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, and flight dynamics and control are the major areas of emphasis. A great 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 a graduate certificate in both Aerospace Engineering and Mechanical Engineering entitled Composite Materials and Structures.

The master of science thesis program consists of a minimum of 30 semester hours, normally including 24 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 nine hours must be from the aerospace engineering core curriculum, and at least six hours in mathematics and/or computer science. 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.

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, 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, ramjet and supersonic combustion ramjet 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 highlift devices, aerospace system design, and viscous effects in transonic flows.

The Department of Mechanical and Aerospace Engineering has many well equipped laboratories located in the Mechanical Engineering Building 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 UMR 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, cellular engineering, 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 UMR campus.

Graduate study in Biological Sciences is characterized by close interactions with productive 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 MS - with thesis

BioSci 402	Problems in Applied and Environmental Biology
BioSci 410	Graduate Seminar
BioSci 475	Techniques in Modern Biology
BioSci 490	Graduate Research

Degree Requirements MS - without thesis

BioSci 402	Problems in Applied and Environmental Biology
BioSci 410	Graduate Seminar
BioSci 475	Techniques in Modern Biology

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 rooms 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 the other disciplines. The UMR 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 UMR such as the Environmental Research Center, the Center for Environmental Science and Technology (CEST), and the Graduate Center for Materials Research. The Department of Biological Sciences is also equipped with state-of-the-art 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, PCR machines, 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 (including a Nanodrop instrument), dark room, 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 chamber.

Biomaterials

The biomaterials program in the Department of Materials Science & Engineering offers comprehensive graduate education in a number of areas including 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. Further information on these opportunities and facilities available to carry out research in biomaterials may be found under Materials Science & Engineering.

Degree Requirements:

The Biomaterials program is an interdisciplinary program that offers the Master of Science degree in Biomaterials, either with or without a thesis. A baccalaureate degree in any branch of materials science and engineering, biological sciences, chemistry, chemical engineering, mechanical engineering, or other related disciplines is required. The total number of credit hours required for graduation is 30. The M.S. degree with thesis is oriented more toward research. The program requirements are: at least 6 but not more than 12 credit hours devoted to research, 9 credit hours of biomaterials core courses, and the remainder chosen from a list of approved courses with the consent of the advisor. For the M.S. degree without thesis, the program requirements are 9 credit hours of biomaterials core courses, 3 credit hours of practice-oriented research, and the remainder chosen from a list of approved courses with the consent of the advisor.

Business Administration

The Business Administration department offers a unique Master of Business Administration (M.B.A.). This program combines business, technology, enterprise development and Enterprise Resource Planning (ERP) to develop leaders for a technology driven business world. Demand for M.B.A. graduates with a strong technology background is very high. The growth rate in careers in technology is the greatest for any career path with growth in ERP jobs leading the technology field.

ERP software systems are the technology backbone of the proposed program. ERP systems are large-

scale software systems such as SAP, Microsoft Dynamics and Oracle/PeopleSoft that integrate the business processes of an organization. UMR hosts both Microsoft Dynamics and SAP providing students with an exceptional opportunity to learn ERP systems and how they support business excellence.

Enterprise development is an interweaving thread that integrates the functional disciplines. The 18-hour core course presents the student with a new product case that is the basis for learning the functional areas of business administration. The course takes the new product through the development process, providing the student with a strong understanding of business planning and management.

The M.B.A. program is distinctive as a calendar year program combining mandatory residence for five months with distance education options for the remainder of the course work. The program starts in January and students can complete the degree requirements by the end of the calendar year. After completing the 18 credit hour integrated core, the student takes 6 credit hours of internship or practicum during the summer and completes the program with 12 hours of electives.

The department also offers a graduate certificate entitled Business Essentials.

Admissions Requirements

M.B.A. applicants are required to have a four-year bachelor's degree from an approved (accredited) institution in addition to the requirements listed in the Admissions and Academic Program Procedures of this catalog. In order to be considered for admission, the applicant must meet the following standards:

GPA>3.0 (on a 4.0 scale)

GMAT+50* GPA (on a 4.0 scale)>700

TOEFL>600/computer based 250 or IELTS>6.0 (International students)

Students are required to have completed microeconomic and macroeconomic theory, finance, management and organizational behavior, business law, financial and managerial accounting, management information systems, marketing, operations, and inferential statistics with a "B" or better or to have completed an approved waiver examination before beginning the Integrated Core. Students are also expected to have mastered the basic of Microsoft Office (Word, Excel, PowerPoint, and Access) and to have basic knowledge of computer programming before beginning the Integrated Core.

Degree Requirements

The program requires residency on the UMR campus for the mandatory 18 credit hour spring integrated core course. The program is a master's degree without thesis. A minimum of 36 credit hours must be completed for graduation.

The summer practicum provides students with the opportunity to apply the knowledge from the integrated core to real world projects. Two options are provided: an off-campus internship or an on-campus research project. One option is required for 6 credit hours.

Students are required to take an additional 12 credit hours to complete the M.B.A. degree. A minimum of 9 credit hours should be from a designated specialization area of study. Available specialization areas and their respective course options are:

E-Commerce
- Internet Computing
- E-commerce Architecture
- Network Economy
- Law and Ethics in E-commerce
- Mobile Data Management and Applications

Enterprise Resource Planning
- ERP Design and Implementation
- Supply Chain Management Systems
- Strategic Enterprise Management Systems
- ERP Systems Configuration and Integration

Human-Computer Interaction
- Human Computer Interaction
- Human Computer Interaction Prototyping
- Human Computer Interaction Evaluation
- Research Methods in Human Computer Interaction

Supply Chain Management
- ERP Design and Implementation
- Supply Chain Management Systems
- Negotiations
- Information Systems Project Management

Information Technology Management
- Internet Computing
- Network Performance
- Leadership in Technology Based Organizations
- Information Systems Project Management

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 400 level lectures and a minimum of 11 hours graduate research on the UMR campus are required. A maximum of 6 hours 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 exam in accordance with UMR rules.

Chemical & Biological Engineering

The Department of Chemical and Biological Engineering offers MS and PhD degrees in chemical engineering.

A baccalaureate degree in chemical engineering from an ABET - approved program with a minimum undergraduate grade point average of 3.0/4.0 or equivalent is generally required for admission to the graduate program. Non-chemical engineering majors may be admitted to the program but will be required to take some prerequisite undergraduate courses.

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.

The master of science thesis program consists of a minimum of 30 semester hours, including 18-24 hours of coursework, of which at least 9 in department credit hours must be at the 400 level with 6 hours taken from the chemical engineering core curriculum consisting of CHE 433 and CHE 445. In addition, a thesis from research that is equivalent to 6-12 credit hours in a major area must be prepared and defended.

