

Finance

Finance Courses

- 200 Special Problems** (IND 0.0-6.0) (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 201 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 250 Corporate Finance I** (LEC 3.0) This course studies the need for funds in business and the techniques of analysis used to determine how effectively these funds are invested within the firm. Topics include the institutions, instruments, and markets concerned with raising funds. Prerequisites: Bus 120 or Eng Mgt 130 or Eng Mgt 131 or Eng Mgt 230; Econ 121 or Econ 122.
- 300 Special Problems** (IND 0.0-6.0) (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 305 Finance Essentials** (LEC 1.5) This course is an introduction to the essentials of corporate finance for running a business. This course is designed for students planning to enter the MBA program. Credit in this course cannot be applied to any major or minor in Business, Information Sciences and Technology. Prerequisites: Senior or Junior Standing; 3.0 GPA required.
- 350 Corporate Finance II** (LEC 3.0) This course provides a rigorous and consistent presentation of the theory of financial decisions. Capital markets are analyzed under assumptions of risk aversion and uncertainty. Models of modern portfolio theory are discussed including the CAPM and the Modigliani-Miller analysis. Prerequisite: Finance 250 or Eng Mgt 147 or Eng Mgt 252.
- 360 Investments I** (LEC 3.0) Introduction to fundamental elements of investment analysis. Students learn financial tools and gain necessary knowledge to select among alternative financial assets. Real world experience includes stock analysis, portfolio simulations and interactions with professionals in the securities industry. Field trip required. Prerequisite: Finance 250 or Eng Mgt 147 or Eng Mgt 252.
- 390 Undergraduate Research** (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed towards graduation credit. Subject and credit to be arranged with the instructor.

Foreign Languages

(French, German, Russian, Spanish)

Missouri S&T offers courses in French, German, Russian, and Spanish. Previous training is not required for language study at Missouri S&T.

After two semesters of foreign language study on campus, you should be able to converse on an elementary level. You will be introduced to foreign literature in the second or third semester.

A minor in French, German, Russian or Spanish is available. You may fulfill your B.A. language requirement from any of the four foreign languages offered.

Faculty

Professor:

Gerald Cohen, Ph.D., Columbia University

Assistant Professors:

Irina Ivliyeva, Ph.D., Russian Academy of Sciences

Audra Merfeld-Langston, Ph.D., Penn State

Jorge Porcel, Ph.D., University of Pittsburgh

Minor in Foreign Languages

A foreign language minor will consist of nine hours beyond the 12 hours B.A. foreign language requirement selected in consultation with a faculty advisor.

The additional nine hours must be at the 100 level or higher, with at least two of the courses at the 300 level.

French

French Courses

- 1 Elementary French I** (LEC 4.0) Introduction to reading, conversation, and grammar. Laboratory optional. Prerequisite: Entrance requirements.
- 2 Elementary French II** (LEC 4.0) A continuation of French 1. Prerequisite: French 1.
- 80 French Readings And Composition** (LEC 4.0) Readings in French narrative literature and composition. Prerequisite: French 2.
- 100 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 110 Basic French Conversation** (LEC 2.0) French conversation and oral practice. Prerequisite: French 2.
- 170 Masterpieces Of French Literature** (LEC 3.0) Selected major works and movements in French literature. Prerequisite: French 80.
- 180 Basic French Composition** (LEC 3.0) Composition and translations from English. Prerequisite: French 2.
- 200 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

- 201 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 310 Seminar** (IND 0.0-6.0) Discussion of current topics. Prerequisite: Senior standing.
- 311 Advanced French Conversation** (LEC 2.0) Advanced conversation and oral practice. Prerequisite: French 110.
- 360 French Culture And Civilization** (LEC 3.0) A survey of French culture and civilization of the past 2,000 years, including art, architecture, music, literature, geography and politics. Prerequisite: French 170.
- 370 Survey Of French Literature I**(Early Period) (LEC 3.0) The history and development of French literature from Les Chansons De Geste through the important philosophers of the 18th century to Beaumarchais. Assigned readings are in French, and lectures are largely in French. Prerequisite: French 170.
- 375 Survey Of French Literature II**(Modern Period) (LEC 3.0) 19th and 20th century French literature. Prerequisite: French 170.

Freshman Engineering Program

Entering freshmen desiring to study engineering are admitted to the Freshman Engineering Program. They may state a preference for a major in a particular engineering field if they wish. In the event a preference is stated, it will be used in the consideration for freshmen scholarships, if available, in the preferred department.

The goals of the Freshman Engineering Program are:

- 1) to provide high quality advising in order to enhance the likelihood of student academic success, and
- 2) to provide information about careers in the various engineering fields so that students can make an informed decision regarding an engineering major.

Students will complete a set of required courses common to all engineering fields and then may apply for admission as degree candidates to the program of their choice.

Faculty

Professors:

- Jeffrey D. Cawfield¹ (Director Freshman Engineering Program), Ph.D. University of California-Berkeley
- F. Scott Miller (Associate Director of Freshman Engineering Program and Associate Teaching Professor), Ph.D. University of Missouri-Rolla

Other Faculty

Each engineering program contributes faculty members to the cadre of Freshman Engineering advisors in order to provide a centralized and coordinated advising effort for engineering students in their beginning semesters.

Common Engineering Freshman Year

The following courses are common to all the engineering programs offered at Missouri S&T and are normally taken while the student is in the Freshman Engineering Program.

- Mathematics 14 and 15
- Chemistry 1, 2, and 4
- English 20
- Humanities/Social Sciences courses¹
- Freshman Engineering 10
- IDE 20
- Physics 23

Courses required in the remainder of each specific engineering program are listed under that program's description in the catalog.

¹Students must receive credit prior to graduation for a course that fulfills the Williams law requirement (History 112, 175, 176 or Political Science 90). Students planning to major in architectural engineering should take History 112.

Students planning to major in ceramic engineering, chemical engineering, environmental engineering, geological engineering, metallurgical engineering or petroleum engineering will require additional chemistry or chemistry/geochemistry electives. It is recommended that, during the freshman year, these students should plan on taking Chemistry 3, Metallurgical Engineering 125, Geology 275, or other suggested courses as outlined in the curriculum of those specific majors.

Students planning to major in chemical engineering should take Chemical Engineering 20 during their freshman year. Students planning to major in mining engineering should take GE 50, Mining 3, and Mining 151 during their freshman year. Students planning to major in nuclear engineering should take NE 25 during their freshman year. Students planning to major in petroleum engineering should take GE 50 and PE 121 during their freshman year.

Students may transfer from the Freshman Engineering Program to their selected degree program after having satisfied all of the above requirements except two courses, provided the degree programs will accept them. Students are advised to check special program requirements as listed with the program curricula in the catalog.

Freshman Engineering Courses

- 10 Study And Careers In Engineering** (LEC 1.0) Examination of fields of engineering and career opportunities in engineering. Professional expectations. Introduction to campus resources for assisting student success.

¹ Registered Professional Engineer

Geological Engineering

Bachelor of Science

Master of Science

Doctor of Philosophy

Doctor of Engineering

Emphasis areas at the Bachelor of Science level in environmental protection and hazardous waste management, groundwater hydrology and contaminant transport, engineering geology and geotechnics, petroleum, energy and natural resources, and quarry engineering.

The Geological Engineering program is offered under the department of Geological Sciences and Engineering.

Geological engineering - we care about the earth! We care for the earth, its resources and its inhabitants.

Geological engineers apply their engineering skills to projects which protect and preserve the earth and the environment in which we live. Do you like working outdoors? Do you enjoy solving problems using your skills and creativity? Do you like helping people and the environment? Then you may be a good candidate for geological engineering!

Geological engineers work on a variety of projects that involve the earth and its resources. For example, a geological engineer may be involved in the design of a project to protect wetlands. A geological engineer may be involved in the cleanup of lead contaminated soil which threatens peoples' homes. Geological engineers may develop safe drinking water supplies in parts of the world where infant mortality is many times higher than it is in the United States. Geological engineers work on protecting infrastructure like bridges, buildings and utilities from earthquake damage. Geological engineers evaluate the use of naturally-occurring materials like clay to prevent the spread of subsurface contamination. Geological engineers are interested in the development of renewable energy resources to conserve traditional sources of energy. Geological engineers work with the environment to improve conditions for everyone and the world around us.

The curriculum for geological engineers includes the familiar engineering subjects like math, chemistry, physics and mechanics. However, geological engineers also take courses that are focused on the earth - its soil, rock and fluids; these courses frequently include field work! Of course, geological engineers also are well-trained in engineering design and such design courses typical focus on projects that help people and society through careful consideration of where, when, and how the earth's resources are utilized.

Because the use and conservation of the earth's resources is an ever-growing concern and responsibility, there is an increasing need for geological engineers in a wide variety of areas including industry, government agencies, and research applications. Scholarships are available as are summer internships and, ultimately, challenging and rewarding permanent employment.

Mission Statement

It is the mission of the Geological Engineering program to teach integrated concepts of geology and engineering in such a manner that graduates will graduate as competent, ethical, professional geological engineers. The program is designed to provide background in geological and engineering sciences courses in the lower division which support the applied analysis and design concepts courses taught in the upper division. It is expected that the students will have gained the ability to identify and, through analysis and design, solve problems resulting from the interaction of man's activities with the geologic environment. The curriculum is intended to blend theoretical concepts with practical application, so as to offer the student a well-rounded education, and to include sufficient discussion and project oriented work with real-world issues to provide the student with a thorough awareness of the graduate's responsibility to society. Since geological engineering students are oriented toward careers in environmental protection, social awareness and the engineer's responsibility to both client and society is strongly emphasized throughout the curriculum, particularly in the senior seminar and design courses.

Program Objectives and Outcomes

Objectives: Graduates will be prepared to serve public and private interests as future professional geological engineers practicing in the State of Missouri, the nation, and international situations; they will be prepared to ultimately achieve the status of licensed engineers.

Outcome Group 1: General Engineering and Science Competence. Graduates will be well trained in the fundamentals of general engineering, mathematics, and the sciences; with particular focus on geology and engineering applications.

Outcomes:

1. Students will have a fundamental knowledge of basic mathematical principles particular to Geological Engineering, and to prepare them to write the Fundamentals of Engineering Exams.
2. Students will have a fundamental knowledge of basic science principles particular to Geological Engineering, and to prepare them to write the Fundamentals of Engineering Exams.
3. Students will have a fundamental knowledge of general engineering mechanics particular to Geological Engineering (including design, statics, mechanics of materials), and to prepare them to write the Fundamentals of Engineering Exam.
4. Students will have a fundamental knowledge of basic geology topics particular to Geological Engineering (geological processes, identification of rocks and minerals, visualize and solve problems in 3 and 4 D, and to apply principles of geology and geophysics).

5. Students will have the ability to apply mathematics including differential equations, calculus based physics and chemistry to geological engineering.

Outcome Group 2: Geological Engineering Competence. Graduates will acquire a broad knowledge of geological engineering principles and practices and understand what practicing geological engineers do.

1. Students will have a fundamental knowledge of principles associated with geological engineering and closely related disciplines, and to design solutions to geological engineering and geomechanics problems.
2. Students will have an applied specific knowledge of aspects of geological engineering and closely related disciplines, including specialization in one or more emphasis area of geological engineering.
3. Students will learn the importance of professional licensure and the appropriate path to professional licensure.
4. Students will learn practical professional skills required of practicing engineers.
5. Students will learn what some practicing professionals in our field do as a part of their job.
6. Students will gain exposure to international engineering situations.

Outcome Group 3: Problem solving skills. Graduates will have the ability to use mathematics and scientific principles and analytical and other problem-solving skills necessary to systematically solve problems within the environmental, economic, social, political, and professional constraints of society and the geological engineering community, by themselves and in teams.

Outcomes:

1. Students will be able to conduct experiments, design projects, and analyze and interpret data.
2. Students will be able to design components and integrated systems to solve a typical geological problem associated with subsurface conditions or the environment.
3. Students will be able to successfully work in design teams.
4. Students will have the ability to function on multi-disciplinary teams.
5. Students will have an appreciation for the inherent uncertainty and variability of naturally occurring materials and the risks and difficulties of decision making and engineering design within such a framework, especially with respect to the economic and optimum use of resources.
6. Students will have the ability to understand how to use non-invasive imaging technologies for geotechnical, environmental, hydrologic, and structural investigations.
7. Students will have the ability to use state-of-the-practice computer software.
8. Students will have the ability to use state of the practice accepted field methods and equipment.
9. Students will have the confidence to provide leadership and communicate effectively in a

multidisciplinary team in order to analyze and interpret data, transmit results, make proposals, and prepare reports.

Outcome Group 4: Social Skills. Graduates will possess the highest level of personal and professional ethics, have a broad based knowledgeable of Humanities and Social Sciences, and have the communication and personal skills necessary to be leaders and effective members of multidisciplinary teams.

Outcomes:

1. Students will have knowledge of, and appreciation for, historical and contemporary issues and the impact of such issues, by taking non-technical classes as part of an engineering education.
2. Students will have broad knowledge of environmental, economic, social, political and professional issues relevant to the practice of engineering in today's world.
3. Students will be able to communicate effectively.
4. Students will understand how to development personal and professional ethics and professional responsibility.
5. Students will be encouraged to join a professional society.
6. Students will be encouraged to participate in extra-curricular activities.
7. Students will be encouraged to become leaders.

Outcome Group 5: Life-long learning skills. Graduates will have the skills and motivation to continue learning throughout their careers.

Outcome:

1. Students will understand the need for and attain the skills to develop life-long learning.

Faculty

Professors:

Neil Anderson^{1,2}, Ph.D., University of Calgary
David Barr¹, (Emeritus), Ph.D., Purdue
Jeffrey Cawlf^{1,2} (Director of Freshman Engineering),
Ph.D., University of California-Berkeley
C. Dale Elifrits, (Emeritus), Ph.D., UMR
John Rockaway², (Emeritus), Ph.D., Purdue
Don Warner^{1, 2} (Dean Emeritus), Ph.D., California-Berkeley

Associate Professor:

Curt Elmore¹, Ph.D., University of Arizona
Leslie Gertsch, Ph.D., Colorado School of Mines
Norbert Maerz¹, (Program Head), Ph.D., University of Waterloo

J. David Rogers^{1,2}, (Karl Hasselmann Chair), Ph.D., California-Berkeley

Adjunct Professors:

Lynn Usery, Ph.D., University of Georgia

¹ Registered Professional Engineer

² Registered Geologist

Bachelor of Science Geological Engineering

Entering freshmen desiring to study Geological Engineering will be admitted to the Freshman Engineering Program. They will, however, be permitted, if they wish, to state a Geological Engineering preference, which will be used as a consideration for available freshman departmental scholarships. The focus of the Freshman Engineering program is on enhanced advising and career counseling, with the goal of providing to the student the information necessary to make an informed decision regarding the choice of a major.

For the Bachelor of Science degree in Geological Engineering a minimum of 128 credit hours is required. These requirements are in addition to credit received for algebra, trigonometry, and basic ROTC courses. A student must maintain at least two grade points per credit hour for all courses taken in the student's major department, and an average of at least two grade points per credit hour must be maintained in Geological Engineering.

The Geological Engineering curriculum contains a required number of hours in humanities and social sciences as specified by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. Each student's program of study must contain a minimum of 18 credit hours of course work from the humanities and the social sciences areas and should be chosen according to the following rules:

1) All students are required to take one American history course and one economics course. The history course is to be selected from History 112, 175, History 176, or Political Science 90. The economics course may be either Economics 121 or 122. Some disciplines require one humanities course to be selected from the approved lists for art, English, foreign languages, music, philosophy, speech and media studies, or theater.

2) Of the remaining hours, six credit hours must be taken in humanities or social sciences at the 100 level or above and must be selected from the approved lists. Each of these courses must have as a prerequisite one of the humanities or social sciences courses already taken. Foreign language courses numbered 70 to 80 can be considered to be one of these courses. (Students may receive humanities credit for foreign language courses in their native tongue only if the course is at the 300 level.)

3) Some departments list specific requirements; e.g. a psychology course, a literature course, and /or a second semester of economics. Selections should be made to ensure that these requirements are met.

4) Skill courses are not allowed to meet humanities and social sciences requirements except in foreign languages. Students who select the foreign language option are urged to take more than one course.

5) Special topics, special problems courses and honors seminars are allowed only by petition to and approval by the student's Program Head.

The Geological Engineering program at Missouri S&T is characterized by its focus on the scientific basics of engineering and its innovative application; indeed, the underlying theme of this educational program is the application of the scientific basics to engineering practice through attention to problems and needs of the public. The necessary interrelations among the various topics, the engineering disciplines, and the other professions as they naturally come together in the solution of real world problems are emphasized as research, analysis, synthesis, and design are presented and discussed through classroom and laboratory instruction.

FRESHMAN YEAR

First Semester	Credit
Math 14-Calculus for Engineers I	.4
Chem 1-General Chemistry	.4
Chem 4-Intro Lab Safety	.1
Chem 2-General Chemistry Lab	.1
English 20-Exposition & Argumentation	.3
FE 10-Study & Careers in Eng	.1
H/SS Elective ^(a)	<u>.3</u>
	17

Second Semester

Math 15-Calculus for Engineers II	.4
Chemistry/Geochemistry Elective ^(b)	.3
IDE 20-Intro to Engr Design	.3
Physics 23-Engineering Physics I	.4
H/SS Elective ^(a)	<u>.3</u>
	17

SOPHOMORE YEAR

First Semester	Credit
Math 22-Calc w/Analytic Geometry III	.4
Physics 24-Engineering Physics II	.4
Ge Eng 248-Fund of Geographic Info Systems	.3
Ge Eng 50-Geology for Engineers	.3
Economics Elective (Econ 121 or 122)	<u>.3</u>
	17

Second Semester

Math 204-Elementary Differential Equations	.3
IDE 50-Statics	.3
Ge Eng 110-Principles of Ge Eng	.1
Geo 125-Physical Mineralogy & Petrology	.3
Ge Eng 275-Geomorphology & Terrain Analysis	.3
Humanities/Soc Sci Elective ^(a)	<u>.3</u>
	16

JUNIOR YEAR

First Semester	Credit
IDE 150-Dynamics	.2
IDE 110-Mechanics of Materials	.3
Geo 220-Structural Geology	.4
Hum/Soc Sc Elective ^(a)	.3
Earth Energy Elective ^(c)	<u>.3</u>
	15

Second Semester

Cv Eng 230-Fluid Mechanics	.3
Ge Eng 315-Geostatistical Meth in Eng and Geol	.3
Ge Eng 343-Subsurface Exploration	.3
Technical Communications Elective ^(d)	.3
Humanities/Soc. Sci elective ^(a)	<u>.3</u>
	15

161 — Geological Engineering

SENIOR YEAR

	Credit
First Semester	
Geophysics Elective ^(a) . . . . .	.3
Ge Eng 310-Senior Seminar	0.5
Ge Eng 331-Subsurface Hydrology . . . . .	.3
Ge Eng 341-Eng Geology & Geotechnics . . . . .	.3
Ge Eng 350-Geol Eng Senior Design or GE 352-Intl Engr and Design ^(h) . . . . .	.3
Cv Eng 215-Elementary Soil Mechanics or Mi Eng 331-Rock Mechanics I . . . . .	.3
	15.5
Second Semester	
Ge Eng 374-Eng Geologic Field Methods . . . . .	.3
Ge Eng 310-Senior Seminar	0.5
Earth Mechanics Elective ^(e) . . . . .	.3
Eng Econ Elective ^(f) . . . . .	.3
Technical Electives ^(g) . . . . .	.6
	15.5

- ^{a)} The sequence of course selection must provide both breadth and depth of content and must be selected from the list of approved Humanities/Social Science electives available from your advisor. A total of 18 hours of humanities and social science credit is required.
- ^{b)} The Chemistry/Geochemistry elective must be selected from chemistry, geochemistry or biology courses as approved by your advisor.
- ^{c)} Students should select GE 356, or other Earth Energy Electives such as PE 232, PE 240, or Geology 340.
- ^{d)} The Technical Communications elective can be selected from English 60, 160, SP&MS 85, or the complete four-course sequence in Advanced ROTC (Mil Sci 105, 106, 207, and 208 or Aerospace Studies 350, 351, 380, and 381).
- ^{e)} To be selected from GE 371, GE 381, Mining 331, PE 240, PE 241, CE 215, CE 229, or CE 315.
- ^{f)} To be selected from CE 241, Eng Mgt 208, Eng Mgt 209, or PE 357.
- ^{g)} To be selected from advanced courses in geological, mining, petroleum or civil engineering, geology or other courses with approval of your advisor. Must contain design content and must be approved by your advisor.
- ^{h)} Students may take GE 350 or GE 352 for senior design credit.
- ⁱ⁾ The Geophysics elective can be selected from GE 336, GE 361, or GE 382.

