a Johnson-Matthes 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 Difractometer 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.

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 doil 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:
CE 319 Applied Mechanics in Structural Engineering
CE 320 Structural Analysis II
CE 323 Computer Methods of Structural Analysis
CE 384 Structural Dynamics

II. Structural Design Courses:
CE 326 Advanced Steel Structures Design
CE 327 Advanced Concrete Structures Design
CE 328 Prestressed Concrete Design
CE 3xx Structural Masonry Design

III. Structural System Courses:
CE 375 Low-Rise Building Analysis & Design
CE 426 Advanced Design in Steel & Lightweight Structures
AE/ME/EM 334 Stability of Engineering Structures

Geoenvironmental Engineering

A minimum of two of the following geotechnical courses must be taken:
CE 314 Geosynthetics in Engineering
CE 315 Intermediate Soil Mechanics
CE 329 Foundation Engineering II

A minimum of two of the following environmental courses must be taken:
CE 360 Environmental Law and Regulations
CE 361 Remediation of Contaminated Groundwater & Soil
CE 363 Solid Waste Management
CE 367 Introduction to Air Pollution
CE 380 Water Resources and Wastewater Engineering

Geotechnical Earthquake Engineering

The following courses are required:
CE 316 Geotechnical Earthquake Engineering
CE 413 Dynamics of Earth Materials

Two of the following three courses are required:
CE 315 Intermediate Soil Mechanics
CE 329 Foundation Engineering II
CE 412 Numerical Methods in Geotechnical Engineering

Infrastructure Renewal
Two of the following courses are required:
CE 374 Infrastructure Strengthening with Composites
AE 311/ME 382 Intro to Composite Materials & Structures
CE 314 Geosynthetics in Engineering

One of the following courses is required:
CE 326 Advanced Steel Design
CE 327 Advanced Concrete Design
CE 328 Prestressed Concrete Design

One of the following courses is required:
CE 329 Foundation Engineering
CE 345 Construction Methods
CE 384 Structural Dynamics
AE/ME/EM 484 Analysis of Laminated Composite Structures

Military Construction Management
(Offered in CE and EMgt disciplines ONLY at the Fort Leonard Wood campus.)
SysEng 411 Systems Engineering Management
EMgt 313 Managerial Decision Making
CE 345 Construction Methods
CE 442 Construction Adm., Planning and Control

Project Engineering and Construction Management
(Offered in both CE and EMgt disciplines)
Two of the following civil engineering courses are required:
CE 345 Construction Management
CE 349 Engineering Construction Contract Specifications
CE 442 Construction Administration Planning and Control
CE 445 Advanced Construction Engineering
Two of the following engineering management courses are required:
EMgt 308 Economic Dec
EMgt 314 Management for Engineers
EMgt 361 Project Management
EMgt 362 Case Studies in Project Management
EMgt 368 Systems Engineering and Analysis I
EMgt 461 Advanced Project Management

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 ngineering. 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

SysEng/CpE 419-Network-Centric Systems Architecting and Engineering

CpE/SysEng 449 Network Centric Systems Reliability and Security

Elective Courses

(Select two courses from the following)

Communications Engineering

CpE 317-Fault Tolerant Digital Systems
CpE 319-Digital Network Design
CpE 349-Trustworthy, Survivable Cmp Networks
CpE 348-Wireless Networks
CpE 448-Highspeed Networks
CpE/SysEng 401-Wireless Adhoc and Sensor Network
CS 483-Computer Security
CS 486-Mobile and Sensor Data Mgt

Smart Engineering Systems Modeling

SysEng 433-Distributed Systems Modeling
SysEng 479-Smart Engineering Systems Design
SysEng 478-Advanced Neural Networks

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.

Computer Science

The Computer Science Department offers comprehensive M.S. and Ph.D. degree programs that focus on computer network security, software engineering, web databases, wireless systems, intelligent systems, data mining, bioinformatics, parallel and distributed processing pervasive computing, computer networks, scientific visualization, and algorithms. These research activities support the department's two major areas of excellence: Software Engineering and Critical Infrastructure Protection.