A master of science non-thesis program consists of 30 semester hours coursework, including a minimum of 9 credit hours of 400-level coursework with 6 hours taken from the chemical engineering core curriculum consisting of CHE 433 and CHE 445 and 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 candidate for the degree of doctor of philosophy must pass a written qualifying examination on chemical reaction engineering, transport phenomena and thermodynamics. A grade of B or better 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.

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 Biological 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; bioconversion; 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, cosmochemistry, 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 requires that all of its graduates 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 & Biological 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 liquid, diffusion, and variable-temperature capabilities; a Varian/ Oxford 400 MHz solids NMR; a Bruker X-ray diffractometer with low-temperature attachment; X-ray photoelectron/Auger electron spectroscope/temperature programmed desorption (XPS/AES/TPD) ultra- high vacuum surface analysis chamber; 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; a Spex 1403 laser Raman spectrometer with a coherent argon ion source; 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; TA Instruments and Perkin-Elmer themogravimetric analyzers; Perkin-Elmer, Par 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; and a Wyatt HPLC with Dawn EOS light-scattering detection system. 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, Macintosh 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. 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 University of Missouri. 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 several areas of specialization. These are construction materials, environmental engineering, geotechnical engineering, hydraulic engineering and engineering hydrology, structural engineering, transportation, construction engineering, and infrastructure engineering. Samples of recent and ongoing funded research are drainage of highway subgrades, liquefaction of soils, earthquake mitigation of highway structures, determining stream stability and storm water detention in urban watersheds, evaluation of storm water drainage structures on bridges, urban watershed modeling, sediment transport, river mechanics, environmental fluid mechanics, mathematical modelling, constitutive modeling of reinforced and prestressed concrete structures, collapse studies of building structures and bridges subjected to interacting ground motion, theoretical studies and shake-table tests of various controlled structures, structural optimization with multi objective functions, a computerized tutoring system for structural analysis, behavior of concrete structures reinforced with composites, traffic operations in work zones, and studies on driver behavior. While this list is representative, it is not all-inclusive.

Faculty expertise includes analysis, design and control of seismic-resistant structures, design of cold-formed steel structures, design of reinforced and prestressed concrete structures, FRP composite material for civil infrastructure, treatment processes for liquid industrial waste, behavior of granular base materials, asphalt and concrete as they relate to pavement analysis and design, river engineering and urban watershed dynamics, indoor air pollution, phytoremediation, advanced oxidation processes, bioremediation of metals, pollution control from concentrated animal feed operations, blast loading of structures, traffic operations and safety, traffic modeling and simulation, traffic flow theory and characteristics, driver behavior, armor/anti-armor, and geotechnical engineering problems such as earthquake response of soils and foundations, dynamic soil-structure-interaction, and evaluation of resistance of helical anchors. The breadth of faculty expertise and experience is wide, and the nature of ongoing research in any particular emphasis area varies considerably over time.

The basic prerequisite for admission to graduate study in the department is a bachelor of science degree in civil engineering from an ABET accredited school or equivalent. Students who have a degree from a nonaccredited school, or hold a bachelor of science degree in a field other than civil engineering, may be required to take civil engineering prerequisites to prepare for graduate courses. Specific prerequisites will depend on their 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, (D.E.), and doctor of philosophy (Ph.D.).

The Department is housed in the Butler-Carlton Civil Engineering Hall. The building provides office space for CArE engineering faculty, staff, and graduate students, and contains classrooms and laboratories in which most civil engineering courses are taught. On the premises are a 175-seat auditorium and several smaller auditoria with large-screen video projection capability. The building contains geotechnical laboratories, a water resources laboratory, a bituminous materials testing laboratory, environmental engineering laboratories, structures and materials testing laboratories, a transportation laboratory, and a machine shop. Laboratories are used for instruction and research and shop facilities are used for construction and maintenance of specialized mechanical and electronic testing equipment needed to support teaching and research.

In addition, the building houses several computer learning centers (CLC) and research computing labs. Departmental and campus network servers offer word processing, spreadsheet, graphing, CADD, and various specialized data analysis and processing software. All faculty, graduate students, and staff have access to network to facilitate communications, teaching and research. Wireless communication and access to the Internet is also available.

The Department is home to the Environmental Research Center for Emerging Contaminants, the W.W.Yu Center for Cold-formed Steel Structures, the

Natural Hazards Mitigation Institute and a high-bay structural engineering laboratory. The Environmental Research Center for Emerging Contaminants is campus-wide and interdisciplinary with research focused on the fate and control of compounds associated with newly emerging health issues in natural systems, drinking water and sewage treatment plants, agriculture, and industry. The structural engineering laboratory is used for graduate research in structural dynamics as well as testing of reinforced concrete structures and cold-formed steel structures. It features a strong floor and a two-story tall reaction wall. A "shake table" simulates earthquake conditions for the evaluation of earthen structures. The Department has the faculty, staff, and physical facilities to support a wide range of research within the traditional emphasis areas of civil engineering. Although there are nationally recognized theorists among the faculty, the emphasis is on applied research with increasing attention given to interdisciplinary and interdepartmental work.

Graduate Certificate Programs

(Offered in civil engineering discipline only unless an additional discipline is specified.)

Contemporary Structural Engineering

One of the following courses is required:

CE 319 Applied Mechanics in Structural Engineering
CE 320 Structural Analysis II
CE 323 Computer Methods of Structural Analysis

One of the following courses is required:

CE 326: Advanced Steel Structures Design
CE 327: Advanced Concrete Structures Design
CE 328: Prestressed Concrete Design

Two of the following courses are required:

CE 375: Low-Rise Building Analysis and Design
CE 424: Structural Dynamic & Earthquake Engineering
CE 425: Finite Element Application in Structural Design
CE 426: Adv. Design in Steel & Lightweight Structures
AE/ME/EM 334: Stability of Engineering Structures
AE/ME 431: Gas Dynamics I

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 Grndwtr. & 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

The following courses are required:

CE 374 Infrastructure Strengthening with Composites
AE 311/ME 382/EM 381 Intro to Composite Materials and Structures

Two of the following courses are required:

CE 326 Advanced Steel Structures Design
CE 327 Advanced Concrete Structures Design
CE 328 Prestressed Concrete Design
AE/ME/EM 484 Analysis of Laminated Comp. 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.)