All GE students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade is not required; however, it is the first step toward becoming a registered professional engineer. This requirement is part of the Missouri S&T assessment process. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

Geological engineering students must earn the grade of "C" or better in all geological engineering courses to receive credit toward graduation. The total number of credit hours required for a degree in Geological Engineering is 128. The assumption is made

that a student admitted to the Department has completed 34 hours toward graduation to fulfill the requirements of the Freshman Engineering program.

Minor in Geological Engineering

Geological Engineering offers employment opportunities for a broad spectrum of disciplines including Civil, Mining, Nuclear, and Petroleum Engineering as well as for geologists and geophysicists. A minor in Geological Engineering or Engineering Geology, therefore, enhances the academic credentials of a student and broadens employment choices. A minor in Geological Engineering requires 15 hours of Missouri S&T credit to include the following:

Ge Eng 50 ¹ -Geo for Eng or Phy Geo . . . . .	.3 hrs.
Ge Eng 275-Geomorphology . . . . .	.3 hrs.
Ge Eng 331-Groundwater Hydrology . . . . .	.3 hrs.
Ge Eng 341-Eng Geo & Geotechnics . . . . .	.3 hrs.
Ge Eng Elective ² . . . . .	.3 hrs.
	15 hrs.

¹Geo 051 may be substituted for geology and geophysics majors.

²To be selected with geological engineering advisor approval

Geological Engineering Emphasis Areas

Electives are selected by the student with advisor approval. Some appropriate electives are listed for each emphasis area.

Environmental Protection and Hazardous Waste Management

- Ge Eng 335-Environmental Geological Engineering
- Ge Eng 337-Geological Aspects of Hazardous Waste Management
- Ge Eng 381-Intermediate Subsurface Hydrology and Transport Mechanics
- Ge Eng 331-Subsurface Hydrology
- Ge Eng 315-Statistical Methods in Environmental Geology and Engineering
- Ge Eng 376-Environmental Aspects of Mining
- Ge Eng 333-Risk Assessment in Environmental Studies
- Cv Eng 215-Fundamentals of Geotechnical Engr

Groundwater Hydrology and Contaminant Transport

- Ge Eng 381-Intermediate Subsurface Hydrology and Transport Mechanics
- Ge Eng 333-Risk Assessment in Environmental Studies
- Ge Eng 374-Engineering Geologic Field Methods
- Ge Eng 331-Subsurface Hydrology
- Ge Eng 315-Statistical Methods in Environmental Geology and Engineering
- Pe Eng 341-Well Test Analysis
- Cv Eng 215-Elementary Soil Mechanics
- Pe Eng 232-Well Logging

Engineering Geology and Geotechnics

- Ge Eng 371-Rock Engineering
- Cv Eng 215-Elementary Soil Mechanics
- Mi Eng 331-Rock Mechanics
- Cv Eng 229-Foundation Engineering
- Mi Eng 308-Drilling and Blasting
- Ge Eng 346-Applications of Geographic Info Systems
- Ge Eng 341-Engineering Geology and Geotechnics
- Ge Eng 315-Statistical Methods in Environmental Geology and Engineering

Petroleum, Energy and Natural Resources

- Pe Eng 241-Petroleum Reservoir Engineering
- Mi Eng 331-Rock Mechanics
- Ge Eng 346-Applications of Geographic Info Systems
- Ge Eng 381-Intermediate Subsurface Hydrology and Transport Mechanics
- Geo 341-Applied Petroleum Geology
- Pe Eng 232-Well Logging I
- Pe Eng 240-Properties of Hydrocarbon Fluids
- Pe Eng 121-Introduction to Oil Well Drilling
- Pe Eng 341-Well Test Analysis

Quarry Engineering

- Mi Eng 331-Rock Mechanics
- Ge Eng 375-Aggregates and Quarrying
- Cv Eng 216-Construction Materials-Properties and Testing
- Ge Eng 371-Rock Engineering
- Ge Eng 376-Environmental Aspects of Mining
- Mi Eng 221-Mining Exploration
- Mi Eng 307-Principles of Explosives Engineering
- Mi Eng 308-Drilling and Blasting
- Mi Eng 345-Strata Control

Geological Engineering Courses

- 50 Introduction to Physical Geology** (LEC 2.0 and LAB 1.0) A study of Earth materials, surface features, internal structures and processes. Particular attention is paid to Earth resources, geological hazards, engineering and environmental problems. Prerequisite: Entrance requirements. (Co-listed with Geology 50)
- 75 Geological Engineering in Popular Media** (LEC 1.0 and LAB 2.0) Examination of the issues and topics related to geological engineering as presented in movies, television programs, and other communications media.
- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 105 Mathematical Concepts for Military Engineers** (LEC 2.0) Review of fundamental concepts in Algebra, Trigonometry and Calculus for students in Geological Engineering. Designed as a bridging course for Military Reserve officers enrolled in the On-Line Certificate in Military Geological Engineering. Prerequisite: Permission of instructor. This course was designed for military officers

registered in either the GE DL MS Degree Program or the GE FLW MS Degree Program.

- 110 Principles Of Geological Engineering** (LEC 1.0) Introduce GE students to the GE program. Topics include career paths, professional development, licensure, life long learning, engineering ethics, societal issues, engineering law, international engineering, and GE program outcomes and objectives. Discussion of the teaching and research of the faculty. Prerequisite: Sophomore standing in the GE program.
- 123 Osha 40 Hr Hazwopper Course** (LAB 1.0) This course covers environmental health and safety considerations required by federal regulation to work with hazardous substances. The course meets training and performance standards for working at sites of uncontrolled hazardous waste and at sites requiring emergency response operations following the release of hazardous substances.
- 200 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 201 Special Topics** (Variable 1.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 205 Statics and Mechanics of Geologic Materials** (LEC 3.0) Fundamental statics of rigid bodies and mechanics of deformable bodies for entering graduate students, focusing on behavior of rock and soil in engineering situations. Not for students intending to register as professional engineers. Prerequisite: Permission of instructor. This course was designed for military officers registered in either the GE DL MS Degree Program or the GE FLW MS Degree Program.
- 207 Geology and Engineering of Ancient and Modern Peru** (LEC 1.0) A study of the geological engineering of the Cuzco-Machu Picchu corridor, including the interrelations of geology, climate, archeology, and history. A technical report and a week-long field trip to Peru during Spring Break are required.
- 236 Basic Weather** (LEC 2.0 and LAB 1.0) A course to study basic concepts of atmospheric science such as air masses, frontal weather patterns and weather forecasting. The course also will include topics on climate and severe weather. Prerequisites: Physics 23, Ge Eng 50.
- 248 Fundamentals Of Geographic Information Systems** (LEC 2.0 and LAB 1.0) Introduction to the fundamental concepts and components of Geographic Information Systems. Techniques for acquiring, manipulating and analyzing digital terrain data for geological and geotechnical applications. (Co-listed with Geology 248)
- 249 Fundamentals Of Computer Applications In Geological Engineering** (LEC 2.0 and LAB 1.0) Applications of existing and available software packages utilizing a variety of hardware systems for geological engineering purposes. Emphasis on practical utilization of personal computers and network operations for graphical analysis of

- geologic data, mapping of surface and subsurface configurations and modeling of geologic processes. Prerequisites: Ge Eng 50, Cmp Sc 73, 77.
- 275 Geomorphology And Terrain Analysis** (LEC 2.0 and LAB 1.0) Study of geomorphic processes, landform development and surficial materials. Course content stresses the evaluation of the engineering properties of terrain factors for site selection and design of engineered structures. Prerequisite: Ge Eng 50.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 310 Seminar** (RSD 0.5) Discussion of current topics. (Course cannot be used for graduate credit). Prerequisite: Senior standing. (Co-listed with Geology 310, Pet Eng 310)
- 311 Introduction to International Engineering and Design Lab** (LAB 1.0) The lab for multi-disciplinary design will be as follows: Students will develop a work plan to address design objectives and other considerations including scheduling, budgeting, environmental impacts, and life cycle design. Prerequisites: Senior standing, instructor approval, accompanied by Geo Eng 345.
- 315 Geostatistical Methods in Engineering and Geology** (LEC 3.0) Study of statistical methods in engineering and geological applications including site investigations and environmental data analyses. Introduction to spatial correlation analysis and geostatistical techniques such as kriging for resource evaluation and estimation.
- 331 Subsurface Hydrology** (LEC 3.0) Introduction to the theory and engineering concepts of the movement of subsurface fluids. Properties of water and other subsurface fluids. Hydraulic characteristics of earth materials. Engineering problems related to subsurface fluids. Prerequisites: Geo Eng 50, Math 204.
- 333 Risk Assessment In Environmental Studies** (LEC 3.0) This course will present the concepts required to assess the human health and environmental risks resulting from contaminants in soil and groundwater. Course topics include evaluation of data sets, exposure calculation, chemical fate and transport, and development of conceptual site models.
- 335 Environmental Geological Engineering** (LEC 3.0) Introduction to engineering geologic mapping for site selection for solid waste disposal facilities; landfill site selection, design, permitting, construction, operation, and closeout/reclamation. Prerequisites: Ge Eng 275, accompanied or preceded by Cv Eng 215.
- 336 Geophysical Field Methods** (LEC 2.0 and LAB 1.0) Imaging of selected subsurface features and engineering structures using various geophysical tools. Special emphasis is placed on ground penetrating radar and surface wave techniques. One field trip at student expense required. Prerequisite: Junior level standing or higher. (Co-listed with Geophys 336)
- 337 Geological Aspects Of Hazardous Waste Management** (LEC 3.0) Nature and classification of hazardous wastes; federal and state regulation for treatment and disposal; geological characterization of facility sites; design of impoundments, storage and containment facilities; ground water monitoring and protection; site permitting and licensing planning. Prerequisite: Ge Eng 275.
- 339 Groundwater Remediation** (LEC 3.0) A survey of conventional and innovative techniques for remediation of contaminated groundwater. Topics include groundwater cleanup standards, physico-chemical properties of groundwater and contaminants, fate and transport of contaminants in the subsurface, hydrogeologic site characterization, and selection process of a remedial technology. Various computer programs developed to assist in preliminary selection and design of remediation technologies will be used. Prerequisite: Ge Eng 331.
- 341 Engineering Geology And Geotechnics** (LEC 3.0) Study of procedures and techniques used to evaluate geologic factors for site selection and the design of engineered structures. Prerequisite: Ge Eng 275.
- 342 Military Geology** (LEC 3.0) This course will familiarize geologists, geophysicists, civil and geological engineers with the fundamental principles of physical geology, geohydrology and geomorphology as applied to military problems, such as development of fortifications, core infrastructure, water resources and combat engineering requirements. Prerequisite: Ge Eng 275 or graduate standing.
- 343 Subsurface Exploration** (LEC 2.0 and LAB 1.0) Lectures and field and laboratory exercises in the use of geologic and geophysical techniques for evaluation of subsurface geology and resources. Prerequisite: Cv Eng 215 or Pe Eng 131.
- 344 Remote Sensing Technology** (LEC 2.0 and LAB 1.0) Principles of digital image processing including image enhancement and multispectral classification. Emphasis upon design and implementation of remote sensing systems and analysis of remotely sensed data for geotechnical and environmental investigations. Prerequisite: Geo Eng 248. (Co-listed with Geology 344)
- 346 Applications Of Geographic Information Systems** (LEC 2.0 and LAB 1.0) Applications of Geographical Information Systems and remote sensing to environmental monitoring, mineral resource exploration, and geotechnical site evaluation. Prerequisite: Geo Eng 275 or consent of instructor. (Co-listed with Geology 346)
- 347 Introduction to International Engineering and Design** (LEC 2.0) A multi-disciplinary design course focused on sustainable design and technology transfer to developing countries. Students will develop a work plan to address design

objectives and other considerations including scheduling, budgeting, environmental impacts, and life cycle design. Prerequisites: Senior standing, instructor approval, accompanied by Geo Eng 311.

- 350 Geological Engineering Design** (LEC 2.0 and LAB 1.0) Geological engineering design is an open-ended project course requiring the collection of data, analysis and synthesis of that data and design of a socially acceptable, economical solution to the selected problem. Oral and written reports are required. Prerequisite: To be taken in the semester before graduation.
- 352 International Engineering and Design** (LEC 3.0) A multi-disciplinary engineering course focused on sustainable design and technology transfer to developing countries. Course includes elements of traditional capstone design classes. Experiential learning through competitions and/or field work is a major component of the class. Prerequisite: Senior standing, instructor approval. (Co-listed with Met Eng 352 and Cer Eng 352)
- 353 Regional Geological Engineering Problems In North America** (LEC 3.0) A physiographic approach to engineering materials and problems. Course emphasizes the distribution and engineering characteristics of soil and rock to construction and site problems and includes aggregates, foundations, excavations, surface and ground water, slope stability and arctic conditions.
- 356 Renewable Energy Systems** (LEC 3.0) Introduction to the theory and performance prediction of typical renewable energy systems such as, but not limited to, those based on energy from the sun, wind and water, and geothermal. The use of environmental data, including stochastic modeling, for renewable energy system (including wind turbine, photovoltaic, and geothermal) design is addressed. Prerequisites: Math 204, Phys 24, and preceded or accompanied by Stat 217 or Geo Eng 315. Junior or senior status is required.
- 361 Transportation Applications of Geophysics** (LEC 2.0 and LAB 1.0) Overview of geophysical and non-destructive test methods that are commonly used to investigate transportation structures and their foundations. Emphasis is placed on bridge system substructure, bridge system superstructure, pavement, roadway subsidence, subsurface characterization and vibration measurements. Prerequisite: Junior level standing or higher. (Co-listed with Geophys 361 and Civ Eng 351)
- 371 Rock Engineering** (LEC 3.0) Data requirements for design; engineering properties of rock; characterization of fractures and rock masses; stereonet analysis of discontinuities; graphic analysis of failure; ground stress distribution; tunnel construction methods; ground support principles; selection of tunneling equipment; and specifications for underground construction. Prerequisite: Ge Eng 275.
- 372 Soil Science In Engineering Practice** (LEC 3.0) A study of the ways in which soils and geologic conditions influence engineered projects. Soil formation, soil chemistry and properties to include composition, organic component, ion exchange and water relationships as well as erosion control and revegetation will be covered. Prerequisite: Ge Eng 275.
- 373 Geologic Field Methods** (LAB 3.0) Field practice in geologic mapping and interpretation in the Western United States using topographic base maps and aerial photos. Emphasizes the description and interpretation of stratigraphic sections, sedimentary and tectonic structures. Prerequisite: Two courses in either Geology or Geological Engineering.
- 374 Geological Engineering Field Methods** (LAB 3.0) Instruction in methods of field investigation required for geological engineering studies. Course will include procedures for qualitative and quantitative data collection for characterizing surficial geologic conditions, groundwater and surface water investigations, and other engineering activities. Written reports and field trip required.
- 375 Aggregates And Quarrying** (LEC 3.0) Properties and uses of aggregates. Finding aggregate deposits and methods of extraction. Aggregate processing. Aggregate testing. Economics and politics of aggregates. Special topics in aggregates and quarrying. Prerequisites: Ge Eng 50, Ge Eng 275.
- 376 Environmental Aspects Of Mining** (LEC 3.0) Permitting: the legal environment of reclamation and environmental impact assessment; post-mining land-use selection and mine planning for optimum reclamation of all mines: metal, nonmetal, and coal; unit operations of reclamation; drainage, backfill, soil replacement, revegetation, maintenance, etc. Prerequisites: Ge Eng 50; Mi Eng 324 and 326 or prereq./coreq. Cv Eng 215. (Co-listed with Mi Eng 376)
- 381 Intermediate Subsurface Hydrology And Contaminant Transport Mechs** (LEC 3.0) A study of the physical/chemical properties of rocks and sediments in the subsurface environment. Emphasis is put on waterrock properties such as permeability, capillarity, and mechanical dispersion. Both microscopic and macroscopic approaches are used. Prerequisites: Cv Eng 230 & Ge Eng 331.
- 382 Environmental And Engineering Geophysics** (LEC 2.0 and LAB 1.0) An introduction to the theory and application of the gravity, magnetic, resistivity, self-potential, induced polarization and electromagnetic methods as applied to the solution of engineering and environmental problems. Prerequisite: Math 22. (Co-listed with Geophys 382)
- 390 Undergraduate Research** (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

Geology and Geophysics

Bachelor of Science

Master of Science

Doctor of Philosophy

Emphasis areas at the Bachelor of Science level in geochemistry, geology, geophysics, groundwater and environmental geochemistry, and petroleum geology.

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

Geology, geochemistry and geophysics study the history, composition, and structure of Earth and other planetary bodies. The expertise and activities in the Geology and Geophysics program make the Missouri University of Science and Technology one of the leading U.S. research universities. Faculty and students are investigating areas such as the study of nuclear waste disposal, ground water pollution, palynostratigraphy (micro fossils), geophysical characterization of geological hazards (e.g., earthquakes, collapsed caverns) reflection and theoretical seismology, computational geophysics, 3D seismic applications to petroleum exploration, evolution of petroleum reservoirs, genesis of ore deposits, the role of magmatism and tectonics, and industrial processing of minerals. We provide the only program in Missouri in geophysics and geochemistry with an emphasis upon exploration and environmental applications.