The Computer Science Department at Missouri S&T makes use of both its own Technology Learning Spaces (TLSs) as well as university TLSs. Class sizes are kept small to facilitate student and faculty interactions. Research laboratories provide support for both undergraduate and graduate students. These laboratories include:

- Experimental Computation Lab
- McDonnell Douglas Software Engineering Lab
- Natural Computation Lab
- Network Research Lab
- Web and Wireless Computing (W2C)
- Pervasive and Mobile Computing Lab

Networked and wireless computer access is available to all students, faculty, and staff.

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
- Computer Organization/Architecture
- Database and File 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.)

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 CmpSc 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.

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 CmpSc 410.

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.

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.

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).

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:
EE 305 Electric Drive Systems
EE 402 Advanced Theory of Electric Machines

A minimum of two of the following electric power systems courses must be taken:
EE 304 Power Quality
EE 331 Digital Control
EE 353 Power Electronics
EE 371 Grounding and Shielding
EE 401 Electric and Hybrid Vehicles
EE 406 Power System Stability
EE 431 Linear Control Systems

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:
EE 304 Electric Power Quality
EE 307 Power Systems Engineering
A minimum of two of the following electric power systems courses must be taken:
EE 302 Extra High Voltage Engineering
EE 304 Electric Power Quality
EE 352 Photovoltaic Power Systems
EE 404 Economic Operation of Power Systems
EE 405 Power System Protection
EE 406 Power System Stability
EE 407 Surge Phenomena in Power Systems
EE 408 Computer Methods in Power Systems Analysis
EE 431 Linear Control Systems

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. Crewniak
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 Ferdows.

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.

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.

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

EMGT 314 Management for Engineers and Scientists
EMGT 361 Project Management
EMGT 365 Operations Management Science
EMGT 452 Advance 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 (EMGT 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 EMGT 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

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 Exchange 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

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 elsewhere. Specific requirements for the Masters and Ph.D. programs are given below.

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.

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 (300 or 400 level) classes after conditional admission.

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

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

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.

EMGT 314 Management for Engineers and Scientists
EMGT 361 Project Management
EMGT 365 Operations Management Science
EMGT 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 EMGT 308 (Economic Decision Analysis), EMGT 452 (Advanced Financial Management), or an equivalent introduction to finance and/or engineering economics course, as a prerequisite to the certificate program.

EMGT 408 Financial Risk Management
EMGT 480 Investment
EMGT 481 Financial Engineering
EMGT 482 Advanced Financial Engineering

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.

EMGT 311 Human Factors
EMGT 411 Human Systems Integration
IST 385 Human Computer Interaction
And one of:
EMGT 386 Safety Engineering Management
IST 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.

EMGT 313 Managerial Decision Making
EMGT 418 Leadership for Engineers
Psych 316 Psych of Leadership in Organization
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 work place. 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

EMGT 309 The Six Sigma Way
EMGT 409 Design for Six Sigma
EMGT 472 Lean Manufacturing Systems
And one of:
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.

EMGT 375 Total Quality Management
EMGT 385 Statistical Process Control
EMGT 475 Quality Engineering
EMGT 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:

EMGT 308 Economic Decision Analysis
EMGT 361 Project Management
EMGT 458 Case Studies in Project Management
EMGT 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)

EMgt 313 Human Relations in Technical Mgt
EMgt 314 Mgt for Engineers and Scientists
CE 345 Construction Methods
And one of:
CE 443 Contract Formulation & Project Delivery Systems
CE 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 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.

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://dec.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 various 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/.

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.