Civil Engineering Courses. Choose any 2 from:

CE 345 Construction Methods
CE 349 Engineering Construction Contract Specs.
CE 442 Construction Adm., Planning and Control
CE 445 Advanced Construction Engineering

Systems Engineering and Engineering Management Courses. Choose any 2 from:

EngMgt 361 Project Management
SysEng 413 Economic Analysis of Sys Eng
SysEng 411 Systems Engineering Management
SysEng 412 Cmplx Eng Sys Project Mgt
SysEng 368 Systems Engineering and Analysis I

Computer Engineering

The mission of the Computer Engineering Program, consistent with the School of Engineering and the UMR 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 nonthesis 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

Admission requirements: The nominal GPA requirement for admission to the MS 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 can not 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 4.5 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 and 580 on the paper based TOEFL. The minimum recommended score on the IBT (internet based testing) version of the TOEFL exam is 80.

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

Program Requirements: Additional minimum departmental requirements beyond those stated in the section on Admission and Program Procedures of this catalog are as follows. M.S. with thesis programs require a minimum of 21 hours of course work. For M.S. with thesis and M.S. without thesis programs, 200 level out of department courses should be prerequisite for 300 level courses. For Ph.D. programs approximately 90 hours beyond the B.S. or 60 hours beyond the M.S. are required.

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 is expected for the M.S. thesis and Ph.D. dissertation as well as publication of the results. The student should work closely with the Major Advisor and Committee to determine when these expectations are met. Length of research time and/or research credit hours will not automatically satisfy this requirement.

Network Centric Systems Graduate Certificate

(Offered in Systems Engineering discipline also.)

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 graduate courses selected for the program will count towards an MS degree in Systems Engineering or Computer Engineering and they address the intersection between network engineering and systems engineering and architecting. The requirements are the successful completion of two core courses and two specialty courses. (A grade of a “B” or better is required in each course before the student is eligible for the Masters of Science program.

Core courses:

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

CmpEng/Sys Eng 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://www.ece.umr.edu. We can be contacted by telephone at 573-341-4506 or email at graduate @ece.umr.edu. For information about the Engineering Education Center in St. Louis, visit their web page at http://www.umr.edu/umreec.

Computer Science

The Computer Science Department offers comprehensive M.S. and Ph.D. degree programs that focus on the design and implementation of software systems and algorithms (problem solving techniques). While instruction and research are on the leading edge of computing, we endeavor to keep class size small to facilitate student and faculty interactions.

The CS faculty has a broad range of scholarly interests which include software engineering, computer security, web databases and wireless systems, intelligent systems (artificial intelligence, machine learning, and evolutionary computation), data mining, web databases and wireless systems, bioinformatics, parallel and distributed processing, computer networks, scientific visualization, computational science, and algorithms. The research being done in these areas supports the department's three major areas of excellence; Software Engineering, Critical Infrastructure Protection, and Bioinformatics.

The Computer Science Department at UMR makes use of both its own computer learning centers (CLCs) as well as university CLCs. Research laboratories provide support for both undergraduate and graduate students. These laboratories include:

- Algorithms and Complexity Lab
- Bioinformatics Lab
- Data Mining Knowledge Discovery Lab
- Experimental Computation Lab
- McDonnell Douglas Software Engineering Lab
- Natural Computation Lab
- Network Research Lab
- Web and Wireless Computing (W2C)

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

Admission 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 nonthesis):

A minimum GRE verbal score of 370 and for those not speaking English as their native language, a TOEFL score of 570/230/89.

Minimum GRE Quantitative Score >= 700

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 UMR, with at least a 3.0 GPA, as per graduate requirements. Content of the following courses:

Calculus I, II, and III
Linear Algebra
Statistics
C or C++ or Java
Computer Organization
Data Structures
File Structures or Database
Numerical Methods
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 UMR 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. Admission to the Ph.D. program in computer science is granted by majority vote of the Computer Science Graduate Faculty and approval of the Vice Provost of Graduate Studies.

Program Requirements:

M.S. with Thesis: The M.S. degree with thesis requires the completion of 24 hours of graduate course work (a minimum of 6 at the 400 level), 6 hours of research, 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 9 hours at the 400 level).

Ph.D. Program: Requirements for the Ph.D. in Computer Science include:

Qualifier exam over graduate-level courses in core areas. Research Readiness presentation based on survey of current Computer Science Literature. Com-

prehensive exam. Dissertation and Defense reporting the results of original research which meets the standards of current disciplinary journal-quality research publications

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.

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 University of Missouri-Rolla instructors 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 UMR 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, software quality and testing theory and practice, and an advanced treatment of software metrics.

Multi Media and Information Systems Certificate

The Multi Media and Information Systems certificate is tailored to the working professional who wants to expand their knowledge of advanced data management technologies. Object-oriented database structure, data mining, and multimedia storage and retrieval techniques and bioinformatics 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. Program coverage includes network architecture and protocols, computer communication and networking basics, principles of network security, and techniques for preventing, detecting and recovering from attacks, as well as advanced topics that address the specific issues and challenges in the wireless and mobile environment, including wireless network provisioning and deployment, location and mobility management, security and privacy, attacks and counter measures, mobile computing applications, and data management in networked sensor systems.

Financial Assistance

Financial assistance is available to graduate students in the form of 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 UMR 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 www.cs.umr.edu or email csdept@umr.edu or phone at 573-341-4491. More information about distance education can be obtained from dce.umr.edu.

Economics and Finance

The Department of Economics and Finance 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 UMR (with no more than 9 credit hours at the 300 level).

Electrical Engineering

The mission of the Electrical Engineering Program, consistent with the School of Engineering and the UMR 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 nonthesis 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 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 constitutes 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 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 MS 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 can not 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 4.5 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 and 580 on the paper based TOEFL. The minimum recommended score on the IBT (internet based testing) version of the TOEFL exam is 80.

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

Program Requirements: Additional minimum departmental requirements beyond those stated in the section on Admission and Program Procedures of this catalog are as follows. M.S. with thesis programs require a minimum of 21 hours of course work. For M.S. with thesis and M.S. without thesis programs, 200 level out of department courses should be prerequisite for 300 level courses. For Ph.D. programs approximately 90 hours beyond the B.S. or 60 hours beyond the M.S. are required.

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 is expected for the M.S. thesis and Ph.D. dissertation as well as publication of the results. The student should work closely with the Major Advisor and Committee to determine when these expectations are met. Length of research time and/or research credit hours will not automatically satisfy this requirement.

Graduate Certificates

Electrical Machine and Drives

Purpose

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 electric power systems 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 Assistant Chair for Graduate Affairs must approve the substitution prior to enrolling in the course.