Students are drawn to geology and geophysics by a desire to explore a topic that is for many a personal passion. As a student in the Geology and Geophysics program, you may become involved in a wide range of studies. We have students investigating their world and beyond in areas as diverse as planetary geology, fossils and evolution, volcanology, structure and dynamics of Earth's deep interior, development of cave systems, exploration for oil and gas, adsorption of pollutants by soils, ore mineralization, creation of mountain systems, the beauty of minerals, to name but a few. Many courses involve work outdoors within the state of Missouri as well as in national parks such as the Grand Canyon. You may even find yourself snorkeling over a coral reef in the Caribbean Sea, working in the rifted valleys in Africa or examining geologic evolution of the Egyptian Nile.

In the first two years of study, students develop a strong foundation in geology through the core curriculum. This foundation is strengthened by course work in chemistry, physics, mathematics and computer science, and the humanities and social sciences. Students begin to take more specialized courses pertaining to their particular area of interest in their junior and senior years. The numerous elective courses offered by the Geology and Geophysics program, as well as courses outside the department, provide our majors with the flexibility to custom design an emphasis area of

their choice, focusing in on aspects of Earth Science that are of most interest to them. In this way, our majors develop a broad understanding of the fundamentals of our diverse discipline while preserving this important opportunity to develop their own passion within geology and geophysics.

The Earth Sciences have been an integral part of Missouri S&T since its founding in 1870. Our student organizations in geology and geophysics are among the oldest in the nation and include the Dake Society, American Association of Petroleum Geologists, Society of Exploration Geophysicists, and the Sigma Gamma Epsilon (Eta Chapter) honor society. These organizations provide numerous opportunities for social and scientific interaction among students, professionals, and faculty.

The Geology and Geophysics program is located in McNutt Hall and it is especially well endowed with modern, state-of-the-art equipment for teaching and research in most areas of the Earth Sciences. The availability of such equipment provides our students with an excellent laboratory and field educational experience. In addition, cooperative studies with the Missouri Geological Survey and the U.S. Geological Survey provide students with opportunities for part time employment and on-the-job experience while they pursue their degree.

Geological Scientists enjoy their work. As a professional geologist or geophysicist you may explore for oil, gas, and coal to provide for our nation's energy needs. You may search for minerals critical to industry. You may become involved in minimizing environmental hazards. In all cases, you will have the opportunity to work outdoors, in the lab, and with cutting edge technology.

Mission Statement

- 1) Provide the highest quality education to students leading to the B.S., M.S., and Ph.D. degrees in geology and geophysics. Prepare students for professional careers in five emphasis areas: geology, geochemistry, geophysics, groundwater and environmental geochemistry, and petroleum geology. Provide service courses for students in related programs (including geological engineering, mining engineering, petroleum engineering, metallurgical engineering, ceramic engineering, civil engineering, physics, biology and chemistry) as well as many of the programs in the humanities and liberal arts.
- 2) The program has both the opportunity and the mission to engage in basic and applied research that contributes to the solution of problems related to mankind and the environment. To meet this goal, the program collaborates on projects that transcend the traditional boundaries between scientific and engineering disciplines. Faculty and students commonly conduct research with geologists in the Rolla offices of the United States Geological Survey and the Missouri Geological Survey, with scientists and engineers from various disciplines at Missouri S&T and other campuses of

the University of Missouri system, as well as with other Earth Scientists in universities within the United States and abroad (e.g. Ireland, Republic of South Africa).

- 3) Provide graduates to the mining, petroleum, groundwater, and environmental industries; to the Missouri Geological Survey, the U.S. Geological Survey and other educational research institutions.
- 4) Provide professional service in the fields of geology, geophysics, geochemistry, groundwater and environmental geology. Such service includes the identification of minerals, rocks, and fossils that are sent to the department, the assessment of geologic hazards, contributing to the development and operation of professional organizations, and when called upon, assisting local and state agencies with the evaluation of geological problems.
- 5) Provide a strong foundation in fundamental principles of geology and geophysics for undergraduate students who desire to pursue opportunities for advanced research in the top graduate schools across the United States. Our graduates have continued their education in prestigious programs, including Arizona State, California-Berkeley, Colorado, Colorado School of Mines, Delaware, MIT, Michigan, Michigan State, Oklahoma, Stanford, Texas, Virginia Tech, Washington, University of Missouri-Columbia and the Missouri University of Science and Technology.

Faculty

Professors:

Mohamed Abdelsalam, Ph.D., University of Texas at Dallas

Stephen Gao, Ph.D., University of California, Los Angeles

Kelly Liu, Ph.D., University of California, Los Angeles

Francisca Oboh-Ikuenobe (Program Head)¹, Ph.D., Cambridge

Associate Professors:

John P. Hogan, Ph.D., Virginia Poly Tech.

David J. Wronkiewicz, Ph.D., New Mexico Institute of Mining and Technology

Wan Yang, Ph.D., University of Texas at Austin

Lecturers:

Cheryl Seeger, Lecturer, Ph.D., University of Missouri-Rolla

James E. Vandike, M.S., South Dakota School of Mines

Emeritus Professors:

Richard Hagni^{1,2} (Curators' Professor Emeritus), Ph.D., University of Missouri-Columbia

Robert Laudon^{1,2} (Emeritus), Ph.D., University of Texas at Austin

Gerald Rupert (Emeritus), Ph.D., University of Missouri-Rolla

Alfred Spreng^{1,2} (Emeritus), Ph.D., Wisconsin

¹ Certified Professional Geologist

² Registered Geologist

Bachelor of Science Geology and Geophysics

A minimum of 129 credit hours is required for a Bachelor of Science degree in Geology and Geophysics and an average of at least two grade points per credit hour must be obtained.

The Geology and Geophysics curriculum requires nine semester hours in humanities, exclusive of a foreign language, and must include English 60. A minimum of six semester hours is required in social sciences and must include either Economics 121 or 122 and either History 112, 175, 176 or Political Science 90. Six semester hours of course work are available to the student to choose course work that best fits their individual needs for completion of the degree. Specific requirements for the bachelor degree program are outlined in the sample program below

FRESHMAN YEAR

First Semester	Credit
Math 4-College Algebra or Sci & Eng Elective . . . . .	.3
Math 6-Trig (or 2 hours free electives) . . . . .	.2
English 20-Exposition and Argumentation . . . . .	.3
Chem 4-Intro to Lab Safety . . . . .	.1
Geo 51-Physical Geology . . . . .	.3
Geo 53-Physical Geology Lab . . . . .	.1
Free elective ⁽¹⁾	<u>.1</u>
	14

Second Semester	
Math 8-Calculus w/Analytic Geometry I . . . . .	.5
Chem 1-General Chemistry . . . . .	.4
Chem 2-General Chemistry Lab . . . . .	.1
Geo 52-Evolution of the Earth ⁽⁵⁾3
Geo 54-Evolution of the Earth Lab	<u>.1</u>
	14

SOPHOMORE YEAR

First Semester	Credit
Math 21-Calculus w/Analytic Geometry II . . . . .	.5
Geop 270-Intro to Geophysics . . . . .	.3
Geo 113-Mineralogy & Crystallography . . . . .	.4
Geo 338 or Cmp Sc 53, (71 or 73) & 77	<u>.3</u>
	15

Second Semester	
English 60 (writing course) . . . . .	.3
Econ 121-Prin of Micro or 122-Prin of Macro . . . . .	.3
Geo 130-Igneous and Metamorphic Petrology ⁽⁵⁾4
Geo 275-Intro to Geochemistry	<u>.3</u>
	16

JUNIOR YEAR

First Semester	Credit
Physics 23-Engineering Physics I ⁽²⁾4
Stat 213,215,217 or Ge Eng 315-Stat . . . . .	.3
Geo 220-Structural Geology ⁽⁵⁾4
History (112,175 or 176) or Pol Sc 90 . . . . .	.3
Elective (Geo & Geop) ⁽⁴⁾	<u>.3</u>
	17

Second Semester	
Physics 24-Engineering Physics II ⁽²⁾4
Geo 223/224-Stratigraphy & Sedimentation Lab . . . . .	.4
Elective (Geo & Geop) ⁽⁴⁾3
Hum/Soc Sci Elective . . . . .	.3

167 — Geology and Geophysics

Free Elective⁽¹⁾ 3
17

SUMMER OF JUNIOR YEAR

Geo 373-Field Geology 3
Geo 374-Advanced Field Geology 3
6

SENIOR YEAR

First Semester
Elective (Science & Eng)⁽³⁾ 6
Geo 344-Remote Sensing Technology 3
Elective (Geo & Geop)⁽⁴⁾ 3
Hum/Soc Sci Elective 3
15

Second Semester
Electives (Science & Eng)⁽³⁾ 6
Electives (Geo & Geop)⁽⁴⁾ 5
Geo 310-Seminar 1
Geop 381-Global Tectonics⁽⁵⁾ 3
15

- ¹⁾ Free elective hours may be taken in any combination of credit hours (1,2,3 etc.) and can include any course offerings at the University.
- ²⁾ Students may substitute Physics 21 and 22 for Physics 23; Physics 25 and 26 for Physics 24.
- ³⁾ All Geology/Geophysics students must complete at least 15 hours of course work in science (which may include additional Geology/Geophysics courses), mathematics, and/or engineering in addition to Geology/Geophysics, mathematics, and science courses required for the basic program. 12 hours of this course work must be numbered 100 or above.
- ⁴⁾ All Geology/Geophysics students including those taking emphasis areas, must complete at least 14 hours of course work numbered 200 or above in the Geology and Geophysics program, in addition to the required core curriculum. Of these 18 hours, at least one course should be selected from each of three (out of five) emphasis area groups listed in the program.
- ⁵⁾ Communications emphasized (CE) courses

Core Curriculum

Taken by all students in Geology & Geophysics.

	Credit
Geo 51-Physical Geology	3
Geo 53-Physical Geology Lab	1
Geo 52-Evolution of the Earth	3
Geo 54-Evolution of the Earth Lab	1
Geo 113-Mineralogy & Crystallography	4
Geo 130-Igneous & Metamorphic Petrology	4
Geo 220-Structural Geology	4
Geo 223-Stratigraphy & Sedimentation	3
Geo 224-Stratigraphy Lab	1
Geop 270-Intro to Geophysics	3
Geo 275-Intro to Geochemistry	3
Geo 310-Seminar	1
Geo 344-Remote Sensing Technology	3
Geo 373-Field Geology	3
Geo 374-Advanced Field Geology	3
Geop 381-Global Tectonics	3
Total	43

Geochemistry Emphasis Area

The following courses are required:

	Credit
Geo 234-Petrology & Petrography	3
Geo 275-Intro to Geochemistry	3
Geo 294-Metallic & Industrial Mineral Deposits	3
Geo 376-Aqueous Geochemistry	3
Total	12

In addition, to complete degree requirements with an emphasis area in Groundwater and Environmental Geology students must complete 4 courses (12 hours minimum) to be selected from an approval list and with guidance from student's advisor.

General Geology Emphasis Area

The following courses are required:

	Credit
Geo 227-Systematic Paleontology	3
Geo 275-Introduction to Geochemistry	3
Geo 234-Petrology and Petrography	3
Geo 294-Metallic and Industrial Mineral Deposits	3
Geo 340-Petroleum Geology	3
Total	15

In addition to complete degree requirements with an emphasis area in General Geology students must complete 4 courses (12 hrs. minimum) to be selected from an approved list and with guidance from student's advisor.

Geophysics Emphasis Area

The following courses are required:

	Credit
Math/Stat 22-Calculus III	3
Geop 286-Intro to Geophysical Data Analysis	3
Geop 320-Computational Geophysics	3
Geop 377-Seismic Interpretation	3
Total	12

12 hours from the following courses:

Math 204-Elementary Differential Equations	3
Math 208-Linear Algebra I	3
Math 325-Partial Differential Equations	3
Geop 336-Geophysical Field Methods	3
Geo 340-Petroleum Geology	3
Geop 382-Environmental and Eng Geophysics	3
Geop 385-Exploration and Development Seismology	3

Groundwater and Environmental Geochemistry Emphasis Area

The following courses are required:

	Credit
Geo 275-Intro to Geochemistry	3
Geo 375-Applied Geochemistry	3
Geo 376-Aqueous Geochemistry	3
Ge Eng 335-Environmental Geological Eng or Ge Eng 331-Subsurface Hydrology	3
Ge Eng 337-Geol Aspects of Haz Waste Mgt	3
Total	15

In addition, to complete degree requirements with an emphasis area in Groundwater and Environmental Geology students must complete 4 courses (12 hrs.

minimum) to be selected from an approval list and with guidance from student's advisor.

Petroleum Geology Emphasis Area

The following courses are required:

	Credit
Geo 227-Systematic Paleontology	3
Geo 275-Intro to Geochemistry	3
Geo 324-Adv Stratigraphy & Basin Evolution	3
Geo 338-Computer Mapping	2
Geo 340-Petroleum Geology	3
Geo 385-Exploration & Dev Seismology	3
Pe Eng 232-Well Logging I	3
Total	20

In addition, to complete degree requirements with an emphasis area in Petroleum Geology students must complete two courses (6 hours minimum) to be selected from an approval list and with guidance from student's advisor.

Minor Curriculum in Geology

The minor will consist of 18 hours of Geology related course work and must include Geo 125 and one of Geo 51 or GE 50 or Geo 52. Six additional hours of course work must come from any combination of 100, 200, 300 geology courses. The remaining 6 hours of course work can be from any combination of geology related courses approved by the Geology and Geophysics program. Approved Geology related course work:

Bio 110	Geo Eng 315
Bio 111	Mi Eng 221
Bio 235	Mi Eng 232
Bio 251	Mi Eng 312
Env Eng 263	Mi Eng 331
Eng Eng 361	Pe Eng 232
Env Eng 364	Pe Eng 333
Geo Eng 275	Pe Eng 366

Geology Courses

- 50 Introduction to Physical Geology** (LEC 2.0 and LAB 1.0) A study of Earth materials, surface features, internal structures and processes. Particular attention is paid to Earth resources, geological hazards, engineering and environmental problems. Prerequisite: Entrance requirements. (Co-listed with Geo Eng 50)
- 51 Physical And Environmental Geology** (LEC 3.0) Materials, structure, and surface features of the Earth and planets are studied in the context of the processes that continuously transform the Earth and affect management of Earth resources, hazards, and environmental challenges. A one day field trip is required. Prerequisite: Entrance requirements.
- 52 Evolution Of The Earth** (LEC 3.0) A survey of the Earth history from the coalescence of the solar system to the present and the events that have profoundly transformed the planet in the context of the dynamic feedback between physical and biological systems. A one day field trip is required.
- 53 Physical and Environmental Geology Laboratory** (LAB 1.0) Geology 53 is designed to accompany Geology 51 and consists of laboratory explorations of the study of common rocks and minerals, air photographs, maps, and case studies of geological problems related to management of Earth resources, hazards, and environmental challenges. Prerequisite: Preceded or accompanied by Geology 51.
- 54 Evolution of the Earth Laboratory** (LAB 1.0) Geology 54 is designed to accompany Geology 52 and consists of laboratory explorations of fundamental concepts in geology and the diversity of the fossil record. Prerequisite: Preceded or accompanied by Geology 52.
- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 113 Mineralogy And Crystallography** (LEC 3.0 and LAB 1.0) An introduction to the study of minerals, including their systematic classification, crystallography, morphology, chemistry, societal use, geologic occurrence, environmental application and impact, and identification by means of their physical and chemical properties. Prerequisites: Chem 1 and Chem 2.
- 125 Physical Mineralogy And Petrology** (LEC 2.0 and LAB 1.0) An introduction to the study of physical mineralogy and petrology, overviewing systematic determination of minerals and rocks by means of their physical properties. Includes the recognition of crystal forms and field relationships of rocks. Course designed for non-geology majors, credit will not count towards a geology-geophysics degree. Prerequisites: Chem 1 and Chem 2 or Chem 5; Ge Eng 50 or Geo 51
- 130 Igneous And Metamorphic Petrology** (LEC 3.0 and LAB 1.0) A comprehensive study of megascopic and microscopic characteristics of igneous and metamorphic rocks. Fundamental theories for their origin are presented. The class includes a trip to examine these rock types in the field. Prerequisite: Geology 113.
- 200 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 201 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 220 Structural Geology** (LEC 3.0 and LAB 1.0) A study of the architecture of the earth. Geologic structures, criteria for recognition, solution of structural problems, and properties and behavior of rocks under different geologic conditions are emphasized. Field trip fee required. Prerequisite: Geo 51 or Ge Eng 50.
- 223 Stratigraphy And Sedimentation** (LEC 3.0) Principles of physical stratigraphy, biostratigraphy and introductory sedimentation. Introduction to depositional systems, facies,

- unconformities, stratigraphic nomenclature and correlation. One field trip at student expense is required. Prerequisite: Geo 130 or Geo 125.
- 224 Stratigraphy Lab** (LAB 1.0) This course reinforces the principles of stratigraphy and sedimentation through the use of "hands-on" laboratory procedures such as seive and pipette analyses, correlation problems, fence diagrams and stratigraphic maps. One field trip at student expense is required. Prerequisite: Concurrent with Geo 223.
- 227 Systematic Paleontology** (LEC 2.0 and LAB 1.0) Introduction to the study of fossil invertebrates. Emphasis of the course is on fossil morphology, classification, and environmental relationships. Prerequisite: Geo 52.
- 248 Fundamentals Of Geographic Information Systems** (LEC 2.0 and LAB 1.0) Introduction to the fundamental concepts and components of Geographic Information Systems. Techniques for acquiring, manipulating and analyzing digital terrain data for geological and geotechnical applications. (Co-listed with Geo Eng 248)
- 260 Methods Of Karst Hydrogeology** (LEC 3.0) This course is designed to familiarize geologists and geological engineers with karst hydrogeology. It will include the formation of karst, aquatic geochemistry in karst areas, identifying karst features and understanding their hydrologic significance. The techniques for investigating groundwater in karst areas will be emphasized, and will include groundwater tracing using fluorescent dyes. Several field trips at student expense will be required. Prerequisites: Geo 51 or Ge Eng 50 and Geo 223.
- 275 Introduction To Geochemistry** (LEC 3.0) Application of basic chemical principals towards investigations of element distributions in geologic systems. Emphasis on origin of elements in our Solar System, element distribution during planetary formation, phase equilibria, rock-water interactions, thermodynamic principles, environmental and isotope geochemistry. Prerequisite: Chem 1.
- 294 Metallic And Industrial Mineral Deposits** (LEC 3.0) Basic processes involved in the formation of metallic and industrial mineral deposits illustrated by typical examples of deposits from throughout the world. Exploration and economic factors in mineral exploration and development are reviewed. Two all day field trips at student expense required. Prerequisites: Geo 51 and 113.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 305 Hydrogeology** (LEC 3.0) This course discusses geologic aspects of major surface and subsurface hydrologic systems of North America. Chemical and physical relationships between groundwater and fractures, faults, karst, subsurface pressures, mineral deposits plus both contaminant and hydrocarbon migration are discussed. Prerequisites: Ge Eng 50 or Geo 51, Geo 223 recommended.
- 307 Physical Oceanography** (LEC 3.0) An introduction to the study of the physical and geological processes in the world's oceans including the importance of the oceans to the environment and to life on Earth. Prerequisite: Geology 325 or equivalent.
- 308 Astronomy and Planetary Science** (LEC 3.0) Basic principles of astronomy, the origin and evolution of the universe, stellar evolution, and the origin, composition, and processes operating on the planetary bodies in the solar system (besides the Earth). Prerequisite: Entrance requirements for the MST program in Earth Science.
- 309 Meteorology and Climatology** (LEC 3.0) An introduction to the atmospheric and climatic systems of the Earth including weather, paleoclimatology, and global climate change. Prerequisite: Geology 325 or equivalent.
- 310 Seminar** (RSD 0.0-6.0) Discussion of current topics. Required for two semesters during senior year. (Course cannot be used for graduate credit). Prerequisite: Senior standing. (Co-listed with Geo Eng 310, Pet Eng 310)
- 312 Ore Microscopy** (LEC 1.0 and LAB 2.0) A study of polished sections of minerals and ores under reflected light. Includes the preparation of polished sections, the identification of ore minerals, and the study of the textures, associations, and alterations of ore minerals. Prerequisite: Geo 113.
- 320 Advanced Structural Geology** (LEC 2.0 and LAB 1.0) The course provides theoretical background, analytical techniques, and hands-on experience for analyzing geologic structures at a variety of scales hand sample to global. Prerequisites: Geology 220, Geophysics 381.
- 324 Advanced Stratigraphy And Basin Evolution** (LEC 3.0) Advanced topics in sedimentary geology including: tectonic controls on sedimentary basin development, global sequence stratigraphy, regional facies and diagenetic patterns, basin hydrogeology, thermal evolution of basins and distribution of economic resources. Prerequisites: Geo 223, 220, preceded or accompanied by Geo 275 recommended.
- 326 Advanced Historical Geology** (LEC 2.0 and LAB 1.0) Study of the physical and biological history of the Earth beginning with the origin of the solar system up to the present. Emphasis will be placed on processes that shaped the Earth and its ecosystems. Prerequisite: Entrance requirements for the MST program in Earth Science.
- 329 Micropaleontology** (LEC 2.0 and LAB 1.0) Introduction to the preparation and study of microscopic fossils. Prerequisite: Geo 227.