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 (ExpEng 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:

ExpEng 307/MinEng 307 Principles of Explosives Engineering
ExpEng 350/MinEng 350 Blasting Design and Technology
ExpEng 351 Demolition of Building and Structures
MinEng 383 Tunneling and Underground Construction Techniques
ExpEng 402 Environmental Controls for Blasting
ExpEng 406 Scientific Instrumentation for Explosives and Blasting

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 (ExpEng 497) or industry project (ExpEng 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.

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 prediction 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, IDRIS, 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://www.mst.edu/~gee.

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/Petrology/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.

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 professions, 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.

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:

GeE 381-Int. Subsurface Hydrology &Cont. Trans. Mechs.
GeE 371-Rock Engineering
GeE 341-Engineering Geology & Geotechnics
CE 315-Intermediate Soil Mechanics
or
Min Eng 432-Rock Mechanics II

An additional 18 hours of coursework are required, included a 3 hour industrial (practice oriented) project (GeE 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.

Contact information e-mail gtech@mst.edu or visit our website at http://www.mst.edu/~gtech.

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 certificates. 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.

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 (IST 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.

- IST 351 Leadership in Technology-Based Organizations
- IST 385 Human Computer Interaction
- IST 436 Foundations of Internet Computing
- IST 461 Advanced Information Systems Project Management

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
ERP 446

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:

IST 385 Human-Computer Interaction
IST 386 HCI Prototyping
IST 387 HCI Evaluation

and one advanced HCI elective from:

IST 487 Research Methods in HCI
IST 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
PSYCH 374 Organizational Psychology
ERP 348 Strategic Enterprise Management Systems
IST 351 Leadership in Tech-Based Organizations

and one elective course from:

PSYCH 350 Psychology of Women
PSYCH 372 Group Dynamics
PSYCH 378 Social Influence
IST 480 Advanced Web and New Media Studies
IST 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
IST/ERP 444 Essentials of Data Warehouses

The other two courses may be chosen from the following:

ERP 346 ERP Systems Design and Implementation
ERP 348 Strategic Enterprise Management Systems
ERP 442 Customer Relationship Management
IST 443 Information Retrieval and Analysis
IST 445 Database Marketing
ERP 448 Enterprise Performance Management System 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:

IST 461 Advanced Information Systems Project Management
EMGT 458 Case Studies in Project Management
EMGT 461 Global Project Management
EMGT 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.

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
- Rapid Product Realization
- Programmable Controllers
- Assembly & Automation
- Manufacturing Plant Layout
- Jig, Fixture & Tool Design
- CNC machining
- Environmentally Friendly Manufacturing
- Product Quality Control

This is a truly interdisciplinary program, which will provide you with a variety of options in manufacturing. The existing laboratories which can be used in this proposed program include Computer Integrated Manufacturing Lab (CIM lab), Agile Manufacturing and Automated Inspection Lab (AMAIL), Rapid Prototyping Lab, Laser Aided Manufacturing Processes (LAMP) Lab, Augmented Reality Lab, High Pressure Waterjet Lab, Sustainable Design Lab, Laser Welding Lab, Composite Manufacturing Lab, Computer Vision Lab, Lab for Industrial Automation and Flexible Machining, Automated PC Board Milling Machine, Foundry to Melt and Cast Ferrous and Non-ferrous Alloys, Intelligent Control of Machining Lab and Digital Image and Signal Processing Lab.

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: ME 363-Computer Applications in Mechanical Engineering Design

Course II: ME 308-Rapid Product Design and Optimization; EMgt 354/ME 357-Integrated Product and Process Design

Course III: ME 459-Advanced Topics in Design and Manufacturing

Course IV: Select one from the following courses: AE/EMgt/ME-360 Probabilistic Engineering Design; ME 356-Design for Manufacture

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
- ME 320 Advanced Mechanics of Materials
- ME 336 Fracture Mechanics
- ME 382 Introduction to Composite Materials & Structures
- ME 459 Advance Topics in Design and Manufacturing

Course II-Process, Assembly and Product Engineering
- EMgt 345/ME 357 Integrated Product Design
- ME 308 Rapid Product Design and Optimization
- ME 363 Computer Applications in Mechanical Engineering Design