Administrative Coordinator:

Dr. Richard E. DuBroff
Assistant Chair for Graduate Affairs
Department of Electrical and Computer Engineering

Technical Coordinator:

Dr. Badrul H. Chowdhury

Contributing Faculty:

Dr. Keith Corzine
Dr. Mehdi Ferdowsi
Dr. Badrul Chowdhury
Dr. Mariesa Crow
Dr. Todd Hubing
Dr. Levent Acar

Electrical Power Systems Engineering

Purpose

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

Admission

The Electric 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 307:Electrtic Power Quality
EE 408: Computer Methods in Power System Analysis

A minimum of two fo the following electric power systems courses must be taken.
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 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 Assistant Chair for Graduate Affairs must approve the substitution prior to enrolling the course.

Administrative Coordinator:
Dr. Richard E. DuBroff
Assistant Chair for Graduate Affairs
Department of Electrical and Computer Engineering

Technical Coordinator:
Dr. Badrul H. Chowdhury

Contributing Faculty:
Dr. Mariesa Crow
Dr. Badrul Chowdhury
Dr. Keith Corzine
Dr. Mehdi Ferdowsi
Dr. Levent Acar
Dr. Norman Cox

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://www.ece.umr.edu. We can be contacted by telephone at 573-341-4506 or e-mail at graduate@ece.umr.edu. For information about the Engineering Education Center in St. Louis, visit their web page at http://www.umr.edu/~umreec.

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 6000 graduates at the B.S., M.S., and Ph.D. level since its inception in 1968. The Engineering Management Department is one of only a few institutions in the world that offers B.S., M.S. and PhD 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. Over 30% of the B.S. graduates have reached top executive positions by the age of 50.

Master of Science

The M.S. degree program is offered on the Rolla campus and several locations including the UMR 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 UMR 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 352 - Financial Decision Analysis
EMGT 365 - Operations Management Science

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. Student have the option to take up to two out-of-department elective courses.

Students must submit a typed Form I to the EMGT graduate office by advising week of their first semester. Links to forms are available at: http://emgt.umr.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 Masters 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
- Collective Behavior in Robots Using Evolutionary Neural Networks
- Intelligent Technical Analysis Using Neural Networks and Fuzzy Logic
- Applying the Six Sigma Methodology to Improve the Admissions Process at UMR
- 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
- Activity product affiliation network to study product convergence.

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 UM-Rolla. 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:

- Evolvability in the Phylogeny of the Ontogenesis of Artificial Networks of Spiking Neurons
- Development and Analysis of Intelligent Computation Based Stock Forecasting and Trading
- An Analysis of Intermodal Transportation Mode Selection Considering Stochastic System Parameters
- Development of an ISO 9000 Advisory System
- 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
- An Analysis of TQM Effects on An Organization's Productivity
- Global Stock Index Forecasting Using Multiple Generalized Regression Neural Networks With A Gating Network
- Factors Leading to Successful Application of Improvement Tools for Quality Management
- 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, certain physical sciences, mathematics, or computer science, including a superior academic record. 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 without credit toward the graduate degree through courses at UM-Rolla or elsewhere. Specific requirements for the Masters and Ph.D. programs are given below:

M.S. Admission Standards

B.S. in Engineering, applied mathematics, computer science or a phsycial science

GPA: Regular status: 3.0 cumulative and 3.0 on last 60 credit hours. Conditional status: 3.0 on last 60 credit hours. Condition: Student must earn B or better in each of first four graduate (300 or 400 level) classes after conditional admission.

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=1150, A=4.5

Conditional Status: V+Q=1100, A=4.5

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

Conditional status: 560/220/83. Condition: Student must earn B or better in each of first four graduate (300 or 400 level) classes after conditional admission.

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

Conditional Status: missing coursework in one or both of these areas

Condition: Student must complete missing coursework without credit toward the M.S. degree either at UMR or elsewhere.

Ph.D. Admission Standards

B.S. in Engineering, applied mathematics, computer science, or a physical science

GPA: M.S. GPA = 3.5

Graduate Record Exam (GRE): All students must submit current GRE scores. V+Q=1150, A=4.5. Students holding an M.S. in engineering Management from UMR are exempt from this requirement.

TOEFL: All international applicants must submit a current TOEFL score, regardless of prior academic experience or place of study.

Regular status: 580/237/92

Conditional status: 560/220/83

Condition: Student must earn B or better in each of first four graduate (300 or 400 level) classes after conditional admission.

Statement of Purpose: All applicants must submit a statement of purpose.

PREREQUISITES: Engineering Economy and Engineering Statistics

Conditional Status: missing coursework in one or both of these areas

Condition: Student must complete missing coursework without credit toward the M.S. degree either at UMR or elsewhere.

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 UMR Registrar's Office during his or her last semester. Assistance on this final step can be provided by the Engineering Management Department's Academic Services & Records office, if necessary. More details about requirements can be found in the University Catalog, and are available from the Engineering Management Graduate Program office.

Graduate Certificate Programs

Engineering Management Certificate

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 352-Financial Decision Analysis

EMGT 361-Project Management

EMGT 365-Operations Management Science

Financial Engineering Certificate

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 fincial 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 insructors and are expected to have taken EMGT 308 (Economic Decision Analysis), EMGT 352 (Financial Decision Making), SYSENG 413 (Economic Analysis of Systems Engineering), 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

Leadership in Engineering Organizations Certificate

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, evalute, 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 301-Leadership for Engineers

EMGT 313-Managerial Decision Making

Psychology 316-Psychology of Leadership in Organization

Psychology 374-Organizational Psychology

Project Management Certificate

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 4 required courses:

EMGT 308 - Economic Decision Analysis
EMGT 361 - Project Management
EMGT 458 - Case Studies in Project Mgt.
EMGT 461 - Global Project Management

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 Project Management Certificate program is open to all persons holding a B.S., M.S., or Ph.D. degree and who have a minimum of 12-months of professional employment experience or are currently accepted into a graduate degree program at UMR.

Once admitted to the program, the student must take the four designated courses as given above. 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.

Military Construction Management Certificate

(Offered in CE and EMGT disciplines only at the Fort Leonard Wood campus.)

EMgt 314 Management for Engineers and Scientists

EMgt 313 Human Relations in Technical Management

CE 345 Construction Methods

CE 442 Construction Administration,Planning & Control

Departmental Laboratories

The department has several "hands on" laboratories that have both a research and teaching focus. Each of our labs is directed by faculties 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.