- 330 Granites And Rhyolites** (LEC 3.0 and LAB 1.0) Processes governing the generation and crystallization of felsic magma will be covered, with specific reference to: 1) crust vs mantle sources, 2) melt migration and emplacement, 3) magma chamber dynamics, 4) the volcanic-plutonic connection, and 5) the relationship to tectonic setting. A field trip at the student's expense is required. Prerequisite: Geo 130.
- 332 Depositional Systems** (LEC 3.0) Development of three dimensional depositional models using Walther's Law, Walther's Warning and seismic stratigraphy. Emphasis on overall geometries and internal porosity and permeability characteristics of aquifers and hydrocarbon reservoirs. Includes 3-D models for clastic, carbonate and evaporate sequences. Prerequisite: Geology 51 or Geo Eng 50.
- 334 Advanced Igneous and Metamorphic Petrology** (LEC 3.0 and LAB 1.0) Processes governing the formation of igneous and metamorphic rocks as constrained by geochemical, isotopic, and thermodynamic data, with particular reference to the relationship between rock suites and tectonic setting. The laboratory will emphasize the description of rock suites in hand sample and thin section. A field trip at the student's expense is required. Prerequisite: Geology 130.
- 338 Computer Mapping In Geology** (LEC 2.0 and LAB 1.0) This course introduces the basics of both surface and subsurface geologic mapping. It introduces procedures and problems associated with digitizing, gridding, contouring, volumetrics and generation of three dimensional diagrams on the PC. Integration of field gathered data with USGS and GSI databases for the purpose of making surface geologic maps is also included. Prerequisite: Geo 51.
- 340 Petroleum Geology** (LEC 2.0 and LAB 1.0) Principles of origin, migration, and accumulation of oil and gas. The laboratory introduces the procedures used for exploration, and development of hydrocarbon resources. Prerequisite: Geology 51 or Geo Eng 50 (Introductory Geology course)
- 341 Applied Petroleum Geology** (LEC 1.0 and LAB 2.0) The principles of petroleum geology are applied in solving hydrocarbon exploration and developmental problems. Geological and economical techniques for evaluating hydrocarbonbearing reservoirs are presented, with methods for decision making under conditions of extreme uncertainty. Prerequisite: Geo 340.
- 344 Remote Sensing Technology** (LEC 2.0 and LAB 1.0) Principles of digital image processing including image enhancement and multispectral classification. Emphasis upon design and implementation of remote sensing systems and analysis of remotely sensed data for geotechnical and environmental investigations. Prerequisite: Ge Eng 248. (Co-listed with Geo Eng 344)
- 345 Radioactive Waste Management And Remediation** (LEC 3.0) Sources and classes of radioactive waste, long-term decay, spent fuel storage, transport, disposal options, regulatory control, materials issues, site selection and geologic characterization, containment, design and monitoring requirements, domestic and foreign waste disposal programs, economic and environmental issues; history of disposal actions, and conduct of remedial actions and cleanup. Prerequisite: Math 204. (Co-listed with Nu Eng 345)
- 346 Applications Of Geographic Information Systems** (LEC 2.0 and LAB 1.0) Applications of Geographical Information Systems and remote sensing to environmental monitoring, mineral resource exploration, and geotechnical site evaluation. Prerequisite: Geo Eng 275 or consent of instructor. (Co-listed with Geo Eng 346)
- 350 Paleoclimatology and Paleoecology** (LEC 3.0) This course will introduce students to the elements of climate, evidence of climate changes, proxy measurements and paleoclimate models. There is a review of Holocene climates and Archean to Pleistocene paleoclimates. Prerequisite: Geology 52.
- 372 Geological Field Studies** (LEC 3.0) Intensive review of the scientific literature corresponding to a selected geographical region of geologic interest; followed by a 7 to 10 day long field trip to be held over spring break or after the end of the semester. Students will be expected to bear a portion of the field trip expenses. Repeatable for credit. Prerequisites: Geology 51 or Geo Eng 50.
- 373 Field Geology** (LAB 3.0) Field practice in geologic mapping and interpretation in the Western United States using topographic base maps and aerial photos. Emphasizes the description and interpretation of stratigraphic sections, sedimentary and tectonic structures. Prerequisite: Two Geology courses.
- 374 Advanced Field Geology** (LAB 3.0) Detailed field work in areas related to the projects of Geology 373. Courses to be taken the same summer. A written report on the full summer's projects is required. Prerequisite: Geo 373.
- 375 Applied Geochemistry** (LEC 2.0 and LAB 1.0) Application of the principles of geochemistry and techniques of geochemical analysis in a student research project investigating geochemical processes (mineral deposits, environmental geochemistry, trace element migration, or water-rock interaction). Field trip fee required. Prerequisites: Geo 113 and Geo 275.
- 376 Aqueous Geochemistry** (LEC 3.0) Studies of the interaction of water with minerals and organic materials at low temperatures; including processes affecting the migration of elements (alteration, precipitation, and adsorption), the influence of geochemical processes on water

composition, weathering, soil formation, and pollution. Field trip fee required. Prerequisite: Geo 275.

- 378 Isotope Geochemistry** (LEC 2.0 and LAB 1.0) Introduction to the fundamentals of radiogenic and stable isotopes as used to understand geologic processes. The use of selected isotopic systems in petrology, ore petrogenesis, paleontology, and the global climate systems will be discussed. Prerequisites: Geology 130, 223, 275.
- 383 Electrical Methods In Geophysics** (LEC 3.0) The theory and instrumentation for measurements of the electrical properties of the earth. Includes passive and active techniques, the advantages and disadvantages of the various techniques, and geologic interpretations of electrical soundings. Several weekends are spent making a variety of electrical surveys of local features. Prerequisites: Math 325 and Geop 321.
- 390 Undergraduate Research** (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.
- 394 Coal Petrology** (LEC 3.0) Formation, composition, and properties of coals. Discussion of the geology of selected coal deposits, the analysis of coal, and the optical identification of coal minerals. Prerequisite: Permission of instructor.

Geophysics Courses

- 201 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course.
- 270 Introduction to Geophysics** (LEC 3.0) An introduction to a broad area of solid earth geophysics and exploration geophysics. Topics include plate tectonics, earthquake study, structure and dynamics of the Earth's deep interior, gravity, magnetism, heat flow, and geophysical exploration for natural resources. Prerequisites: Math 8 and Geology 51.
- 285 Geophysical Imaging** (LEC 2.0 and LAB 1.0) A study of the major geophysical methods applicable to shallow engineering and environmental geoscience. Topics include the background theory and practical application of gravity, magnetics, radiometrics, resistivity, induced polarization, spontaneous potential, reflection and refraction seismics, ground penetrating radar, electromagnetics, and borehole logging methods. Prerequisites: Physics 24; Ge Eng 50 or Geo 51.
- 286 Introduction To Geophysical Data Analysis** (LEC 3.0) The application of time series and spatial series analysis techniques to geophysical data. Topics covered include digitization and aliasing of geophysical signals, frequency and wave number spectra, digital filtering and linear systems theory. Prerequisites: Math 22 and Cmp Sc 53, 73 & 77, or 74 & 78.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 320 Computational Geophysics** (LEC 1.0 and LAB 2.0) Scientific programming in a UNIX/Linux environment, with emphasis on solving geophysical problems such as linear and nonlinear inversion, spectral analysis, seismicity, seismic wave attenuation, shear-wave splitting, and seismic tomography. Prerequisite: Geophys 270.
- 321 Potential Field Theory** (LEC 3.0) The mathematics and physics of gravitational, magnetic, and electrical fields of the earth as derived from potential functions, with applications to practical problems. The theorems of Laplace, Poisson, Gauss, and Green and their applications to geophysics are presented. Prerequisite: Accompanied or preceded by Math 325.
- 336 Geophysical Field Methods** (LEC 2.0 and LAB 1.0) Imaging of selected subsurface features and engineering structures using various geophysical tools. Special emphasis is placed on ground penetrating radar and surface wave techniques. One field trip at student expense required. Prerequisite: Junior level standing or higher. (Co-listed with Geo Eng 336)
- 361 Transportation Applications of Geophysics** (LEC 2.0 and LAB 1.0) Overview of geophysical and non-destructive test methods that are commonly used to investigate transportation structures and their foundations. Emphasis is placed on bridge system substructure, bridge system superstructure, pavement, roadway subsidence, subsurface characterization and vibration measurements. Prerequisite: Junior level standing or higher. (Co-listed with Geo Eng 361 and Civ Eng 351)
- 377 Seismic Interpretation** (LEC 1.0 and LAB 2.0) An introduction to 2-D/3-D seismic structural interpretation, stratigraphic interpretation, reservoir identification and evaluation, and horizon and formation attributes. The students are expected to master interactive 2-D/3-D seismic interpretation software packages that are routinely used in the petroleum industry. Prerequisite: Geophys 270 or 385.
- 380 Seismic Stratigraphy** (LEC 2.0 and LAB 1.0) A study of the seismic expression of depositional models. Reflection patterns and reflection amplitudes are interpreted to determine bed thicknesses, fluid content, depositional environment, and lithology. Special data acquisition and processing techniques are examined. Prerequisites: Geop 385, Geo 220, 223.

- 381 Global Tectonics** (LEC 3.0) An integrated view of the Earth's structure and dynamics with an emphasis on information gained through geophysical methods. Topics include seismology, heat flow, gravity, rheological and compositional structure, plate motions and intermotions, and mantle driving mechanisms for plate tectonics. Prerequisite: Geo 220.
- 382 Environmental And Engineering Geophysics** (LEC 2.0 and LAB 1.0) An introduction to the theory and application of the gravity, magnetic, resistivity, self-potential, induced polarization and electromagnetic methods as applied to the solution of engineering and environmental problems. Prerequisite: Math 22. (Co-listed with Geo Eng 382)
- 383 Electrical Methods In Geophysics** (LEC 2.0 and LAB 1.0) The theory and instrumentation for measurements of the electrical properties of the earth. Includes passive and active techniques, the advantages and disadvantages of the various techniques, and geologic interpretations of electrical soundings. Several weekends are spent making a variety of electrical surveys of local features. Prerequisites: Math 325 and Geop 285 or Geop 382.
- 385 Exploration And Development Seismology** (LEC 2.0 and LAB 1.0) Principles of reflection seismology as applied to the delineation of geologic structures and the determination of stratigraphy and lithology. Emphasis on both the capabilities and limitations of the seismic method. The laboratory utilizes both modeled and actual seismic data. Prerequisite: Math 22.
- 386 Wave Propagation** (LEC 3.0) A study of Hamilton's principle and energy theorems, fundamentals of plane wave theory, waves in stratified fluids, elastic waves in solids, electromagnetic and hydromagnetic radiation, and Allen's functions and point sources. Prerequisites: Geop 281, 321.
- 388 Geophysical Instrumentation** (LAB 1.0) Field and laboratory practice in the use of geophysical instrumentation. Techniques of geophysical data reduction and interpretation are also covered. May be taken more than once for credit with Geop 383 and Geop 384. Prerequisite: Concurrent registration in Geop 382, 283 or 384.
- 389 Seismic Data Processing** (LEC 2.0 and LAB 1.0) Introduction to seismic data processing. Topics to be covered include statics corrections, filtering, velocity analysis, deconvolution, stacking and migration. Prerequisites: Math 22, and Geop 285 or Geop 385.
- 390 Undergraduate Research** (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

German

German Courses

- 1 Elementary German I** (LEC 4.0) Introduction to grammar, reading, and conversation. Laboratory required. (One extra hour per week.) Prerequisite: Entrance requirements.
- 2 Elementary German II** (LEC 4.0) A continuation of German 1. Prerequisite: German 1.
- 80 Classical And Modern German Readings** (LEC 4.0) Readings in German narrative literature. Prerequisite: German 2.
- 100 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 110 Basic German Conversation** (LEC 2.0) Conversation and oral practice. Prerequisite: German 2.
- 170 Masterpieces Of German Literature** (LEC 3.0) A study of selected major works and movements in German literature. Prerequisite: German 70.
- 200 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 201 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 310 Seminar** (RSD 0.0-6.0) Discussion of current topics. Prerequisite: Senior standing.

Global Studies

Global Studies Minor

Global Studies is a multi-disciplinary undergraduate minor program designed to aid in the preparation of Missouri S&T students to be successful in an increasingly global workforce. Students who complete the Global Studies minor will have an increased awareness of the society, culture, technical issues, and/or language of at least one country other than the United States prior to the completion of their Missouri S&T undergraduate experience. Any Missouri S&T student enrolled in an undergraduate degree program is eligible for the Global Studies minor program, which consists of 12 credit hours from an approved list of classes and at least 2 weeks (14 days) of experience in a foreign country acquired during an approved Missouri S&T class or research project, Missouri S&T extracurricular activity, and/or Missouri S&T study abroad activity.

Courses must be selected from the list of approved courses maintained by the Global Studies Advisory Committee. At least one three hour course must focus on the society, culture, and/or language of a foreign country. Approved courses that meet this criterion are from the Arts, Languages, Humanities, or Social Sciences. The other nine hours comes from approved courses that include at least 25 percent international studies content. "International studies content" is defined as course content addressing countries or regions outside of the United States. "International studies content" does not include content that is universal but rather that which addresses specific countries or regions outside of the United States. To satisfy the multi-disciplinary aspect of the minor, no more than six hours may be taken from a single Missouri S&T degree program.

The minor requires personal experience in a foreign country. Students will participate in one or more approved Missouri S&T-sponsored trips to a foreign country for no less than 14 days total. Examples of approved trips include, but are not limited to, those that may be a part of Missouri S&T classes and/or an OURE project-related trip, an extracurricular activity including Missouri S&T's Engineers Without Borders field trips, and/or Missouri S&T sanctioned study abroad. The list of approved activities is maintained by the Global Studies Advisory Committee.

The curricula criteria, including course lists and the list of approved activities for foreign country experience, are maintained by the Global Studies Advisory Committee and are available on the Quick Links section of the Missouri S&T Undergraduate Studies website at <http://ugs.mst.edu>.

History

Bachelor of Arts/History

Master of Arts

History is a response to the eternal desire of human beings to know more about themselves. For this reason, history students experience a variety of courses, which emphasize the importance of people, their individual choices, their values and their ways of seeing themselves and their world. History majors study man's accumulated heritage from the fossil past to the nuclear present.

This varied course of study includes fundamental survey classes, specific chronological or topical investigations, and special topic seminars. At Missouri S&T individuals who hold Ph.D. degrees and are publishing scholars teach virtually all of your history and political science courses. The hallmark of the program is individual attention. In upper-level courses, efforts are made to keep class sizes small enough to enable discussion, which in turn provides for a greater breadth of knowledge and depth of understanding, and for personal student-professor associations.

As a history major you learn to analyze information, communicate effectively, and engage in research. Such skills are useful for careers in government service, business, industry, and social service institutions, as

well as being the fundamental requisites for graduate and professional studies beyond the undergraduate degree.

If you plan to become a secondary school history teacher, you can fulfill the general requirements for the Bachelor of Arts degree, the requirements for the history major, and the requirements for Missouri certification in the teaching of history. See Education for further information. Contact the Missouri S&T history department for advising.

A minor in history is an option for non-majors who wish to complement their major field of study. This five-course option allows you to gain a broader perspective on human events and to develop your abilities in historical analysis.

In short, when you study history you not only learn important information and skills but you also are challenged to think, to communicate, and to cope with complexity.

Faculty

Professors:

Wayne M. Bledsoe (Emeritus), Ph.D., Michigan State
 Russell D. Buhite (Emeritus), Ph.D., Michigan State
 Lawrence Christensen (Curators' Teaching Professor Emeritus), Ph.D., University of Missouri-Columbia
 H.J. Eisenman (Emeritus) Ph.D., Case Western Reserve
 Larry D. Gragg (Department Chair and Curators' Teaching Professor), Ph.D., University of Missouri-Columbia
 Jack Ridley (Curators' Teaching Professor Emeritus), Ph.D., Oklahoma

Associate Professors:

Diana Ahmad, Ph.D., University of Missouri-Columbia
 Patrick Huber, Ph.D., University of North Carolina
 Tseggai Isaac, Ph.D., University of Missouri-Columbia
 John C. McManus, Ph.D., University of Tennessee
 Michael Meagher, Ph.D., Southern Illinois University
 Donald Oster (Emeritus), Ph.D., University of Missouri-Columbia

Shannon Fogg, Ph.D., University of Iowa
 Jeffrey W. Schramm, Ph.D., Lehigh University
 Lance Williams (Emeritus), Ph.D., Georgia

Assistant Professors:

Michael Bruening, Ph.D., University of Arizona

Lecturer:

Petra DeWitt, Ph.D., University of Missouri-Columbia

Bachelor of Arts History

(In addition to general requirements for Bachelor of Arts Degree.)

Major Hours	
History 10	.1 credit hour
History 397	.3 credit hours
History 175	.3 credit hours
History 176	.3 credit hours
History 299	.3 credit hours
2 American History courses	.6 credit hours
2 European History courses	.6 credit hours
2 History Electives	.6 credit hours

Total:31 credit hours

NOTE: 9 hours of the 31 major hours must be taken at the 300 level.

NOTE: Entering students will normally take English 20 either semester of the first year.