Course III-Manufacturing Competitiveness
- EMgt 309 Introduction to the Six Sigma Way
- AE/ME 360 Probabilistic Engineering Design
- EMgt 364 Value Analysis
- EMgt 385 Statistical Process Control
- EMgt 472 Lean Manufacturing
- ERP 346 Enterprise Resource Planning Systems Design and Implementation

Course IV-Manufacturing Systems Design
- ME 355 Automation in Manufacturing
- ME 356 Design for Manufacture
- ME 378 Mechatronics

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 MSE 421, 422 and 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, MSE 421, 422, and 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.

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 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: www.mst.edu/mathstat/.

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.

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

Area I.

Mech Eng 363 Computer Applications in Mechanical Engineering

Area II. Select one from the following courses:

Eng Mgt 354/ Mech Eng 357 Integrated Product and Process Design.

Mech Eng 308 Rapid Product Design and Optimization.

Area III.

Mech Eng 459 Advanced Topics in Design and Manufacturing.

Area IV. Select one from the following courses:

Mech Eng 356 Design for Manufacture.

AE/Eng Mgt / Mech Eng 301.

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:

Mc Eng 336/Ae Eng 336 Fracture Mechanics

Mc Eng 382/Ae Eng 311 Introduction to Composite Materials and Structures.

Mc Eng 484/Ae Eng 484 Mechanics of Laminated Composite Structures.

Mc Eng 485/Ae 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:

Mc Eng 311 Introduction to Continuum Mechanics.

Mc Eng/Ae Eng 320 Advanced Mechanics of Materials.

Mc Eng/Ae Eng 334 Stability of Engineering Structures.

Mc Eng/Ae Eng 336 Fracture Mechanics.

Mc Eng 338/Mc Eng 344 Fatigue Analysis.

Mc Eng 382/Ae Eng 311 Introduction to Composite Materials and Structures.

Mc Eng /Ae Eng 422 Applied Linear Elasticity

Mc Eng 430 Theory of Plates.

Mc Eng/Ae 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

ME 382 Introduction to Composite Materials & Structures.
MET 305 Nondestructive Testing.
MET 307 Metals Casting.
MSE 325 Materials Selection in Mechanical Design.

Course II - Process, Assembly and Product Engineering

EMgt 354/ME 357 Integrated Product and Process Design.
ME 308 Rapid Product Design and Optimization.
ME 363 Computer Applications in Mechanical Engineering.

Course III - Manufacturing Competitiveness

EMgt 309 Introduction to the Six Sigma Way.
AE/ME 360 Probabilistic Engineering Design.
EMgt 364 Value Analysis.
EMgt 372 Production Planning and Scheduling.
EMgt 385 Statistical Process Control.
EMgt 472 Lean Manufacturing.

Course IV – Manufacturing Systems Design

ME 356 Design for Manufacture.
EMgt 334 Computer Integrated Manufacturing Systems.
ME 355 Automation in Manufacturing.
ME 459 Advanced Topics in Design and Manufacturing.

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:

AE/EE/ME 301, Emgt/ME 344, ME 353, ME 355, ME 363, ME 453, ME 455.

Group II:

EE 332, EE 335, Emgt 334, Emgt 434.
Ae Eng/Mc Eng/EE 378-Mechatronics.
EE 332 Plantwide Process Control.
EE 335 Advanced PLC.
Egmt 334 Computer Integrated Manufacturing Systems.
EMgt/Mc Eng 344 Interdisciplinary Problems in Manufacturing Automation.
EMgt 434 Advanced Manufacturing Systems Integration.
Mc Eng 353-Computer Numerical Control of Manufacturing Processes.
Mc Eng 355 Manufacturing Equipment Automation.
Mc Eng 363 Principles and Practices of Computer Aided Design.
Mc Eng 453 Advanced CNC of Manufacturing Processes and Engineering Metrology.
Mc Eng 455 Modeling and Control of Manufacturing Processes.