Integrated Systems Facility (ISF)

The Integrated Systems Facility in the Engineering Management Department (www.umr.edu/~isf) is a state-of-the-art 5000 square foot facility housing seven work cells with over $500,000 worth of modern manufacturing equipment. The facility aims to provide an excellent foundation for undergraduate and graduate level courses, M.S. and Ph.D. theses, and research. ISF provides a strong educational background in the areas of manufacturing processes, computer aided design and manufacturing (CAD/CAM), quality assurance and control, process planning, scheduling, packaging, shop floor control, automation in manufacturing, computer integrated manufacturing, and flexible manufacturing systems. Automation and integration in manufacturing is the major focus of research at the Integrated Systems Facility. In that scope, ISF deals with a wide spectrum of research from process planning to shop floor control and deepens the understanding of processes and systems in today's complex manufacturing environment. The research carried out at the Integrated System Facility is anticipated to make both the local and state-manufacturing base more competitive by increasing the rate of innovation and responsiveness to changing needs. The ISF also provides technical service and technological support to industry at local and state levels.

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, fractels, 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 re-

search 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.

Sustainable Design Lab (SDL)

The Sustainable Design Lab (SDL) in the Engineering Management & Systems Engineering Department has been established under the National Science Foundation and industry grants such as AT&T, Society ofManufacturing Engineering (SME), Halliburton, and Lucent Technologies. The mission of the SDL is to establish a state-of-the-art research and teaching facility for advancing technologies enabling rapid and sustainable product realization. The research and teaching topics pursued at SDL include the following: environmentally conscious design and manufacturing, life cycle engineering, lean enterprise thinking, lean and rapid response manufacturing, integrated product/process design (IPPD), CAD/CAM, reverse engineering, design automation, design for assembly and manufacture (DFMA), and supply chain management. Additional information about SDL and its various activities can be found at www.umr.edu/~sdl.

Design Engineering Center (DEC)

The center is one of the outreach arms of the Engineering Management 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://web.umr.edu/~design/.

Laboratory for Investment and Financial Engineering

The goal of the Laboratory for Investment and Financial Engineering (www.umr.edu/~life) 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, 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://emgt.umr.edu/.

English and Technical Communication

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 UMR (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 UMR 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 UMR 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. Students must submit fiction or poetry in application for the creative writing track. Three emphasis areas are available: literature, composition, and creative writing.

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 UMR Department of English and Technical Communication.

Environmental Engineering

The Civil, Architectural, and Environmental Engineering Department offers three environmental degree options: the M.S. in Environmental Engineering (MSEnvE), and M.S. in Civil Engineering (MSCE) with an environmental emphasis. The Environmental Engineer-

ing Program's curriculum prepares graduates to provide leadership in their careers as environmental professionals by providing a strong foundation in the fundamental and applied chemical, biological, physical and engineering principles of environmental engineering. Program faculty have diverse backgrounds including civil, environmental, and chemical engineering. To enter the graduate program, applicants should hold a B.S. degree in an engineering discipline from an ABET accredited school or equivalent. Those who hold a non-engineering degree may be required to complete prerequisite courses in mathematics, chemistry, fluid mechanics, hydraulics, engineering mechanics, mechanics of materials, and/or engineering economics.

The program includes strong design and research components. The curriculum is tailored to the individual while providing all students with a strong foundation in environmental engineering principles. Current research emphasis areas of the environmental engineering faculty include fundamental and applied aspects of: 1) fate and control of emerging contaminants such as antibiotics, estrogens, endocrine disrupting chemicals and pharmaceuticals in water and sewage treatment; 2) phytoremediation technology; 3) indoor air pollution; 4) control of heavy metals in natural and engineering treatment systems; 5) control of mercury and other metals in fly ash; 6) innovative sewage treatment technologies; 7) fundamental chemistry and biology; and 8) analytical methods development and validation.

Graduate and undergraduate research is conducted primarily in the Environmental Research Center for Emerging Contaminants (ERCEC) located in Butler Carlton Hall and elsewhere on campus. The environmental engineering laboratories used for teaching and research total more than 14,000 square feet. The ERCEC provides state-of-the-art instruments (e.g., GC/MS, ICP/MS, ICP/OES, HPLC, LC/MS, AA, TOC, spectrophotometers, retc.) and facilities. Additionally, excelt computing facilities are available to students in the research labs and computing centers. Faculty in the Environmental Engineering Program collaborate extensively with faculty and researchers from other departments, in the ERCEC at UM-Rolla and elsewhere.

Geological Engineering

The Geological Engineering program is offered in the Department of Geological Sciences and Engineering.

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.

The geotechnical laboratory houses equipment to conduct basic soil and rock testing, including shear and compressive strength, durability, consolidation, permeability, and basic physical properties. Field equipment is available to conduct strength and permeability testing, advance shallow exploratory boreholes, measure water levels and water quality parameters.

Recent research projects utilizing this laboratory have evaluated slope stability and novel slope stabilization methods, measured the long-terms effects of weathering on rock strength and durability, and assessed sliding shear strength of dam foundations.

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.umr.edu/~gee.

Geology and Geophysics

The Geology and Geophysics program is offered in the Department of Geological Sciences and Engineering.

Graduate work in geology and geophysics is offered at both the master of science 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.

The program offers a single program and degree in geology and geophysics. The program also offers five emphasis areas 1) geology, 2) geochemistry, 3) geophysics, and 4) groundwater environmental geology, and 5) petroleum geology.

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, polynology, 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 seismology, theoretical seismology, geophysical data analysis, gravity, magnetics, seismic hazards, 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 department has a long and proud history of faculty and students who have contributed to the advancement of the science and to mineral exploration. The university was formerly the University of Missouri School of Materials, Energy, and Earth Resources. Because of the school's tradition and location near the Missouri Lead District the emphasis of the department has been in hard rock exploration. While still maintaining its traditional role in hard rock mining, the department has expanded to include geochemistry, geophysics, and soft rock geology. Our graduates find employment in both the mining 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 the facilities of the department, the Missouri State Geological Survey, 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, 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 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 granted with the thesis option only. A qualifying examination is required of all Ph.D. students within 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 University of Missouri-Rolla (UMR) is one of the top geotechnology schools in the country. Geotechnical Engineering is one of the Missions of UMR, and has been recognized by receiving Mission Enhancement Funding from the State of Missouri for this purpose. UMR is now pioneering a web based masters of engineering degree in Geotechnics. The upward mobility of professionals in the field requires advanced degrees, but not all are willing or able to take an extended leave of absence to attend UMR. Web based education will allow students to continue their work, while taking virtual classes at their convenience.

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

History

The department of History has entered into a cooperative agreement with the Department of History of the University of Missouri – St. Louis to offer a Master of Arts in History. A maximum of 12 graduate semester hours may be taken at UMR (with no more than 9 credit hours at the 300 level). When the student applies to UMSL, he/she should provide three letters of recommendation and the GRE score.