Secondary Education Emphasis Area

You may earn a B.A. Degree in History from Missouri S&T and certification to teach in the schools of Missouri. This program may be completed in four academic years and student teaching is arranged with public schools within 30 miles of the Rolla campus.

Students interested in the Certification Program should consult with the advisor for History/Education majors in the Department of History and Political Science for requirements particular to those interested in this degree. Students should process a change of major form to designate History with an emphasis area of Secondary Education.

History students must complete 124 credit hours, including the requirements of the Teacher Education Program listed in this catalog. A minimum grade of "C" is required by the department in all history and political science courses counted towards this degree. Students must take the following courses:

Communications Skills: 9 hours

English 20, 60, and Speech & Media Studies 85

Humanities: 12 hours with at least one course from the first three areas

Art or Music or Theater Appreciation; Philosophy; Literature; Foreign Language, and Etymology 306

Social Sciences: 15 hours

Political Science 90; Political Science 237 or 250 or 290 or 315 or 316; Economics 121 or 122; Psychology 50, History 110

Natural Sciences: 7 hours = 2 courses and 1 lab

One course in Physics or Chemistry or Geology and one course in Biology; One laboratory in any of the above science courses.

Mathematics: 3 hours

Math 2 or 3 or 4 or higher

Clinical Experience: 16 hours

Education 104, 164, 299

Professional Requirements: 26 hours

Education 40, 174, 216, 251, 280, 298, Psychology 155, 208, 354

History Requirements: 36 hours

History 111, 112, 175, 176, 299 are required of all history majors. History electives: at least 9 hours of the remaining 21 hours must be at the 3xx level. These elective courses must include 6 hours of 2xx or 3xx level American history, 6 hours of 2xx or 3xx level European history, and 9 hours of 2xx or 3xx level history courses.

History Minor Curriculum

The History/Political Science Department offers a minor in history. To qualify, all students must take 15 hours of course work in history to include: (1) History 111 or 112; (2) 175 or 176; (3) An additional 9 hours of History 200 or 300 level courses.

Science, Technology and Politics Minor

The Science, Technology and Politics (STP) minor is designed for students who want to explore the relationship between history, political science, and science and technology. The minor is particularly useful for technologically oriented students, because it provides insight into humanities and social science disciplines and how these disciplines interact with science and technology, thereby broadening their horizon of thought and action and preparing them for an increasingly technologically oriented future. To minor in STP the student must complete one of the following history survey courses: 111 or 112 or 175 or 176; and Political Science 90. After completing the required six hours, the student will select one of two options: The History of Science and Technology option; or the Politics and Public Policy option. Under the History of Science and Technology option, students will complete six additional hours from courses in history plus three hours in political science. Under the Politics and Public Policy option students will complete six additional hours in political science and three hours from history. The upper-level courses to satisfy degree requirements are as follows: HIST 270, 271, 274, 275, 280, or PHIL 345 and POL SC 237, 315, 317, and 325.

History Courses

- 10 Introduction to History** (LEC 1.0) This required course for history majors will introduce them to the study of history, the various fields of history, and the current faculty. The course will also introduce students to the research methods of historians.
- 100 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 110 World Regional Geography** (LEC 3.0) An introduction to the distinguishing cultural and physical characteristics of the major regions of the world. Emphasis on the political problems within the regions and the contemporary issues involved.
- 111 Early Western Civilization** (LEC 3.0) Growth and development of ideas and institutions of western culture from prehistoric man to the voyages of discovery.
- 112 Modern Western Civilization** (LEC 3.0) A continuation of History 111 to the present with special emphasis on the philosophical, political, social, and economic backgrounds of modern society.
- 175 American History To 1877** (LEC 3.0) Survey of the history of the American colonies and United States from colonial times through Reconstruction.

175 — History

- 176 American History Since 1877** (LEC 3.0) Survey of the history of America since Reconstruction.
- 200 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 201 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 210 Seminar** (IND 0.0-6.0) Discussion of current topics.
- 220 Making Of Modern Britain** (LEC 3.0) A survey of modern Britain from the era of Restoration and Glorious Revolution (1660-1689) to the present. Major themes include the social, intellectual, cultural, political and economic aspects of modern and contemporary Britain. Prerequisite: Hist 112.
- 221 Making of Modern Germany** (LEC 3.0) A survey of modern Germany from 1815 through the present. Major themes include social, intellectual, cultural, political, and economic aspects of modern and contemporary Germany, with emphasis on developments during the twentieth century. Prerequisite: Hist 112 or 176.
- 222 The Making Of Modern France** (LEC 3.0) A survey of modern France from the era of Louis XIV (1660-1715) to the present. Major themes include the social, intellectual, cultural, political and economic aspects of modern and contemporary France. Prerequisite: Hist 112.
- 224 Making Of Modern Russia** (LEC 3.0) A survey of modern Russia from the era of "Westernization" and Peter the Great (1660-1725) to the present. Major themes include the social, intellectual, cultural, political and economic aspects of modern and contemporary Russia, with emphasis on the Soviet period. Prerequisite: Hist 112.
- 225 European Diplomatic History 1814 - Present** (LEC 3.0) A survey of European Diplomatic History beginning with The Congress of Vienna to the present, including the Congress system, the Eastern Question, the shift to realpolitik, the diplomatic origins and concluding conferences of the World Wars and Cold War diplomacy. Prerequisite: Hist 112.
- 226 Modern East Asia** (LEC 3.0) An analysis of the history of East Asia in the nineteenth and twentieth centuries. Topics include: social, historical, and intellectual traditions; imperialism and its impact; and the effects of World War II on Modern East Asia. Prerequisite: History 112 or 175 or 176.
- 228 History of the American Pacific** (LEC 3.0) This course examines United States expansion into the Pacific as an extension of 19th century Manifest Destiny. Emphasizing American Pacific possessions, the course includes a historical, political, geographical, and cultural look at the islands from 1800 to the present. Prerequisite: History 175 or History 176 or History 112.
- 237 Contemporary Political Thought** (LEC 3.0) This course will explore the impact of ideas on American politics and history, including the relationship between technological change and public policy; this will be pursued through the study of American political history, social institutions, and intellectual history. Prerequisite: Hist 175 or 176 or Pol Sc 90. (Co-listed with Pol Sc 237)
- 259 History Of Missouri** (LEC 3.0) Survey of Missouri's political, social, economic and cultural development from the beginning of settlement to the present. Prerequisite: Hist 175 or 176.
- 270 History Of Technology To 1900** (LEC 3.0) Technological achievements from prehistoric times to 1900; topics include agriculture, building and construction, communications, transportation, power sources, the Industrial Revolution, relationships between science and technology, factors in invention and innovation and sociocultural effects. Prerequisite: Hist 111 or 112 or 175 or 176.
- 271 Twentieth Century Technology And Society** (LEC 3.0) An investigation of technological achievements since 1900 and their effects on society. Topics include: education in a technological society, technology and the state, the individual and the environment, cybernation, agriculture, scientific and industrial research. Prerequisite: Hist 112 or 176.
- 275 History Of Science** (LEC 3.0) A survey of science from ancient times to the 20th century focusing on the leading conceptual developments within science, the scientific revolution, and science's role in society. Prerequisite: Hist 111 or 112 or 175 or 176.
- 280 The American Military Experience** (LEC 3.0) A study of American military history, strategy, policy and institutions from the colonial period to the present. War will be viewed in the mainstream of history with emphasis on the American Revolution, the Civil War, and the 20th century conflicts. Prerequisite: Hist 112 or 175 or 176 or Pol Sc 90.
- 299 Historiography** (LEC 3.0) Historical interpretation from Herodotus to the present. Emphasis will be placed on reading the works of prominent historians in analyzing the major developments in historical writing. Familiarization with historical source material will be another feature of this course. Serves as capstone course. Prerequisite: Sophomore standing.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 302 Internship** (IND 0.0-6.0) Internship will involve students applying critical thinking skills and discipline specific knowledge in a work setting based on a project designed by the advisor and employee. Activities will vary depending on the student's background and the setting.

Prerequisites: Senior status; must have completed 24 hours in major.

- 310 Seminar** (IND 0.0-6.0) Discussion of current topics. Prerequisite: Senior standing.
- 312 Tudor And Stuart England** (LEC 3.0) A study of England 1485 - 1689 covering the social, political, religious, and cultural developments. Prerequisite: Hist 111 or 220.
- 316 The American Presidency** (LEC 3.0) Historical development of the presidency; emphasis on the constitutional powers and limits of the office and the political contextual variables that influence presidential behaviors. Prerequisite: Pol Sc 90 or Hist 176. (Co-listed with Pol Sc 316)
- 321 Ancient Greece** (LEC 3.0) Aegean and Greek Civilization from Homeric times to the Roman Conquest of the Hellenic World. Designed for the student who wishes to understand the fundamental conditions of classical life and to comprehend the ideas that inspired action. Emphasis will be on social, intellectual, political and religious aspects of the classical world. Prerequisite: Hist 111.
- 322 Ancient Rome** (LEC 3.0) Rome 509 B.C. to 337 A.D. The Roman world from the founding of the Republic through the reign of constantine. Special emphasis is on the transformation of classical culture during the Republic and Imperial age. Prerequisite: Hist 111.
- 323 Medieval History I** (LEC 3.0) The Early Middle Ages, 284 A.D.-753 A.D., transition from ancient to Medieval civilization. The fundamental differences between Roman and Medieval ideas, institutions and life. The triumph of Christianity, the conditions which made this triumph possible and its role in the development of Western Europe. Prerequisite: Hist 111.
- 324 Medieval History II** (LEC 3.0) Medieval Civilization, 11th-13th centuries. The transition from Medieval to Modern world, developments in the political, social and economic institutions of the Medieval world and their enduring effect on Western European Civilization, conflict of faith and reason during this period. Prerequisite: Hist 111.
- 325 History Of Renaissance Thought** (LEC 3.0) Concentrates on the political, religious, and social thought of the Renaissance. Particular emphasis on the revival of the classics, the spread of humanistic values, and reform efforts during the period with relationship to the material basis of society. Prerequisite: Hist 111 or 112.
- 327 Europe In The Age Of The French Revolution And Napoleon** (LEC 3.0) An in-depth examination of the causes, courses and results of the French Revolution and the Napoleonic Era (1789-1815). The impact of the age of the French Imperium upon European economic, diplomatic, intellectual, political and social development. Prerequisite: Hist 112.
- 328 Foundations Of Contemporary Europe 1815-1914** (LEC 3.0) Europe after Napoleon, development of democracy and nationalism, revolutionary movements and leaders, unification of Italy and Germany, national developments of the major powers and the road to the First World War are the bases of this course. Prerequisite: Hist 112.
- 329 Contemporary Europe** (LEC 3.0) First World War, the Versailles Peace Settlement and its aftermath, the Soviet, Fascist and Nazi revolutions and regimes, Western culture between the wars, the Second World War, the age of the atom and Cold War. Prerequisite: Hist 112.
- 330 European Migrations and Nationalism Formation** (LEC 3.0) Analyzes migration patterns into, out of, and within Europe in context of global population movements from Roman Empire through the present. Students will learn to analyze and synthesize factors involved in these movements and correlations to personal and national identity formations. Prerequisite: Hist 112.
- 331 Nazism and Holocaust** (LEC 3.0) This course focuses on the rise of Nazism and its consequences for politics, society, and culture in Europe. The period's history will be examined from the perspective of perpetrators, victims, and bystanders with emphasis on the Holocaust and its legacy. Prerequisite: History 112.
- 331 Nazi Germany and the Holocaust** (LEC 3.0) This course focuses on the rise of Nazism and its consequences for politics, society, and culture in Europe. The period's history will be examined from the perspective or perpetrators, victims, and bystanders with emphasis on the Holocaust and its legacy. Prerequisite: Hist 112.
- 340 Religion And Witchcraft In Early America** (LEC 3.0) An examination of the role of occult ideas and practices in the religious life of early Americans. Emphasis placed upon Puritan beliefs which contributed to seventeenth century effort to eradicate witchcraft. Prerequisite: Hist 175 or Hist 112.
- 341 Colonial America** (LEC 3.0) Political and social trends in America to 1754. Emphasis placed upon native American culture, Spain and France in America, population trends, family, religion, class structure, economic change, social conflict, and the development of individualism in early America. Prerequisite: Hist 175.
- 342 Revolutionary America, 1754-1789** (LEC 3.0) An examination of the causes and consequences of the American Revolution. Emphasis placed upon the social conditions in America which contributed to both the Revolution and the writing of the 1787 Constitution. Prerequisite: Hist 175.
- 343 Age Of Jefferson And Jackson** (LEC 3.0) Economic, political, social and constitutional development of the early American republic; the Federalist and Jeffersonian periods, Jacksonian Democracy, rise of sectionalism. Emphasis placed on historical interpretation and historiography of the period. Prerequisite: Hist 175.

- 344 Civil War And Reconstruction** (LEC 3.0) Lecture, discussion and readings on the causes and consequences of the American Civil War. Focuses on the prewar North-South sectional rivalry: impact of the war on American society, government and politics. Reconstruction including the development of racial crisis in United States history. Prerequisite: Hist 175.
- 348 Recent United States History** (LEC 3.0) Examines America's modern age including the New Era, the New Deal, Internationalism, post-war affluence, the post-industrial era as well as the cultural, intellectual, social and technological features of American society from 1920 to the present. Prerequisite: Hist 176 or 347.
- 352 American Intellectual History II** (LEC 3.0) The ideas of intellectuals and the thought of popular culture, and possible relationships between the two. Among the climates of opinion studied are the Gilded Age, Darwinism, Progressivism, the Twenties, the Great Depression, the Affluent Fifties, the Counter-Culture Sixties. Prerequisite: Hist 176 or 351.
- 353 History Of The Old South** (LEC 3.0) Analysis of the southern region of the United States between 1607-1861 with emphasis on economic, social, political, intellectual, and racial themes. Prerequisite: Hist 175.
- 354 History Of The Modern South** (LEC 3.0) Analysis of the southern region of the United States between 1877 and the present with emphasis on economic, social, political, intellectual, and racial themes. Prerequisite: Hist 176.
- 357 History of the American West** (LEC 3.0) This class examines the American settlement of the Trans-Mississippi West. Areas to be considered include cattle, mining, exploring, women, and Native Americans. Traditional and contemporary views of the American West will be analyzed. Prerequisite: Hist 175 or Hist 176.
- 361 American Environmental History** (LEC 3.0) This class discusses the impact of human interactions with the physical environment and the natural world's influence on human civilizations with emphasis on the 19th and 20th centuries. Prerequisite: History 112 or History 175 or History 176.
- 370 History Of Baseball** (LEC 3.0) This course will survey and interpret the history of baseball from its earliest beginnings down to the present. Main focus will be on the evolution of the professional game in all of its facets. Prerequisite: Hist 175 or 176.
- 375 Architecture, Technology and Society; 1750 to Present** (LEC 3.0) This course investigates the relationships between architecture and technology and, as a consequence, architecture's impact on modern culture and society. A field trip to Chicago is an integral part of the course. Topics include; the industrial revolution, housing styles, new materials, Bauhaus and international style, and post-modern architecture. Prerequisites: History 111 or 112 or 175 or 176 or Pol Sci 90. Recommended: Junior or Senior Standing. Recommended for Arch Eng majors: Art 203 taken prior to course.
- 380 20Th Century Americans In Combat** (LEC 3.0) Through lectures, films, readings, exams, film reviews and discussions, this course examines the American military and combat experience throughout much of the twentieth century. The ultimate goal of the course is for students to understand the realities of warfare and its effect on ordinary Americans as well as American society. Prerequisite: Hist 175 or 176 or 112.
- 381 The United States In World War II** (LEC 3.0) Through lectures, readings and film this course will explore the American experience in World War II. The course will particularly focus on the war's American major battles along with the war's effect on Americans in combat and on the home front. Prerequisite: Hist 175 or 176.
- 382 The United States in Vietnam** (LEC 3.0) Through lecture, film and readings, this course examines the American experience in the Vietnam War. The course covers the causes and consequences of the war as well as its effect on those who fought and on American society as a whole. There is a special emphasis on the realities of combat and the war's impact on individual Americans. Prerequisite: History 176.
- 383 U.S. Diplomatic History to World War II** (LEC 3.0) This course is a history of American foreign relations, broadly conceived, from the War for Independence to WWII. Among other things, it deals with the diplomacy of survival, of expansion and of economic and political hegemony. Prerequisites: Hist 175, 176 or Pol Sc 90. (Co-listed with Pol Sc 383)
- 384 American Diplomatic History Since World War II** (LEC 3.0) American Diplomatic History Since World War II will address the major issues in American foreign policy from WWII to the present. Its primary focus is on the Cold War and the post-Cold War problems the U.S. has faced. Prerequisite: History 176 or Pol Sci 90. (Co-listed with Pol Sci 384)
- 397 Senior Thesis** (LEC 3.0) History majors will complete an extended research paper under the supervision of a department faculty member. Prerequisite: History 299 and senior history majors only.

Information Science and Technology

Bachelor of Science Master of Science

Information Science and Technology offers a bachelors degree focused on today's cutting-edge information technology. Students in Information Science and Technology study the latest technology in areas including networking, database management systems, telecommunications, enterprise resource planning, human-computer interaction, E-commerce, and integrated business systems. Professionals in this field administer, maintain, and support computer systems and networks.

Today's business environments have a critical need for professionals who have an understanding of information technologies based on a broad knowledge of management practices, economics, psychology, and the humanities. These individuals are needed to implement technology to support business processes, managerial decision-making, and organizational communication.

As an information science and technology major, you will take courses that are rigorous and oriented toward building the foundation necessary for lifetime learning. Studying at Missouri's technological university, you will benefit from the world-class computer environment and your association with excellent students from around the country and the world. Students in the program are strongly encouraged to do summer internships or co-ops with companies before they graduate. There are many rich opportunities and students benefit greatly in terms of their education and the edge they have seeking full-time employment once they graduate.

Faculty

Professor:

Arlan DeKock (Emeritus), Ph.D., University of South Dakota

Caroline Fisher (Chair, Ph.D.), Bowling Green State University

Barry Flachsbart, Ph.D., Stanford University

Richard Hall, Ph.D., Texas Christian University

Mike Hilgers, Ph.D., Brown University

Associate Professor:

Bih-Ru Lea (Director of Center for ERP), Ph.D., Clemson University

Vincent Yu, Ph.D., University of Louisville

Assistant Professor:

Craig Claybaugh, Ph.D., University of Wisconsin-Milwaukee

Nicholas Lockwood, Ph.D., Indiana University

Hong Sheng, Ph.D., University of Nebraska-Lincoln

Assistant Teaching Professor:

Yu-Hsien Chiu, M.S., University of Wisconsin-Milwaukee

Adjunct Instructor:

Carla Bates, M.S., University of Missouri-Rolla

Matthew Becker, M.S., University of Missouri-Rolla

Scott Dalton, M.S., University of Missouri-Rolla

Ian Franco, M.S., Missouri University of Science & Technology

Chris Merz, Ph.D., University of California Irvine

James Tharp, MBA, Webster University

Bachelor of Science Information Science and Technology

In Information Science and Technology, the Bachelor of Science degree consists of 120 credit hours. First, all undergraduate students in Information Science and Technology are required to complete a prescribed General Education Requirements Core that corresponds to the recommendations of the Missouri State Coordinating Board for Higher Education and consists of 54 credit hours in the areas of Natural Systems, Human Institutions, Quantitative Skills, and Communication Skills. In addition, all undergraduate students are required to complete a 27 credit hour core consisting of courses in Information Technology, Management, and Entrepreneurship. A minimum grade of "C" is required for courses in these areas. Finally, the degree includes 12 credit hours of free electives.