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:

Mc Eng/Ae Eng 381, Mc Eng/Ae Eng 401, Mc Eng/Ae Eng 479

Group II:

Ae Eng 361, EE 331, EE 431, EE 432
Ae Eng 361-Flight Dynamics: Stability and Control.
EE 331-Digital Control.
EE 431-Linear Control Systems.
EE 432-Optimal Control and Estimation.
Mc Eng/Ae Eng 381–Mechanical and Aerospace Control Systems.
Mc Eng/Ae Eng 401-Linear and Nonlinear Estimation: Theory and Applications.
Mc Eng/Ae Eng 479-Analysis and Synthesis of Mechanical and Aerospace Systems.

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.

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.

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, us 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 10^9 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.

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 rocks@mst.edu. Additional information may also be found at the web pages at: www.gse.edu or http://petroleum.mst.edu/.

Physics

The Department of Physics offers programs leading to both the master of science and doctor of philosophy degrees. The master's degree can be earned with either a thesis or non-thesis option.

Most physics graduate students are supported by either Teaching or Research Assistantships, although some Fellowships are available for exceptionally promising students. Most entering graduate students are supported on Teaching Assistantships, and teach in the introductory physics laboratory. Thereafter, they are usually supported as Research Assistants on external research grants.

Entering graduate students usually have a physics undergraduate degree; however inquiries from students with other technical degrees and a good mathematics background are encouraged, since the program allows minor background deficiencies to be made up.

Each student's graduate degree program is designed around a set of core graduate courses (classical mechanics, electrodynamics, quantum mechanics, and statistical mechanics) and graduate physics electives (see Physics Courses Section). After their second year, Ph.D. students must take a qualifying examination based on the material taken from the core courses. Details of the program and course offerings may be obtained by calling 573-341-4702, or emailing the department chairman at physics@mst.edu. Additional information may also be found on the department's web page at http://physics.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.

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:
Psychology 308 Social Psychology
Psychology 316 Psychology of Leadership
Psychology 374 Organizational Psychology
ERP 348 Strategic Enterprise Mgt Systems
IST 351 Leadership in Technology-Based Org
And a fourth course from one of the following five:
Psychology 350 Psychology of Women
Psychology 372 Group Dynamics
Psychology 378 Social Influence
IST 480 Social Informatics
IST 487 Research Methods in Human Cmp Intr.
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:
Psychology 307 Industrial Psychology
Psychology 364 Tests and Measurements
Psychology 403 Psychometrics
And an additional two from these three:
Statistics 346 Regression Analysis
Statistics 353 Statistical Data Analysis
Statistics 444 Research Design

The Psychometrics Certificate Program is open to all persons holding a Bachelors, Masters, or Ph.D. degree and who have the required pre-requisites 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:
Eng Mgt 313 Managerial Decision Making
Psychology 316 Psychology of Leadership
Psychology 374 Organizational Psychology
Eng Mgt or Psych 418 Leadership for Engineers

Students will be responsible for prerequisite knowledge as determined by course instructors. With the approval of the departments, appropriate courses may be substituted for a certificate course if that course is not available.

The Leadership in Engineering Organizations Certificate program is open to all persons holding a B.S., M.S., or Ph.D. degree in an engineering or related field and who have a minimum of 12-months of professional employment experience or are currently accepted into a graduate engineering degree program at S&T.

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.

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.

Ph.D. Requirements

Admissions Requirements

Applicants needs 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 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.

Major Requirements

May be taken during M.S. degree
Core Curriculum - 24 credit hours
- SysEng 368 Systems Engineering and Analysis
- SysEng 411 Systems Engineering Capstone
- SysEng 412 Complex Eng Systems Project Mgt
- SysEng 413 Econ Analysis Systems Eng Projects
- SysEng/CpE 419 Network Centric Sys Arch&Eng
- SysEng 468 Systems Engineering and Analysis II
- SysEng 469 Systems Architecturing I
- SysEng 479 Smart Engineering Systems Design
- SysEng 490 30 credit hours-Research
- Electives - 36 credit hours

The minimum total credit requirements for graduation are 60 credit hours after successful completion of 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 established specific requirements for each student's Ph.D. by approving the student's plan of study.