Information Science and Technology

Information Science and Technology (IST) offers a M.S. degree program. Information technology has transformed every aspect of our economy and society. Rapid spread of the technology has generated the need for highly trained professionals to implement and maintain information systems. 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, Data Warehouses, Project Management (jointly offered with the Engineering Management and Systems Engineering Department), and Psychology of Leadership (jointly offered with the Psychology 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 School endeavors to keep class sizes small to facilitate student and faculty interactions.

Admission Requirements

In addition to those requirements stated in the section of this catalog devoted to Admission and Program Procedures, the Vice Provost for Graduate Studies has additional requirements for the M.S. in Information Science and Technology (thesis or nonthesis):

- Complete the general portion of the Graduate Record Examination (GRE) with a minimum Verbal Score of 370, Quantitative Score of 600, and Analytical Score of 3.5 - OR - Complete the Graduate Management Admissions Test (GMAT) with a minimum Verbal Score of 21, Quantitative Score of 35, and Analytical/Written Score of 3.5.
- For students whose native language is not English, minimum TOEFL scores are:
  230 if computer-based test is taken
  570 if paper-based test is taken
  88 if Internet-based test is taken.
  Alternatively, an IELTS score of 6.5 may be used to prove English proficiency.
- An undergraduate GPA of 3.0/4.0 or better over the last 2 years or successful completion of 12 graduate hours in IST as a Conditional Graduate Student at UMR, with at least a 3.0 GPA.
- Content of the following courses:
  - Programming Language (IST 51/CSc 53)
  - Data Structures (IST 151/CSc 153)
  - Information Systems (IST 141)
  - Computer Architecture (IST 231)
  - Calculus
  - Statistics

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 6 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 9 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 insure that all IST masters students study the four information systems perspectives of networks and web design, human perception, application implementation, and organizational systems.

- IST 336 Internet Computing
- IST 385 Human Computer Interaction
- IST 361 Information Systems Project Management
- IST 351 Leadership in Technology-Based Organizations

Financial Assistance

Financial assistance is available to graduate students in the form of assistantships and fellowships. Research opportunities for advanced students exist. For applications forms, contact the department.

Additional Information

Visit the departments web page at: http://ist.umr.edu or contact us at 573-341-4482 or email us at: ist@umr.edu

Manufacturing Engineering

The UMR 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 MEng 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 MEng program, which provides an opportunity for the student to participate in a practical project related to a manufacturing process. The MEng 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 engineering; 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 verbal plus quantitative score of 1100 and a minimum analytical score of 3.5 are required.
- For those not speaking English as their native language, a TOEFL score of 88 internet-based, a 230 computer based or 570 paper based is required.

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, and 3 credit hours of graduate courses in manufacturing. The MEng 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 MEng 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 Interdisciplinary Engineering, Ceramic Engineering, Chemical Engineering, Computer Science, Electrical and Computer Engineering, Engineering Management, Mechanical and Aerospace Engineering, Metallurgical Engineering, and Mining Engineering. 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://campus.umr.edu/mfge/. 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

Four course sequence, one each from the four core areas listed below:

Course I-Materials and Manufacturing Processes

ME 382-Introduction to Composite Materials & Structures; Mt Eng 305-Nondestructive Testing; Mt Eng 307-Metals Casting; MSE 301 Materials Selection in Mechanical Design.

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-Six Sigma; 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-Advance Topics in Design and Manufacturing

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, metallurgical engineering, and biomaterials. The department offers the following degrees: M.S. and Ph.D. in Materials Science and Engineering, M.S. and Ph.D. in Ceramic Engineering, M.S. and Ph.D. in Metallurgical Engineering, and M.S. in Biomaterials. 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, biological sciences, chemical engineering, or related discipline is also 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, thermodynamics and kinetics of pyrometallurgical and electrometallurgical processes, environmental aspects of metal manufacturing, and treatment of metals industry wastes. Capabilities for research in these areas include pilot plant facilities for pyrometallurgy, 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 offers an interdisciplinary program involving faculty from several academic departments such as Materials Science and Engineering, Biological Sciences, and Mechanical Engineering, with a focus on biomaterials and tissue engineering for biomedical applications. Emphasis areas within the program include 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 UMR, 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, 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 home to the Electronic Materials Applied Research Center (EMARC), a state/industry/university research and development center whose main activities include the development of new ceramics and polymers as well as associated processing methods for emerging technologies in fuel cells, oxygen permeable membranes, piezoelectric sensors, actuators, emitters, and thin film structures and devices.

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.

The department is also a participating site in the NSF/industry/university Center for Glass Research at Alfred University. Faculty and students have research projects to characterize the performance of refractory materials used by the glass industry, to develop sensors to monitor the glass melting environments, and to understand structure-property relationships for different glass compositions.

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 lectures. 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 UMR 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 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.

Mathematics also offers a graduate certificate in Financial Mathematics and Psychometrics. (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. A reading knowledge of one modern foreign language, typically either French, German, or Russian, 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 well 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.umr.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; heating, ventilation and air-conditioning (HVAC); manufacturing; materials and structures; mechanical design; and thermal and fluid systems. A great 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 master of science thesis program consists of a minimum of 30 semester hours, normally including 24 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; 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 Rolla 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 in the Mechanical Engineering Building 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.

A Graduate Certificate is offered within the department of Aerospace and Mechanical Engineering.

Engineering Mechanics Graduate Certificate

Choose a total of 12 credit hours from the following courses:

ME 311 Intro to Continuum Mechanics
AE/ME 322 Intro to Solid Mechanics
AE/ME 334 Theory of Stability
AE/ME 336 Fracture Mechanics
AE 344/ME 338 Fatigue Analysis
AE 311/ME 382 Intro to Comp Mat & Structures
ME 430 Theory of Plates
ME 432 Theory of Shells
AE/ME 484 Mech of Laminated Comp Structures
AE 485/ME 485 Mech of Composite Materials

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 opportu-

nities 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 UMR 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 exam in accordance with UMR 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. Mining Engineering also offers a graduate certificate in Explosives 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 report. 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 Bachelors degree, including research work for the dissertation. Ph.D. candidates must complete at least 15 credit hours of course work at UMR, and are required to pass the qualifying, comprehensive and final oral examinations of the Ph.D. research. The UMR graduate calendar must be consulted for all the detailed regulations and requirements for completing any graduate degree in Mining Engineering at UMR. The M.E. degree is distance education-based and requires a problem report or design project for program completion.

Graduate studies and research are greatly enhanced by laboratories in McNutt Hall (on UMR 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), the Western Mining Safety & Health Training and Translation Center (WMSHTTC), 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. WMSHTTC is a consortium of four mining schools, including UMR as the leading institution, Colorado School of Mines, University of Utah and Montana Tech, established by the National Institute for Occupational Safety and Health to pursue research and technologies in mine health and safety for promoting workplace health and safety.