The remaining 27 credit hours of the required 120 credit hours for the Information Science and Technology degree are divided into a prescribed 18 credit hour degree core and 9 credit hours of specific degree electives. A minimum grade of "C" is required in these courses. The Information Science and Technology Degree requires courses in Database Management, Systems Analysis, Web and Digital Media Development, Computing Internals, Networks and Communications, and E-Commerce. The electives for this degree consist of advanced coursework in the areas introduced by the required courses.

FRESHMAN YEAR

First Semester	Credit
Bus 10-Introduction to College Success I ¹	0.5
English 20-Exposition & Argumentation	3
Math 4-College Algebra ⁵	3
Science Elective ²	3
IST 50-Intro to Mgt Info Systems	3
Laboratory w/ Science Elective	<u>1</u>
	13.5

Second Semester

Bus 11-Introduction to College Success II ¹	0.5
Psych 50-General Psychology	3
Math 12-Business Calculus	4
History Elective	3
IST 51-Implementation of IS I	3
Econ 121-Micro Economics	<u>3</u>
	16.5

SOPHOMORE YEAR

First Semester	Credit
BUS 110-Mgt & Organizational Behavior	3
Speech 85-Principles of Speech	3
Stat 211-Statistical Tools for Decision Making	3
IST 151-Implementation of IS II	3

179 — Information Science and Technology

English 65 or Tech Com 65-Intro to Tech Com	3
	15
Second Semester	
BUS 120-Financial Accounting	3
Econ 122-Macro Economics	3
Science Elective ²	3
Mktg 311-Basic Marketing	3
ERP 246-Introduction to ERP	3
	15

JUNIOR YEAR

First Semester		Credit
IST 286-Web & Digital Media Development	3	
Fine Art, Social Science, or Humanities Elective ³	3	
Fin 250-Corporate Finance	3	
IST 233-Networks and Communications	3	
IST 223-Database Management	3	
	15	
Second Semester		
Speech or Tech Com Elective	3	
Pol Sci 90-American Government	3	
IST 243-Systems Analysis	3	
IST 231-Comp Inter & Operating Systems	3	
IST 241-E-Commerce	3	
	15	

SENIOR YEAR

First Semester		Credit
Fine Art, Social Science, or Humanities Elective ³	3	
Bus 397-Senior Design I	1	
Free Electives	6	
IST Electives or Emphasis Area ⁴	6	
	16	
Second Semester		
English 260 or Tech Com 260-Practicum in Technical Communication	3	
Bus 398-Senior Design II	2	
IST Elective or Emphasis Area ⁴	3	
Free Electives	6	
	14	

A grade of "C" or better is required in the following courses for graduation; Bus 10, Bus 11, Bus 397, Bus 398, IST 50, IST 51, IST 151, ERP 246, Bus 110, Bus 120, Mktg 311, Fin 250, Econ 121, Econ 122, IST 286, IST 223, IST 231, IST 233, IST 241, and IST 243.

¹Writing Intensive Course

²Any Biology, Chemistry, Geology, Geological Engineering, Physics.

³Any course in the following areas not used for other degree requirements: Art, Economics, English, Foreign Language, History, Literature, Music, Philosophy, Political Science, Psychology, Sociology, Theater.

⁴A grade of "C" or better is required in IST Electives and Emphasis Area courses for graduation. Students choosing the Human-Computer Interaction Emphasis Area must take IST 385, 386, and 387. Students choosing the Enterprise Resource Planning Emphasis Area must take ERP 346, 347, and 348. Students who choose no Emphasis Area must take three courses from: IST 300-level, CSc 317, CSc 319.

⁵Math 002 may be substituted for Math 004.

Emphasis Areas

Two Emphasis Areas may be taken to specialize if the student wishes to do so. The first, Human-Computer Interaction, consists of three courses:

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

The second Emphasis Area, Enterprise Resource Planning, consists of three courses:

- ERP 346-ERP Systems Planning & Design
- ERP 347-Supply Chain Management Systems
- ERP 348-Strategic Enterprise Management Systems

Minors

You must see the department advisor and complete a minor application before beginning your minor. Requirements change over time. You will be held to the requirements in force at the time you apply for the minor. Postponing your application for the minor may result in you having to take additional courses to complete the minor. At least six (6) hours of the minor course work must be taken in residence at Missouri S&T.

Minor in Enterprise Resource Planning (ERP)

A minor in ERP* requires the following 15 hours of course work:

- 1) Bus 120-Financial Accounting
 - 2) ERP 246-Introduction to ERP
 - 3) ERP 346-ERP Systems Design and Implementation
- AND 6 hours of electives in ERP chosen from the following:
- 1) ERP 345-Use of Business Intelligence
 - 2) ERP 347-Supply Chain Management Systems
 - 3) ERP 348-Strategic Enterprise Management Systems
 - 4) ERP 349-ERP System Administration

Minor in Information Science and Technology

A minor in Information Science and Technology will require 15 hours of courses:

- 1) IST 50-Information Systems
- 2) IST 51-Implementation of IS I
- 3) IST 151-Implementation of IS II
- 4) ERP 246-Intro to Enterprise Resource Planning
- 5) One other IST course at the 200 level or above.

Information Science and Technology Courses

50 Introduction to Management Information Systems (LEC 2.0 and LAB 1.0) This course familiarizes the students with the fundamental concepts and principles of management information systems. Topics covered include the strategic role of IT, decision support systems, database and datawarehouse, enterprise applications, mobile applications, and social and ethical issues related to information systems.

- 51 Implementing Information Systems: User Perspective** (LEC 3.0) Introduction to object-oriented programming in the context of developing and implementing the various components of an information system with particular attention given to system interface such as window and web forms. Class will include numerous projects covering foundational programming. Prerequisite: IST 50.
- 101 Special Topics** (Variable 0.0-6.0) This is designed to give the department an opportunity to test a new course. Variable title.
- 151 Implementing Information Systems: Data Perspective** (LEC 3.0) Continuation of object-oriented programming in the context of developing and implementing the various components of an information system with particular attention given to database incorporation. Class will include numerous projects covering intermediate topics. Prerequisite: IST 51 or Comp Sci 53 or Comp Sci 73 or Comp Sci 74.
- 200 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 201 Special Topics** (Variable 0.0-6.0) This is designed to give the department an opportunity to test a new course. Variable title.
- 202 Cooperative Training in Information Science & Technology** (IND 0.0-6.0) On-the-job experience gained through cooperative education with industry with credit arranged through departmental co-op advisor. Grade received depends on quality of reports submitted and work supervisors's evaluation. Prerequisite: Completed 30 hours toward degree.
- 223 Database Management** (LEC 3.0) The course introduces the concepts of database management systems. Issues in database architecture, design, administration, and implementation are covered. Prerequisites: IST 50; IST 151 or Comp Sci 153.
- 231 Computing Internals And Operating Systems** (LEC 3.0) Design-oriented introduction to computer components and operation. Standard codes; number systems; base conversions; computer arithmetic; boolean algebra; operating system components including memory management, device management, and I/O management; and related issues are covered. Prerequisite: IST 151 or Comp Sci 153.
- 233 Introduction To Telecommunications Networks** (LEC 2.0 and LAB 1.0) The course provides an introduction to current and evolving telecommunications technologies, including voice, data and video. It includes network construction, operation and management; discussion of network technologies, standards and protocols; switching; area networks; and hands-on experience with network hardware, software and simulations. Prerequisite: IST 151 or Comp Sci 153.
- 241 E-Commerce** (LEC 3.0) Introduction to fundamental concepts of management and application to Information Technologies. This course examines the use of IT in business processes and the management issues of integrating IT into organization processes to gain a competitive advantage. Topics include: management; organizations and information systems; development life cycle; project management and systems engineering; process reengineering; and organization learning. Prerequisites: IST 50, IST 286.
- 243 Systems Analysis** (LEC 3.0) Introduction to the processes by which business information systems are analyzed, designed, and introduced into the business environment. Topics include investigation of existing systems, requirements analysis, logical and physical design, database design, forms design, and report analysis. Prerequisite: IST 223.
- 286 Web and Digital Media Development** (LEC 3.0) This course covers techniques and tools for design and development of web-based media, including text, graphics, animation, audio, and video. Prerequisite: IST 50.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 302 Internship - IST** (IND 0.0-6.0) Internship will involve students applying critical thinking skills and discipline specific knowledge in a work setting based on a project designed by the advisor and employee. Activities will vary depending on the student's background and the setting. Prerequisite: Completed 30 hours toward degree.
- 321 Network Performance Design And Management** (LEC 3.0) This course provides analytical capabilities needed to effectively design, deploy, and manage computer networks and protocols. Prerequisites: IST 223, IST 233.
- 342 E-Commerce Architecture** (LEC 3.0) Course will cover the issues associated with computer architecture, as it relates specifically to e-commerce applications. Topics will include e-commerce systems and processes, specialized software, and databases. Prerequisite: IST 233 or IST 336.
- 343 Database Applications in Business** (LEC 3.0) Design, development and implementation of application software typical to the modern business environment utilizing popular commercial database management systems such as Oracle and Access. Focus given to business case modeling, requirement analysis, database design, and implementation challenges. Project oriented. Prerequisite: IST 243.
- 351 Leadership In Technology-Based Organizations** (LEC 3.0) The course focuses on the knowledge and skills necessary for the

development and implementation of effective strategies for the management of technology-based organizations. This involves: developing a general management perspective on technology and innovation, examining the problems of new product development, identifying distinctive technological competencies, licensing and marketing technologies, assessing the organizational and industrial context of technology. Prerequisite: Senior or Graduate Standing.

- 352 Advanced Web Development** (LEC 3.0) Advanced Web development techniques to provide dynamic interaction; methods for extracting and delivering dynamic information to/from Web servers -- a hands-on approach. Interaction with other Web servers, especially database servers, to obtain and deliver information. Project work is required. Prerequisite: IST 286.
- 353 Modular Software Systems in Java** (LEC 3.0) Introduction to Software Life Cycle and characteristics of large modular software systems. Exploration of software support for such systems, using Java, including use of GUI interfaces, advanced I/O and String handling, Interfaces, Threads, and other modularity features. Program project included. Prerequisites: IST 151 and IST 231.
- 354 Multi-Media Development And Design** (LEC 3.0) Students will learn current practices for development and design of interactive multimedia. The course covers tools for development of 2-D and 3-D graphics, video, audio, animation, and integrated multimedia environments. Prerequisites: IST 51 or Comp Sci 53 or Comp Sci 73 or Comp Sci 74.
- 357 Network Economy** (LEC 3.0) Emerging Network/Internet economy, using traditional economic tools. Topics: production and reproduction cost of information, information as an "experience good," versions of products, switching cost, lock-in effects, market adoption dynamics, first-mover advantage, intellectual property rights. Prerequisite: Econ 121 or Econ 122. (Co-listed with Econ 357)
- 361 Information Systems Project Management** (LEC 3.0) The course overviews general project management principles and then focuses on information system application development. Topics include requirements analysis, project scheduling, risk management, quality assurance, testing, and team coordination. Prerequisite: Senior or Graduate Standing.
- 368 Law and Ethics in E-Commerce** (LEC 3.0) Provides the ethical framework to analyze the ethical, legal, and social issues that arise for citizens and computer professionals regarding the computerization of society. Topics include: free speech, privacy, intellectual property, product liability, and professional responsibility. (Co-listed with Philos 368)
- 385 Human Computer Interaction** (LEC 3.0) Introduction to the field of Human-Computer Interaction (HCI). Students examine issues and challenges related to the interaction between people and technology. The class explores the social and cognitive characteristics of people who use information systems. Students learn techniques for understanding user needs, interface prototyping, and interface evaluation. Prerequisite: Psych 50.
- 386 Human-Computer Interaction Prototyping** (LEC 1.5 and LAB 1.5) This course covers designs, methods and tools for creating low and high fidelity prototypes of information technology systems, which is part of the iterative design cycle commonly used for the creation of usable information technologies. Prerequisites: IST 286 or web design experience; preceded or accompanied by IST 385.
- 387 Human-Computer Interaction Evaluation** (LEC 1.5 and LAB 1.5) This course covers research and analysis methods and tools for evaluation of the impact of information technology systems on humans and organizations. The focus will be on practical evaluation with the goal of providing recommendations for improving system functionality and usability. Prerequisite: Preceded or accompanied by IST 385.
- 390 Undergraduate Research** (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

Interdisciplinary Engineering

Interdisciplinary Engineering Courses

- 20 Introduction to Engineering Design** (LEC 2.0 and LAB 1.0) Introduction to a systematic approach to engineering design (problem clarification, concept generation, concept selection, prototyping methods, engineering ethics) and fundamental design communication techniques. Computer aided design tools are
- 50 Engineering Mechanics-Statics** (LEC 3.0) Application of the principles of mechanics to engineering problems of equilibrium. Topics include resultants, equilibrium, friction, trusses, center of gravity and moment of inertia. Prerequisites: Physics 23 or 21, preceded or accompanied by Math 22.
- 110 Mechanics Of Materials** (LEC 3.0) Application of the principles of mechanics to engineering problems of strength and stiffness. Topics include stress, strain, thin cylinders, torsion, beams,

columns, and combined stresses at a point. Prerequisites: IDE 50 with grade of "C" or better and Math 22.

- 120 Materials Testing** (LAB 1.0) Designed to assist in the teaching of mechanics of materials. Topics include strain measurement, testing machines and properties of materials. Prerequisite: Preceded or accompanied by IDE 110.
- 140 Statics And Dynamics** (LEC 3.0) An introduction to the principles of mechanics pertaining to problems of equilibrium, motion, and acceleration in two dimensions. Particle and rigid body equilibrium and applications; general planar motion; force, mass, and acceleration; impulse/ momentum; work/energy. This course will not satisfy the prerequisite for IDE 110. Prerequisites: Physics 23 or 21; prec. or acc. by Math 22.
- 150 Engineering Mechanics-Dynamics** (LEC 2.0) Application of the principles of mechanics to engineering problems of motion and acceleration. Topics include plane motion; force, mass and acceleration; work and energy; and impulse and momentum. Prerequisites: IDE 50 and Math 22.
- 200 Special Problems** (IND 1.0-6.0) (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 202 Cooperative Engineering Training** (IND 0.0-6.0) On-the-job experience gained through cooperative education with industry, with credit arranged through the student's advisor. Grades received depends on the quality of the reports submitted and work supervisor's evaluation.
- 214 System Modeling** (LEC 3.0) This course examines the modeling and simulation of dynamic systems. The use of bond graphs to represent the essential structure of system models leads to state space equations for performance analysis and design variable selection. Prerequisites: IDE 105, Math 204; IDE 150 or Mech Eng 160.
- 215 System Prototyping** (LEC 1.0 and LAB 1.0) Students use extensive mathematical and physical modeling to characterize a team-based interdisciplinary design project. A prototype is built and tested to determine the effectiveness of the various modeling techniques used. Prerequisite: IDE 214.
- 220 Engineering Design Methodology** (LEC 3.0) This course examines structured engineering design theory and methodologies for conceptual design and redesign of products. Topical coverage includes customer needs gathering, functional modeling, engineering specifications creation (OFD), concept generation, selection and design embodiment. Team work/hands-on projects emphasized. Prerequisite: At least Senior standing in engineering. (Co-listed with Mech Eng 361)
- 300 Special Problems** (IND 0.0-6.0) (Variable) Problems or readings on specific subjects or

projects in the department. Consent of instructor required.

- 315 Interdisciplinary Design Project** (LEC 2.0 and LAB 1.0) Interdisciplinary design topics include team report writing, patent search and application, prototyping techniques, conflict resolution, critiquing methods, and presentation skills. Student teams will complete a design project for an external or internal sponsor, including a working prototype of the product. Prerequisites: IDE 215, IDE 220.
- 390 Undergraduate Research** (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructors.

Latin

Latin Courses

- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.

Marketing

Marketing Courses

- 200 Special Problems** (IND 0.0-6.0) (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 201 Special Topics** (Variable 0.0-6.0) (Variable) This is designed to give the department an opportunity to test a new course. Variable title.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in marketing. Prerequisite: Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This is designed to give the department and opportunity to test a new course. Variable title.
- 307 Marketing and Strategy Essentials** (LEC 1.5) This course is an introduction to the essentials of marketing and strategy for running a business. It is designed for students planning to enter the MBA program who need this area and for non-business students who want some business background. Credit in this course cannot be applied to any major or minor in Business, IST, or Economics. Prerequisite: Bachelor Degree.
- 311 Marketing** (LEC 3.0) The course examines the distribution, product, price, and promotion policies that underlie the activities of marketing institutions and the managerial, economic, and societal implications of such policies.
- 350 Customer Focus and Satisfaction** (LEC 3.0) Major emphasis is given to the concept of customer focus, with coverage of techniques for obtaining customer needs, measuring customer

satisfaction, developing products and services to satisfy customers, and maximizing the benefits of customer feedback. A semester long HoQ project will be done. Prerequisite: MKT 311 or MKT 307 or Eng Mgt 251. (Co-listed with Bus 350)

380 Marketing Strategy (LEC 3.0) Identification and analysis of strategic managerial marketing issues. Integration of marketing concepts through theoretical overview and practical analysis, including extensive use of simulation. Prerequisite: MKT 311 or MKT 407 or Eng Mgt 251.

390 Undergraduate Research (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor. Prerequisite: Consent of instructor required.

Materials, Science, and Engineering

Materials, Science, and Engineering Courses

301 Special Topics (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.

325 Materials Selection in Mechanical Design (LEC 3.0) This course will introduce the basics of materials selection in mechanical design. It will also introduce the benefits of computational materials and process selection. The students will also learn to use a commercially available materials selection software. This course will be offered as Distance Ed. Prerequisite: Met Eng 121.

341 Tissue Engineering I (LEC 3.0) The course will introduce senior undergraduate students to the principles and clinical applications of tissue engineering including the use of biomaterials scaffolds, living cells and signaling factors to develop implantable parts for the restoration, maintenance, or replacement of biological tissues and organs. Prerequisite: Senior standing. (Co-listed with Bio Sci 341)

348 Energy Materials (LEC 3.0) The objectives of the course are to understand how the rational design and improvement of chemical and physical properties of materials can lead to energy alternatives that can compete with existing technologies. Discussions on the present and future energy needs from a view point of multidisciplinary scientific and technological approaches. Prerequisite: Senior standing.

351 Advanced Phase Equilibria (LEC 3.0) Advanced aspects of unary, binary and ternary organic, phase equilibria. Includes practical examples of the applications of phase diagrams to solve engineering problems. Prerequisite: Graduate standing.