Research Areas

Network Centric Systems

End-to-end System Security, Information Assurance, Vulnerability Assessments, Reliability Analysis, and Sustainable Development of Network Centric Infrastructure Systems.

Systems Architecting

Systems Architecture Evaluation, Network Centric Collaborative Design, and Meta-Systems Design Architecture.

Systems Engineering Process and Design

Design for Flexibility, Smart Systems Engineering, and Lean Systems Engineering.

Network Centric Manufacturing and Control

Network Centric Manufacturing Systems, Control Architectures, Adaptive Inventory Models, Process Planning and Manufacturing Execution System, Integrated Product Development, and Robust Chain Networks.

Modeling and Simulation

Modeling and Simulation for Embedded Systems, Modeling and Simulation for Micro/Nano-electronics, Simulation and Mathematical Optimization of Engineering Systems, and Performance and Cost Optimization of Embedded Systems.

Computational Intelligence

Neural and Fuzzy Logic and Evolutionary Computation, Artificial Life, Swarm Optimization, Intelligent Systems Design, Interoperation between Database Systems, and Integration of Ontologies into Systems Engineering organizational design. Prerequisite: Psych 50.

Infrastructure Systems

Health Mentoring of Infrastructure Systems; Interoperatability; Infrastructure models to ensure the coordination and interaction among multiple stakeholders with lifeline systems consisting of utility systems and transportation systems; Geomechanical and Geotechnical Systems; Environmental Systems; Behavior of Infrastructure systems under extreme conditions.

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

SysEng 368 Systems Eng and Analysis I
SysEng 411 Systems Eng Capstone
SysEng 412 Complex Eng Systems Project Mgt
SysEng 413 Econ Analysis of Systems Eng Projects
SysEng 468 Systems Eng and Analysis II
SysEng 469 Systems Architecting

Specialization Tracks

Chose 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.

Systems Engineering Graduate Certificate

Required CORE courses:

SysEng 368 Systems Eng and Analysis I
SysEng 413 Econ Analysis of Systems Eng Projects
SysEng 468 Systems Eng and Analysis II
SysEng 469 Systems Architecting

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:

SysEng/ CpE 419 Network Centric Systems Architecting and Eng
CpE/ SysEng 449 Network Centric Systems Reliability and Security

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:

CpE358/EE367/SysEng 367 Computational Intelligence

And select one of the following:

CS 347 Intro to Artificial Intelligence
CS 348 Evolutionary Computing
SysEng378/CS 378/EE 368 Intro to Neural Networks and Applications

And select two courses not taken as a core course:

CS 347 Intro to Artificial Intelligence
CS 348 Evolutionary Computing
CS 447 Advanced Topics in Artificial Intelligence
CS 448 Adavnced Evolutionary Computing
SysEng/CpE/EE 458 Adaptive Critic Designs
CS/SysEng/CpE 434 Data Mining and Knowledge Discovery
EE 337 Neural Networks for Control
SysEng 378/CS 378/EE368 Intro to Neural Networks and Applications
CpE/SysEng/EE457 Markov Decision Processes
SysEng 478 Advanced Neural Networks
CpE/EE/SysEng/Stat 439 Clustering Algorithms

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.

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.

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.

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 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

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
ENGL 281 Theories of Written Communication
ENGL 329 Advanced Writing for Science and Engineering
GE 352 International Engineering and Design
IST 487 HCI Research Methods
MATH 209 Foundations of Mathematics
MATH 303 Mathematical Modeling
MATH 308 Linear Algebra 2
MATH 354 Mathematical Logic
MSE 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.