UMR'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 Program offers the master of science, the doctor of engineering, and the doctor of philosophy degrees. To enter our graduate program, you should hold a B.S. degree in some branch of engineering or physical science. The master’s degree program is designed to provide you with competence in designing nuclear energy systems and learning their operation based upon your scientific and engineering background. Competence in at least one supporting area (usually your undergraduate major, if other than nuclear engineering) is required. You may choose an M.S. with or without thesis, each requiring 30 credit hours.

Research areas in which you can specialize are:

- reactor design
- reactor safety
- thermal hydraulics
- radiation effects
- radiation protection
- radiation transport and shielding
- space nuclear power
- materials for nuclear applications
- fuel cycle
- radioactive waste management
- applications of radioisotopes
- radiation dosimetry

In the Ph.D. program, you must complete a research project and write a dissertation of sufficient caliber to demonstrate your capacity to conduct original research, to analyze the results critically, and to develop sound conclusions. The dissertation should represent original research acceptable for publication in a refereed journal. Our department has the following laboratory facilities.

Nuclear Reactor

A 200 kW pool-type reactor has been operating since 1961. It has a beam port, a thermal column, and pneumatic transfer tubes. The reactor was refueled with low enriched uranium in the summer of 1992. The reactor is used for reactivity experiments, neutron activation analysis and radiation damage studies. The reactor facility is equipped with state of the art detection instruments and associated electronics for neutron activation analysis.

Radiation Measurements Laboratory

The laboratory is equipped with modern radiation detection and analysis equipment. The students learn to detect, measure and analyze various forms of radiation energy spectra.

Nuclear Materials Laboratory

The facilities of the Graduate Center for Materials Research, and metallurgical engineering and nuclear engineering departments are also available for nuclear materials-related research. These facilities include instruments such as scanning electron microscope, a 300 keV EM-340 Phillips transmission electron microscope, an atomic absorption spectrometer, and a quadruple mass spectrometer.

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 department maintains an excellent laboratory with IBM compatible and Macintosh computers, and workstations.

Thermal-Fluid Sciences Laboratory

This new lab is dedicated to investigating the fundamental dynamics of single phase and dispersed two-phase flows and heat transfer of energy systems, including nuclear energy systems. In particular, the lab utilizes and develops measurement techniques called particle image velocimetry (PIV) and Ultrasound Doppler velocimetry (UDV). The lab is also exploring application of UDV to bioengineering.

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.
automatic as will registration upon payment.

Petroleum Engineering

The Petroleum Engineering Program is offered in the Department of Geological Sciences and Engineering.

Petroleum Engineering specializes in drilling analysis, formation evaluation, production optimization, reservoir mechanics, oil recovery methods, computer applications, and the mathematical modeling of petroleum reservoirs, and drilling systems.

The petroleum engineering laboratories contain modern equipment designed to study the many problems encountered in oil and gas production. These problems include: determination and interrelation of chemical and physical properties of petroleum and petroleum products, analysis of oil well cores and interpretation of core analysis, determination of physical properties of reservoir fluids, measurement of fluid flows, and formulation of specialized drilling fluids.

Laboratory facilities are available for research in oil recovery. A modern computer laboratory is used for both class work and research.

Physics

The Department of Physics offers programs leading to both the master of science and doctor of philosophy degrees. The masters 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, quantum mechanics, electricity and magnetism, statistical mechanics, and graduate physics electives, such as mathematical physics, solid state physics, quantum statistical mechanics, atomic collisions, subatomic physics, and laser physics. In their second year, Ph.D. students 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@umr.edu. Additional information may also be found on the department's web page at http://campus.umr.edu/physics/.

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, probing laser excited atomic states, 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 spin 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, and studying the nucleation of vapors into droplets.

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, femtosecond lasers used to study and probe excited atoms, Auger and XPS surface characterization spectrometers, specially developed instrumentation for use in aircraft to study rocket and aircraft exhaust characteristics, positron-ion scattering facilities, and Mossbauer and x-ray spectrometers.

Psychology

Graduate Certificate Programs
Psychology of Leadership Certificate

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 (see below).

Choose three courses from the following:
Psychology 308 - Social Psychology
Psychology 316 - Psychology of Leadership
Psychology 374 - Organizational Psychology
IST 348 - Strategic Enterprise Management Systems
IST 351 - Leadership in Technology-Based Organizations

And a fourth course from one of the following five:
Psychology 350 - Psychology of Women
Psychology 372 - Group Dynamics
Psychology 378 - Social Influence
IST 401 - Social Informatics
IST 487 - Research Methods in Human Computer Interaction

Other courses approved by the program advisor may be substituted for any of the above listed courses on a case-by-case basis.

In order to receive a Graduate Certificate, the student must have an average cumulative grade of 3.0 or better in the certificate courses. Students admitted to the Certificate program will have a non-matriculated status as a graduate student. If they complete the four course sequence with a grade of B or better, they will be admitted to the UMR Master's degree program in Information Science and Technology. 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 Certificate

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 (see below).

Choose two courses from the following three:
Psychology 301: Psychometrics
Psychology 307: Industrial Psychology

Psychology 364: Theory and Practice of Psychological Testing

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 UMR 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 Psychology 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

" develop the skill to critically analyze, evaluate, improve, or adapt existing technical and/or managerial systems, and

" organize and lead complex projects, groups, and organizations

The Leadership in Engineering Organizations Certificate Program consists of the four courses listed below.

Engineering Mgt. or Psych 301: Leadership for Engineers

Engineering Management 313: Managerial Decision Making

Psychology 316: Psychology of Leadership

Psychology 374: Organizational Psychology

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 UMR.

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. In essence, 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, and not just problem solvers, and be involved with a system through its life cycle, from development through production, deployment, training support, operation, and disposal.

PhD Requirements

Admissions Requirements:

Applicants needs a BS in engineering, hard science ormath; MS 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 Verbal and Quantitative equal or greater than 1150 and Analytical writing greater than 4.5. 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 at the appropriate time.

Residency Requirements:

All students are expected to follow the UMR 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 conference pe month with their research advisor; The PhD committee will include one person from the student's professional worklocation, the appointment committee member must have a PhD and be familiar with the chosen research; The student is expected to meet with the PhD

committee on a regular basis with at least twomeetings per semester; The student is expected to be on campus a minimum of 16 days per year, visits may be spread over 4 campus visitsl The PhD 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 Defence of Dissertation must take place on campus.