Mathematics

Bachelor of Science (Applied Mathematics)

Master of Science (Applied Mathematics)

Master of Science for Teachers (Mathematics)

Doctor of Philosophy (Mathematics)

Emphasis areas at the Bachelor of Science level include actuarial science, algebra/discrete mathematics, applied analysis, computational mathematics, secondary education, and statistics. Emphasis areas at the doctor of philosophy level of mathematics include analysis, differential and functional equations, and statistics.

Mathematics is a universal language. It is one which scientists use to express ideas and relationships concisely. It is a tool, which they use to investigate problems.

As a mathematician, you will set up and analyze models of physical situations in order to deduce new information and to predict results.

Most students pursue their study of mathematics through a differential equations course and then elect courses in specialized areas such as algebra, analysis, geometry, topology, and statistics. Supporting study in technical electives is required from other departments. Such study includes analytical mechanics, communication theory, control theory, and others.

Your classes, for the most part, will be held in the Rolla Building. You will be provided data processing and computational services to solve complex problems through the computer facilities. (See computer science description.)

You will find that mathematics contributes to the growth in knowledge in most areas. Your program at Missouri S&T will emphasize breadth in mathematics and depth in an associated area of application.

Faculty

Professors:

Leon Hall (Department Chair), Ph.D., Missouri-Rolla
Martin Bohner, Ph.D., Ulm
Wlodzimierz Charatonik, Ph.D., Warsaw
Stephen Clark, Ph.D., Tennessee
Roman Dwilewicz, D.Sc., Warsaw
Vy Le, Ph.D., Utah
V. Samaranayake, Ph.D., Kansas State

Associate Professors:

Elvan Akin-Bohner, Ph.D., Nebraska-Lincoln
David Grow, Ph.D., Nebraska-Lincoln
E. Matt Insall, Ph.D., Houston
Ilene Morgan, Ph.D., Penn State
Robert Paige, Ph.D., Colorado State

Robert Roe, Ph.D., Wyoming

Assistant Professors:

Akim Adekpedjou, Ph.D., South Carolina
 Xiaoming He, Ph.D., Virginia Tech
 Gayla Olbricht, Ph.D., Purdue
 John Singler, Ph.D., Virginia Tech
 Xuerong (Meggie) Wen, Ph.D., Minnesota
 Jingjing Wu, Ph.D., University of Alberta
 Yanzhi Zhang, Ph.D., National University of Singapore

Associate Teaching Professors:

Stephanie Fitch, M.A., University of Texas at Austin

Assistant Teaching Professors:

Kimberly Kinder, M.S., Central Missouri State
 Dee Leach, M.S., Santa Clara University

Emeritus Faculty:

Lee Bain, Ph.D., Oklahoma State
 August Garver, M.S., Missouri-Rolla
 Glen Haddock, Ph.D., Oklahoma State
 Roger Hering, Ph.D., Southern Illinois
 Troy Hicks, Ph.D., Cincinnati
 W. Thomas Ingram, Ph.D., Auburn
 James Joiner, Ph.D., George Peabody
 Mary Kirgan, M.S.T., Missouri-Rolla
 Jagdish Patel, Ph.D., Minnesota
 Anthony Penico, Ph.D., Pennsylvania
 Lyle Pursell, Ph.D., Purdue
 Selden Trimble, Ph.D., Kentucky

**Bachelor of Science
 Applied Mathematics**

A minimum of 132 credit hours is required for a Bachelor of Science degree in Applied Mathematics. A minimum grade of "C" is required by the department in each course counted toward the Math/Stat requirement for the B.S. in Applied Mathematics. Moreover, the department requires that an average of at least two grade points per credit hour must be obtained for all courses taken within the department. These requirements for the B.S. degree are in addition to credit received for algebra, trigonometry, and basic ROTC.

The Applied Mathematics curriculum requires fifteen semester hours of technical electives in addition to basic courses in chemistry or biology, physics, computer science, and economics. Two semesters of a foreign language, English 60 or English 160, and either History 175, 176, 112, or Pol Sc 90 are also required. Specific requirements for the bachelor's degree are outlined in the sample program below.

FRESHMAN YEAR

First Semester	Credit
Math 1-Intro to Math	.1
Math 8-Calculus w/Analytic Geometry I ¹	.5
Chem 4-Intro to Lab Safety & Haz Mat	.1
English 20-Exposition & Argumentation	.3
Campus History Requirement ²	.3
Foreign Language Requirement ³	.4
Basic ROTC (if elected) ⁴	.0
	<u>17</u>

Second Semester

Math 21-Calculus w/Analytic Geometry II ¹	.5
Science Requirement ⁵	.5
Cmp Sc 53 or 73 & 77 or Cmp Sc 74 & 78	.3
Foreign Language Requirement ³	.4
Basic ROTC (if elected) ⁴	.0
	<u>17</u>

SOPHOMORE YEAR

First Semester	Credit
Math 22-Calculus w/Analytic Geometry III ¹	.4
Math 208-Linear Algebra I ¹	.3
Statistics Requirement ^{1,6,7}	.3
Physics 21-General Physics I	.4
Physics 22-General Physics Lab	.1
English 60-Writing & Research	.3
Basic ROTC (if elected) ⁴	.0
	<u>18</u>

Second Semester

Math 204-Elementary Differential Equations ¹	.3
Math 209-Foundations of Mathematics ¹	.3
Econ 121-Microecon or 122-Macroecon	.3
Physics 25-General Physics II	.4
Physics 26-General Physics Lab	.1
Computer Science Requirement ^{7,8}	.3
Basic ROTC (if elected) ⁴	.0
	<u>17</u>

JUNIOR YEAR

First Semester	Credit
Math 309-Advanced Calculus I ¹	.3
Literature	.3
Electives-Math or Stat ^{1,7,9}	.3
Electives-Technical ¹⁰	.3
Electives	.3
	<u>15</u>

Second Semester

Math 311-Advanced Calculus II ¹	.3
Literature	.3
Electives-Math or Stat ^{1,7,9}	.3
Electives-Technical ¹⁰	.3
Electives	.3
	<u>15</u>

SENIOR YEAR

First Semester	Credit
Math 361-Problem Solving Pure Math ^{1,11}	.1
Math 371-Problem Solving Applied Math ^{1,11}	.1
Electives-Math or Stat ^{1,7,9}	.3
Electives-Technical ¹⁰	.6
Electives	.6
	<u>17</u>

Second Semester

Math 381-Great Theorems in Math ^{1,11}	.1
Electives-Math or Stat ^{1,7,9}	.3
Electives-Technical ¹⁰	.3
Electives	.9
	<u>16</u>

¹⁾ A minimum grade of "C" is required by the department in each course counted toward the Math/Stat requirement for the B.S. in Applied Mathematics. Moreover, the department requires that an average of at least two grade points per credit hour must be obtained for all courses taken within the department.

- 2) May be met by History 112, 175, 176, or Pol Sc 90.
- 3) A modern language approved by the advisor (six hours credit is acceptable from transfer students.) Requirement may be met by examination or, with approval of the department, by three years of a foreign language in high school.
- 4) Basic ROTC may be elected in the freshman and sophomore years, but is not creditable toward a degree. Up to six credit hours of advanced ROTC may be credited as free electives towards a degree.
- 5) May be met by Chem 1 and 2 or by Bio Sc 110 and 112.
- 6) May be met by Stat 215, 217, or 343.
- 7) No course may be used to satisfy more than one degree requirement.
- 8) May be met by Cmp Sc 153, 128 or 228.
- 9) The student must choose two from the following five groups and then complete six hours in each of the chosen groups (1) Math 305, 306, 307, 308; (2) Math 315, 330, 351, 385; (3) Math 302, 303, 322, 325, 351, 383; (4) Stat 343, 344, 346, 353; (5) Cmp Sc 228, 328, 329, Stat 346, Math 303, Econ 321.
- 10) Courses in chemistry, physics, mechanics, geology, computer science, economics or engineering approved by advisor.
- 11) The three courses Math 361, 371, and 381, constitute the Capstone experience for mathematics majors.

Math Minor Curriculum

The minor will consist of at least 12 hours of mathematics/statistics courses at the 200* or higher level, 9 hours of which must be completed in residence at Missouri S&T and 3 hours of which must be at the 300 or higher level, and passing all of them with at least a grade of "C". Further, Math 204 and Math 229 cannot both be counted, Math 203 and Math 208 cannot both be counted, and at most one of Stat 211, Stat 213, Stat 215 and Stat 217 may be counted. Finally, the specific choice of courses is subject to the approval of the minor advisor.

*Computer Science 228 (Introduction to Numerical Methods) may be substituted for one of these courses.

Bioinformatics Minor

Students majoring in Mathematics are eligible to pursue a minor in bioinformatics. See the description of the bioinformatics minor.

Emphasis Areas at the Bachelor of Science Level¹²

Actuarial Science Emphasis Area¹²

Required courses:

Stat 343-Probability and Statistics	.3
Stat 344-Mathematical Statistics	.3
Stat 346-Regression Analysis	.3
Stat 353-Statistical Data Analysis	.3
Econ 121-Principles of Microeconomics	.3
Econ 122-Principles of Macroeconomics	.3

Econ 222-Intermediate Macroeconomic Theory	.3
Econ 321-Finance	.3

In addition, the student must pass the first Actuarial Science Exam.

Algebra/Discrete Mathematics Emphasis Area¹²

Required courses:

Math 305-Modern Algebra I	.3
Math 306-Modern Algebra II or Math 405 Finite Flds	.3
Math 307-Combinatorics	.3
Math 308-Linear Algebra II	.3
Stat 343-Probability & Statistics	.3
and three hours from:	
Stat 344-Math Statistics	.3
Cmp Sc 228-Intro to Numerical Methods	.3
Cmp Sc 330-Formal Language & Automata Theory I	.3
Cmp Sc 325-Analysis of Algorithms	.3

Computational Mathematics Emphasis Area¹²

Required courses:

Stat 353-Stat Data Analysis	.3
Stat 346-Regression Analysis	.3
Cmp Sc 228-Intro to Numerical Methods	.3
and six hours from:	
Math 302-Intermediate Differential Equations	.3
Math 303-Mathematical Modeling	.3
Math 325-Partial Differential Equations	.3
and three hours from:	
Cmp Sc 328-Object-Orient Num Mod I	.3
Cmp Sc 329-Object-Orient Num Mod II	.3
EMech 307-Finite Element Approx	.3

Applied Analysis Emphasis Area¹²

Required:
 Cmp Sc 228-Intro to Numerical Methods .3
and two of groups 3, 4, and 5 under Mathematics of Statistics electives must be satisfied.
and choose Technical Electives and Free Electives to satisfy one of the following two options:

Engineering Option (A)

Required courses:

Inter Eng 50-Statics	.3
Inter Eng 110-Mechanics of Materials	.3
<i>And one of the following two courses:</i>	
Inter Eng 150-Eng Mech-Dynamics	.2
ME 160-Dynamics	.3
And nine hours from the following list. Courses, which have any of the listed courses as prerequisites, may also be used to fulfill this requirement. Courses with an asterisk (*) are co-listed in more than one department.	
Ae Eng 213-Aerospace Mechanics I	.3
Ae Eng 207-Vibrations I*	.3
Ae Eng 313-Interm Dyn of Mech & Ae Sys	.3
Ae Eng 314-Spaceflight Mech	.3
Ch Eng 120-Chem Eng Mat Bal	.3
Ch Eng 141-Chem Eng Thermodynamics I	.3

Cv Eng 218-Structural Analysis3
 El Eng 281-Elec Cir or El Eng 282-Elec Cir & Mach . . .3
 Mc Eng 213-Machine Dynamics3
 Mc Eng 219-Thermo or Mc Eng 227-Thermal Analysis 3
 Mc Eng 331-Thermo Fluid Mech II*3
 Nu Eng 203-Interactions of Radiation w/Matter3
 Nu Eng 303-Reactor Physics I3
 Pe Eng 141-Prop of Hydrocarbon Fluids3
 Pe Eng 320-Fund of Petro Reservoir Simulation3
 Cv Eng 230-Elem Fluid Mech or Nu Eng 221-Reactor
 Fluid Mech or Mc Eng 231-Thermo Mech I3
 Cv Eng 323-Class & Matrix Meth of Struct Analysis . .3
 Cv Eng 333-Intermediate Hydraulic Eng3
 El Eng 368-Intro to Neural Networks & Appl3
 EMech 307-Finite Element Approx I3
 EMech 311-Intro to Continuum Mechanics3
 EMech 334-Stability of Eng Structures*3
 EMech 354-Variational Form of Mech Problems3
 Ge Eng 315-Geometrics3
 Geo 286-Intro to Geop Data Analysis or Geop 286-
 Intro to Geop Date Analysis3
 Geop 321-Potential Field Theory3

Physics Option (B)

Required courses:
 Physics 207-Modern Physics I3
 Physics 307-Modern Physics II3

And take at least nine additional hours of physics courses at the 200 level or above. Note that the requirements for a minor in physics will be satisfied with this option.

Secondary Education Emphasis Area

You may earn a B.S. Degree in Applied Mathematics from Missouri S&T and certification to teach at the secondary level in the schools of Missouri with this emphasis area program. This program can be completed in four academic years and student teaching is arranged with public schools within 30 miles of the Missouri S&T Campus.

Students interested in this emphasis area should consult with the advisor for Mathematics Education majors in the Mathematics and Statistics Department.

In order to successfully complete this emphasis area, students must have at least a 22 ACT, maintain a cumulative GPA of at least 2.5, and attain at least a 2.5 GPA in all mathematics courses. Current Missouri S&T or transfer students who wish to pursue this emphasis area must meet both these GPA requirements to be accepted into the program. Students must also meet all requirements listed under the Teacher Education Program in the catalog. Students who do not meet all the teacher certification requirements will not be eligible for the Secondary Education Emphasis Area, even if they have completed all course work.

A degree in this emphasis area requires 132 credit hours. The required courses and a sample four-year program are provided below. (A minimum grade of "C" is required by the department in all mathematics and statistics courses counted toward this degree. No course

may be used to satisfy more than one degree requirement.)

FRESHMAN YEAR

First Semester	Credit
Math 1-Intro to Math	1
Math 8-Calculus w/Analytic Geometry I	5
English 20-Exposition & Argumentation	3
History Requirement (History 175 or 176)	3
Cmp Sc 53 or 73 & 77 or Cmp Sc 74 & 78	3
	15

Second Semester

Math 21-Calculus w/Analytic Geometry II	5
Bio Science 110-General Biology	3
Science Lab Requirement (Bio Sc 112) ¹	2
Psychology 50-General Psychology	3
Education 40-Perspectives in Education	2
	15

SOPHOMORE YEAR

First Semester	Credit
Math 22-Calculus w/Analytic Geometry III	4
Math 208-Linear Algebra I	3
Physics 21-General Physics I	4
Physics 22-General Physics Lab	1
Psychology 208-Psych/Educ of the Adolescent3	
Education 104-Teacher Field Experience	2
	17

Second Semester

Math 204-Elementary Differential Equations	3
Math 209-Foundations of Mathematics	3
English 60-Writing & Research	3
Physics 25-General Physics II	4
Physics 26-General Physics Lab	1
Speech 85-Principles of Speech	3
	17

JUNIOR YEAR

First Semester	Credit
Math 309-Advanced Calculus I	3
Statistics Requirement (Stat 215, 217, or 343)3	
Education 164-Aiding Secondary Schools	2
Education 174-School Organization and Admin2	
Psychology 155-Educational Psychology	3
Econ 121-Microecon or 122-Macroecon	3
	16

Second Semester

Math 311-Advanced Calculus II	3
Math 330-Topics in Geometry	3
Psychology 354-Psych of the Exceptional Child3	
Education 280-Teaching Methods	6
Fine Art Elective ²	3
	18

Summer Semester

Education 216-Teaching Reading	3
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SENIOR YEAR

First Semester	Credit
Math 361-Problem Solving Pure Math ³	1
Math 371-Problem Solving Applied Math ³	1
Electives-Math or Stat ⁴	6
Educ 251-Historical Foundation of Amer Educ3	
Pol Science 90-American Government	3
Literature	3
	17

Second Semester

Math 381-Great Theorems in Math³ 1
 Educ 298 and 299-Student Teaching 13
 14

- ¹⁾ May be met by Bio Sci 112 or Chem 2, but if Chem 2 is used, one extra hour must be attained in any elective area to fulfill the 132 total hour requirement.
- ²⁾ Any three-hour course from the areas of foreign language, music, theater, philosophy or art.
- ³⁾ The three courses Math 361, 371, and 381 constitute the Capstone experience for mathematics majors.
- ⁴⁾ Any two three-hour courses from the following list with the approval of the Mathematics Education advisor. Math 302, 303, 305, 306, 307, 308, 315, 322, 325, 330, 351, 383, 385; Stat 343, 344, 346, 353; Cmp Sc 228, 328, 329; Econ 321.

Statistics Emphasis Area¹²

Required courses:

Stat 343-Prob & Stat 3
 Stat 344-Math Stat 3
 Stat 346-Regression Analysis 3
 Stat 353-Stat Data Analysis 3

and complete 6 hours from:

Bio Sc 231-General Genetics 3
 Cmp Sc 228-Intro to Numerical Methods 3
 Eng Mg 385-Statistical Process Control 3

and complete either A or B:

(A) Complete the following two courses:

Math 315-Intro to Real Analysis 3
 Math 351-Intro to Complex Variables 3

(B) Complete 6 hours from:

Math 303-Math Modeling 3
 Math 307-Comb & Graph Theory 3
 Math 308-Linear Algebra II 3

¹² **Note:** It is not required that students complete an emphasis area to obtain the Bachelor of Science degree in Applied Mathematics. The emphasis area requirements often specify most, if not all, of the electives in Mathematics, Statistics and Computer Science as well as many technical or free electives.

Mathematics Courses

- 1 Introduction To Mathematics** (LEC 1.0) Introduction to the department, program of study, methods of study, and an introduction of the various areas of mathematics. Required of fall semester freshman mathematics majors.
- 2 College Algebra** (LEC 5.0) Contains the same topics as covered in Math 4, and preceded by a thorough review of the basic principles of algebra. Prerequisite: By placement examination.
- 3 Fundamentals Of Algebra** (LEC 3.0) Basic principles of algebra including the number line and an introduction to equations and inequalities, polynomials, rational expressions, exponents and radicals, the quadratic formula and functions. Prerequisite: Entrance requirements.