Major Requirements:

Entering PhD program from BS degree

Core Curriculum - 24 credit hours

SysEng 368-Systems Engineering and Analysis

SysEng 468-Systems Engineering and Analysis II

SysEng 469-Systems Architecturing I

SysEng 411-Systems Engineering Management

SysEng 412-Complex Engineering Systems Project Mgt

SysEng 413-Economic Analysis of Systems Engineering Projects

SysEng 479-Smart Engineering Systems Design

SysEng/CpE 419-Network Centric Systems Arch & Eng

Electives - 36 credit hours

Electives - 30 credit hours

The minimum total credit reuirements for graduation are 60 credit hours after successful completion of MS degree in Systems Engineering or 90 credit hours after a BS degree in engineering,math or hard science. The student's dissertation committee established specific requirements for each student's PhD 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

Distributed Systems Modeling: Distributed Object-oriented System Modeling and Optimization

Structures: Aero-Structure Interaction, Finite Element Analysis, Composite Materials and Structures, Smart Structures, Nano-composites and Bio-composites, Fracture Mechanics, Fatigue and Failure Analysis, and Micromechanics of Biomaterials Interfaces

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

Risk Modeling and Assessment: Financial Engineering Applications for Reducing and Managing Financial Risk, and Developing Mathematical Models for Project Risk Management

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; Inter-operatability; 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.

MS Degree Program

Specialization Tracks

Chose 4 courses in an area or combination of areas. (Please refer to Systems Engineering Program office 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 the Program Director, 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.

Master of Science in Systems Engineering

CORE Courses

SysEng 368 - Systems Engineering and Analysis I

SysEng 410 - Economic Analysis of Systems Engi neering Projects
SysEng 411 - Systems Engineering Management
SysEng 412 - Complex Engineering Systems Project Management
SysEng 468-Systems Engineering and Analysis II
SysEng 469 - Systems Architecting

Systems Engineering Graduate Certificate

Required three core courses:

SysEng 368 - Systems Engineering and Analysis I

SysEng 468 - Systems Engineering and Analysis II

SysEng 469 - Systems Architecting

And one of the following:

SysEng 413 - Economic Analysis of Systems Engineering Projects

SysEng 411 - Systems Engineering Management

SysEng 412 - Complex Engineering Systems Project Management

Upon successful completion of the four courses with a 3.0 or higher GPA, the student may elect to apply to the M.S. program. The GRE is not required if the student has successfully completed the certificate program.

Network Centric Systems Graduate Certificate Program

(Offered in Computer Engineering discipline also)

Two core courses required:

SysEng/ CpE 419 - Network Centric Systems Architecting and Engineering

CpE/ SysEng 449 - Network Centric Systems Reliability and Security

Select two elective courses:

Communications Engineering

CpE 317 - Fault Tolerant Digital Systems

CpE 319 - Digital Network Design

CpE 349 - Trustworthy, Survivable Computer Networks

CpE/ SysEng - 348 - Wireless Networks

CpE/ SysEng 401 - Wireless Adhoc and Sensor Networks

CpE 448 - High Speed Networks

CS 483 - Computer Security

CS 486 - Mobile and Sensor Data Management

Smart Engineering Systems Modeling

SysEng 433 - Distributed Systems Modeling

SysEng 479 - Smart Engineering Systems Design

SysEng 478 - Advanced Neural Networks

Requirements for Admission

A bachelor's degree in an engineering of scientific discipline with a cumulative GPA of at least 3.0 on a 4.0 scale, and a GRE score of 1150 or higher in verbal plus quantitative and 4.5 or higher in analytical. Three years of work experience is recommended.

Requirements for Degree Completion

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.

MS in Systems Engineering with Thesis

36 credit hours are recommended. All department funded students are required to complete 30 credit hours of course work and 6 credit hours of research. All other 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 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.

Systems Engineering Graduate Certificate

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 Graduate Certificate

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.

Financial Engineering Graduate Certificate

Upon successful complete of the four courses desribed above,students will awarded certification. The student must complete the four courses with a minimum of 3.0 or above. After completing the certificate, students may apply to the Systems Engineering MS program or the Engineering Management MS program.

Financial Engineering Certificate

(Offered in Engineering Management discipline also)

SysEng/EngMgt 408-Financial Risk Management

SysEng/EngMgt 480-Investment

SysEng/EngMgt 481-Financial Engineering I

SysEng/EngMgt 482-Financial Engineering II

Systems Engineering Laboratories

The interdisciplinary nature of the Systems Engineering program, the configuration of the students, namely, part-time students working on projects for their thesis for companies and pushing the boundaries of technology and knowledge, on-campus students working at various research units, and the diversity of specialization areas create a different laboratory need for this program. The number and location of laboratories will depend on the thesis topics. Excellent infrastructure for distance education, use of the Internet, and recent developments in communication technology, such as the availability of WebEx collaboration software, among

others, will provide the much needed communication structure among laboratories, faculty, and students. However, most of the research will be abstract and algorithm based. The Smart Engineering Systems Laboratory in the Department of Engineering Management and Systems Engineering (EMSE) will serve as the prime laboratory.

The EMSE 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, Mechanical, Bio-medical, Civil and other related fields, such as Applied Mathematics, Finance, Cognitive Sciences, Biology and Medicine. Current research topics include data mining, artificial life, evolutionary robotics, Internet-based pattern recognition, and systems architecture based on the DoDAF framework. Capabilities of the developed computational intelligence models are demonstrated physically in the lab through mini-autonomous research robots.

Technical Communication

The technical communication program offers an M.S. degree for any student with a bachelor's degree in technical communication or 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 and develop modes for transmitting information. Employers are looking for communicators with sophisticated skills in the integration of visual communication tools with written and spoken communication. Employers are also seeking M.S. graduates because they can move quickly into managerial positions. Academic institutions seek M.S. graduates as teachers in their undergraduate programs in technical 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 will be active in the leading professional societies such as the Society for Technical Communication and the IEEE Professional Communication Society.

The program requires a minimum of 30 hours of graduate credit and includes both a thesis and non-thesis option. A core of three courses is required of all students, as well as a module of courses in an area outside of technical communication.

Degree Requirements

M.S with Thesis: The M.S. degree with thesis requires the completion of 24 hours of graduate course work and six hours of research (TCH COM 490), and the successful completion and defense of a research thesis.

Master's Degree without Thesis--minimum of 30 hours graduate credit; with at least 9 hours at the 400 level. The following core courses are required of all M.S. students in technical communication:

TCH COM - 402 Foundations of Technical Communication

TCH COM - 411 International Technical Communication

TCH COM - 420 Advanced Theories of Visual Technical Communication

Students select 9 to 12 hours of TCH COM electives. For the out-of-department courses in the M.S. degree in Technical Communication, candidates are advised to group these courses into a module that fits their special interest.