- 4 College Algebra** (LEC 3.0) A study of linear equations, rational functions, radicals, quadratic equations, inequalities, determinants, progressions, theory of equations, permutations, combinations, and the binomial theorem. Prerequisite: By placement examination.
- 6 Trigonometry** (LEC 2.0) A study of the trigonometric functions, radian measure, graphing trigonometric functions, identities, trigonometric equations and inverse trigonometric functions. Solutions of general triangles and trigonometric representation of complex numbers are included. Prerequisite: Math 2 or 4 with a grade of "C" or better; or by placement exam.
- 8 Calculus With Analytic Geometry I** (LEC 5.0) A study of limits, continuity, differentiation and integration of algebraic and trigonometric functions. Applications of these concepts in physical as well as mathematical settings are considered. Credit will only be given for one of Math 8 or Math 14. Prerequisites: Math 6; Math 2 or 4, both with a grade of "C"; or better; or by placement exam.
- 10 Introduction To Mathematical Ideas** (LEC 3.0) A course for non-science majors, including liberal arts and education majors. A study of the nature of mathematics and its relation to western culture, number systems, sets, functions, and selected topics from algebra, computer science and other areas of mathematics. Prerequisite: Two years high school mathematics.
- 12 Business Calculus** (LEC 3.0 and LAB 1.0) Calculus for Bus. & Mgt. Sys, Econ & Finance, or Info. Sci. & Tech; also possibly Bio. Sci, Soc. Sci. or Humanities. Derivatives, optimization, exponential and logarithmic functions, integration, multivariate functions, partial derivatives, Lagrange multipliers, applications. May not be used as a prerequisite for either Math 15 or Math 21. Prerequisite: Math 4 with a grade of "C" or better; or by placement exam.
- 14 Calculus For Engineers I** (LEC 3.0 and LAB 1.0) Introduction to limits, continuity, differentiation and integration of algebraic and elementary transcendental functions. Applications in physical science and engineering. Credit will be given for only one of Math 8 or Math 14. Prerequisites: Math 6; Math 2 or 4, both with a grade of "C"; or better; or by placement exam. Math 14 may be accompanied by Math 6 with advisor's approval.
- 15 Calculus For Engineers II** (LEC 3.0 and LAB 1.0) Continuation of Math 014. Transcendental functions, techniques of integration, sequences, series including power series, polar coordinates, polar and parametric equations. Applications in physical science and engineering. Credit will be given for only one of Math 015 or Math 021. Prerequisites: Math 6 and either Math 8 or Math 14 both with a grade of "C" or better; or by placement exam.

- 21 Calculus With Analytic Geometry II** (LEC 5.0) A continuation of Math 8; differentiation and integration of elementary transcendental functions, integration techniques, improper integrals, conic sections, polar coordinates, introduction to sequences and series. Credit will only be given for one of Math 21 or Math 15. Prerequisites: Math 6 and either Math 8 or Math 14 both with a grade of "C" or better; or by placement exam.
- 22 Calculus With Analytic Geometry III** (LEC 4.0) An introduction to multivariable calculus. Vector valued functions, curves and surfaces in two and three dimensions, partial differentiation, multiple integration, line and surface integrals, the major theorems of vector calculus, and applications of these ideas are studied. Prerequisite: Math 15 or Math 21 with a grade of "C" or better.
- 100 Special Problems** (IND 0.0-6.0) Problems or readings in specific subjects or projects in the department. Consent of instructor required.
- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 200 Special Problems** (IND 0.0-6.0) Problems or readings in specific subjects or projects in the department. Consent of instructor required.
- 201 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 202 Cooperative Work Training** (IND 0.0-6.0) On-the-job experience gained through cooperative education with industry. Variable credit arranged with the advisor. P/F grading option is required and maximum credit per semester is 3 hrs., maximum for entire program is 6 hrs.
- 203 Matrix Algebra** (LEC 3.0) Matrix algebra is introduced by means of systems of linear algebraic equations. Gaussian elimination, least squares solutions, orthogonalization, determinants, eigenvalues and an introduction to vector spaces are discussed. Credit will not be given for both Math 203 and 208. Prerequisite: Math 22 with a grade of "C" or better.
- 204 Elementary Differential Equations** (LEC 3.0) First order differential equations and linear differential equations of higher order are studied. The Laplace transform and systems of linear equations as well as selected physical applications are covered. Credit will not be given for both Math 229 and Math 204. Prerequisite: Math 22 with a grade of "C" or better.
- 208 Linear Algebra I** (LEC 3.0) Systems of linear equations, matrices, vector spaces, inner products, linear transformations, determinants, and eigenvalues are studied. Prerequisite: Math 15 or 21 or 22 with a grade of "C" or better.
- 209 Foundations Of Mathematics** (LEC 3.0) Introduction to mathematical reasoning through an axiomatic development of mathematical systems. Strong emphasis is placed on learning to understand what constitutes a sound mathematical argument. Communication, both written and spoken, is emphasized. Prerequisite: Math 15 or 21 with a grade of "C" or better.
- 210 Undergraduate Seminar** (SEM 1.0-3.0) Discussion of advanced or current topics. (Course cannot be used for graduate credit).
- 221 Teaching Math In Elementary And Middle Schools** (LEC 3.0) The course presents an overview of how children learn mathematics, various techniques in teaching mathematics, and examples of applying these techniques to specific mathematical concepts (such as geometry, measurement, basic operations, statistics and probability, etc.). Prerequisite: Educ 40 or Math 2 or 4. (Co-listed with Educ 221)
- 222 Geometric Concepts For Elementary Teachers** (LEC 3.0) The course covers methods of teaching the study of points, lines, polygons, similarity, congruence, constructions, and proof in Euclidean Plane Geometry. Transformational geometry and trigonometry are introduced to elementary teachers. Prerequisite: Educ 40 or Math 2 or 4. (Co-listed with Educ 222)
- 229 Elementary Differential Equations And Matrix Algebra** (LEC 3.0) This course is a combination of selected topics from Math 203 and 204. Solutions of linear differential equations and systems of linear algebraic equations are emphasized. Credit will not be given for both 204 and 229. Prerequisite: Math 22 with a grade of "C" or better.
- 240 Mathematical Software Applications In The Classroom** (LEC 3.0) Students will be introduced to a variety of Mathematical Software applications, both PC and calculator based which will aid teachers in presenting concepts and in classroom management. Specific topics covered will be selected based on student interest. Prerequisites: Math 22 and admission to the MST program.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 302 Intermediate Differential Equations** (LEC 3.0) Linear differential equations, vector-matrix systems, existence and uniqueness theory, nonlinear systems, phase-plane analysis, introduction to stability theory. Prerequisite: Math 204 or Math 229.
- 303 Mathematical Modeling** (LEC 3.0) Model construction and the modeling process, model fitting, models requiring optimization, empirical model construction, modeling dynamic behavior. Individual and team projects. Prerequisites: Math 204 or 229 with a grade of "C" or better, Programming competency.
- 305 Modern Algebra I** (LEC 3.0) Equivalence relations and functions, basic properties of

groups, subgroups, permutations, cosets and Lagrange's Theorem, homomorphisms and isomorphisms, factor groups. Prerequisite: Math 209 or graduate standing; preceded or accompanied by Math 208.

306 Modern Algebra II (LEC 3.0) This course is a continuation of Math 305. Rings and fields are discussed. Euclidean domains, principal ideal domains, unique factorization domains, vector spaces, finite fields and field extensions are studied. Prerequisite: Math 305.

307 Combinatorics And Graph Theory (LEC 3.0) Covers some basics of enumeration and graph theory. Topics are selected from the following: permutations combinations, the inclusion/exclusion principle, generating functions, recurrence relations, trees, networks, graph connectivity and graph coloring. Prerequisite: Cmp Sc 128 or Math 209.

308 Linear Algebra II (LEC 3.0) Eigenvalue problems, Cayley-Hamilton theorem, Jordan normal form, linear functionals, bilinear forms, quadratic forms, orthogonal and unitary transformations, selected applications of linear algebra. Prerequisite: Math 208.

309 Advanced Calculus I (LEC 3.0) Completeness of the set of real numbers, sequences and series of real numbers, limits, continuity and differentiability, uniform convergence, Taylor series, Heine-Borel theorem, Riemann integral, fundamental theorem of calculus, Cauchy-Riemann integral. Prerequisite: Math 22 and Math 209, or a 300-level mathematics course, or graduate standing.

310 Undergraduate Seminar (SEM 1.0-3.0) Discussion of advanced or current topics. (Course cannot be used for graduate credit).

311 Advanced Calculus II (LEC 3.0) Euclidean n -space, differentiation and integration of scalar functions of several variables, maxima and minima theory, change of variables, differentiation and integration of vector functions of several variables, Divergence theorem, Stokes' theorem. Prerequisite: Math 309.

315 Introduction To Real Analysis (LEC 3.0) Riemann-Stieltjes integration, sequences and series of functions, uniform approximation, the Banach Space $C(a,b)$, Lebesgue measure and integration, the space $LP(a,b)$, Fourier series. Prerequisite: Math 309.

322 Vector And Tensor Analysis (LEC 3.0) Vector algebra, vector differential and integral calculus, line and surface integrals, theorems of Stokes and Gauss, tensor algebra and tensor analysis, applications to problems in kinematics, elasticity theory, fluid mechanics, electromagnetic theory, relativity theory. Prerequisite: Math 22; Math 203 or Math 208.

325 Partial Differential Equations (LEC 3.0) Linear equations, heat equation, eigenfunction expansions, Green's formula, inhomogeneous problems, Fourier series, wave equation.

Prerequisite: Math 204 with a grade of "C" or better.

330 Topics In Geometry (LEC 3.0) A survey of non-Euclidean geometries, finite geometries, affine and projective planes, metric postulates for the Euclidean plane, and selected topics. Prerequisite: Math 208.

337 Financial Mathematics (LEC 3.0) The course objective is to provide an understanding of the fundamental concepts of financial mathematics. Topics include pricing, assets-liability management, capital budgeting, valuing cash flow, bonds, futures, swaps, options. Preparation for the financial mathematics actuarial exam will be provided. Prerequisites: Math 15 or Math 21, Econ 221 or Econ 222 or Econ 250 or Econ 321, Stat 211 or Stat 213 or Stat 215 or Stat 217 or Stat 343. (Co-listed with Econ 337)

340 Mathematical Analysis For Secondary Teachers (LEC 3.0) Designed to help teachers gain a deeper understanding of the fundamental idea in analysis, that of a limit. A discovery method is used which includes both individual and group work. Students will present their results in written and oral format. Prerequisite: Math 22 or equivalent.

341 Mathematical Analysis For Secondary Teachers Practicum (LEC 1.0) An instructional unit based on the discovery method used in Math 340 will be designed by each student. These units will be class tested. The unit and results of class testing will be presented both in written and oral format. Prerequisite: Math 340.

351 Introduction To Complex Variables (LEC 3.0) The basic tools of complex variables are studied. These include the Cauchy-Riemann equations, complex contour integration, the Cauchy-Goursat theorem, conformal mappings, the calculus of residues and applications to boundary value problems. Prerequisite: Math 204.

354 Mathematical Logic I (LEC 3.0) A mathematical introduction to logic with some applications. Functional and relational languages, satisfaction, soundness and completeness theorems, compactness theorems. Examples from Mathematics, Philosophy, Computer Science, and/or Computer Engineering. Prerequisite: Philos 15 with junior standing or Math 305 or Comp Sci 253 or Comp Eng 111. (Co-listed with Comp Eng 354, Comp Sci 354 and Philos 354)

361 Problem Solving In Pure Mathematics (LEC 1.0) Problems from pure mathematics, including analysis, algebra, number theory, set theory, finite mathematics, probability and statistics. Emphasis on identifying or inventing ways to solve problems based on the student's entire mathematics background. Prerequisites: Corequisite Math 309 and Senior standing.

371 Problem Solving In Applied Mathematics (LEC 1.0) Problems from applied mathematics which are open-ended, and do not always have a unique correct solution. Emphasis on developing

mathematical models and writing solution narratives, including clarity, analysis, and design. Prerequisites: Math 209 and Senior standing.

381 Great Theorems In Mathematics (LEC 1.0) A study of some of the great theorems which have shaped the development of mathematics and human civilization. History, the changing nature of mathematics, and the mathematical content of the theorems themselves, will all be addressed. Sources as close to the originals as possible will be used. Prerequisites: Math 209 and Senior standing.

383 Operational Calculus (LEC 3.0) The Laplace transformation, properties of the transformation, various applications to ordinary and partial differential equations, systems with step and Dirac functions as driving forces, various non-elementary functions and their transforms, problems in heat conduction and wave motion, Fourier transforms and their operational properties. Prerequisite: Math 204.

385 Introduction To Topology (LEC 3.0) Metric spaces; general topological spaces; connectedness, compactness, separation properties, functions and continuity. Prerequisite: Math 309.

390 Undergraduate Research (IND 0.0-6.0) This course is designed for the undergraduate student who wishes to engage in research. It is not to be used for graduate credit nor for more than six credit hours of undergraduate credit. The subject and credit are to be arranged with the instructor. Prerequisite: Consent of instructor.

operations, design and supervise fabrication and testing of individual machines and complete plants, or be involved in applied or basic research.

In your first few semesters as a mechanical engineering student, you will develop a sound background in the fundamental sciences of mathematics, physics, and chemistry, and you will take a broad selection of liberal arts courses. You will also learn to work with computers. Onto this foundation you will add the basic required courses of engineering sciences and technology including stress analysis, machine design, machine dynamics, electricity, electronics, control theory, thermodynamics, heat transfer, energy conversion, fluid mechanics, computer-aided engineering (CAE), and computer-aided design (CAD).

To provide some degree of specialization for those students who are interested in a particular area of mechanical engineering, there are six hours of technical electives that you can select to concentrate in an emphasis area (such as robotics, manufacturing automation, fluid mechanics, heat transfer, dynamics and controls, solid mechanics, vibrations, and design). If you are interested in getting some background in a closely allied field such as aerospace, petroleum, or nuclear engineering, you can, with the aid of your advisor, select some of your desired technical electives in those fields.

The Mechanical and Aerospace Engineering department also has a departmental honors program. This program provides extra educational opportunities for you if you qualify. Upon satisfactory completion of the program the designation of "Honors Scholar in Engineering" will appear on your diploma and transcript.

Mission Statement

To build and enhance the excellent public program that the Department of Mechanical and Aerospace Engineering currently is, and to be recognized as such; to provide our students with experiences in solving open-ended problems of industrial and societal need through learned skills in integrating engineering sciences, and synthesizing and developing useful products and processes; to provide experiences in leadership, teamwork, communications-oral, written and graphic, and hands-on activities, with the help of structured and unstructured real-life projects.

Program Educational Objectives

The Mechanical Engineering program seeks to prepare its graduates for the following early career and professional accomplishments in their employment by industry, government agencies, academia, or private practice:

- Demonstrated engineering competence, successfully contributing within their career fields with increasing levels of responsibility and influence
- Continuous growth in knowledge and capability, within the Mechanical Engineering field as well as across interdisciplinary boundaries

Mechanical Engineering

Bachelor of Science

Master of Science

Doctor of Philosophy

Doctor of Engineering

Emphasis areas at all levels in control systems, energy conversion, environmental systems, instrumentation, manufacturing processes, materials science, mechanical design and analysis, and thermal science.

The Mechanical Engineering Program is offered in the Department of Mechanical and Aerospace Engineering.

Mechanical Engineering has broad applications and is one of the most basic of all branches of engineering.

As a mechanical engineer you will be concerned with the conversion and transfer of energy from one form to another; with the design, construction, and operation of all types of machines; and with the selection and design of instrumentation and systems for the control of all types of physical and environmental systems.

You may design products and manufacturing processes, supervise production methods and

It is the goal of the program that graduates will be personally satisfied with how their education from Missouri S&T prepared them for their career.

Program Outcomes

Students graduating from this program should have:

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibility
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- (i) a recognition of the need for, and an ability to engage in life-long learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
- (l) an ability to work professionally in both thermal and mechanical systems areas

Faculty

Professors:

Darryl Alofs, Ph.D., Michigan
Bassem Armaly (Curators'), Ph.D., California-Berkeley
Victor Birman, Ph.D., Technion (Israel)
Douglas Carroll, Ph.D., University of Missouri-Rolla
K. Chandrashekhara, Ph.D., Virginia
Alfred Crosbie (Curators'), Ph.D., Purdue
L.R. Dharani (Curators'), Ph.D., Clemson University
James Drallmeier, (Curators' Teaching), Ph.D., Illinois
Walter Eversman¹ (Curators'), Ph.D., Stanford
K. Krishnamurthy, Ph.D., Washington State
Ming Leu, Ph.D., California-Berkeley
Fue-Wen Liou, Ph.D., Minnesota
Ashok Midha (Department Chair), Ph.D., Minnesota
Anthony Okafor, Ph.D., Michigan Tech
John Sheffield Ph.D., North Carolina State
Hai-Lung Tsai, Ph.D., California-Berkeley

Associate Professors:

Xiaoping Du, Ph.D., Illinois
Kelly Homan, Ph.D., Illinois at Urbana-Champaign
Umit Koylu, Ph.D., University of Michigan
Robert Landers, Ph.D., University of Michigan
Gearoid Mac Sithigh, Ph.D., Minnesota
J. Keith Nisbett (Associate Chair), Ph.D., Texas-Arlington
Daniel Stutts, Ph.D., Purdue

Assistant Professors:

A. Banerjee, Ph.D., Texas A & M

Doug Bristow, Ph.D., Illinois at Urbana-Champaign
Shun Takai, Ph.D., Stanford University

Assistant Teaching Professor:

Ryan Hutcheson, Ph.D., Texas A&M University-College Station

Emeritus Professors:

Xavier Avula, Ph.D., Iowa
Clark Barker (Emeritus), Ph.D., Illinois
Charles Benjamin Basye¹, (Emeritus), Ph.D., Iowa State
Ta-Shen Chen (Curators'), (Emeritus), Ph.D., Minnesota
Donald Cronin (Emeritus), Ph.D., California Institute of Technology
Charles Edwards¹ (Emeritus), Ph.D., Arkansas
Virgil Flanigan¹, Ph.D., UMR
Ronald Howell¹ (Emeritus), Ph.D., Illinois
Leslie Koval¹ (Emeritus), Ph.D., Cornell
Shen Ching Lee¹ (Emeritus), Ph.D., Washington
Terry Lehnhoff¹ (Emeritus), Ph.D., Illinois
Dwight Look (Emeritus), Ph.D., Oklahoma
Robert Medrow (Emeritus), Ph.D., Illinois
Robert Oetting¹ (Emeritus), Ph.D., Maryland
Josef Podzimek (Emeritus), Ph.D., Charles University, Prague
Charles Remington¹ (Emeritus), M.S., UMR
¹ Registered Professional Engineer

Bachelor of Science Mechanical Engineering

Entering freshmen desiring to study Mechanical Engineering will be admitted to the Freshman Engineering Program. They will, however, be permitted, if they wish, to state a Mechanical Engineering preference, which will be used as a consideration for available freshman departmental scholarships. The focus of the Freshman Engineering program is on enhanced advising and career counseling, with the goal of providing to the student the information necessary to make an informed decision regarding the choice of a major.

For the Bachelor of Science degree in Mechanical Engineering a minimum of 128 credit hours is required. These requirements are in addition to credit received for algebra, trigonometry, and basic ROTC courses. An average of at least two grade points per credit hour must be attained. An average of at least two grade points per credit hour must also be attained in all courses taken in Mechanical Engineering.

Each student's program of study must contain a minimum of 21 credit hours of course work in general education and must be chosen according to the following rules:

1) All students are required to take one American history course, one economics course, one humanities course, and English 20. The history course is to be selected from History 112, History 175, History 176, or Political Science 90. The economics course may be either Economics 121 or 122. The humanities course must be selected from the approved lists for art, English, foreign languages, music, philosophy, speech and media studies, or theater.

2) Depth requirement. Three credit hours must be taken in humanities or social sciences at the 100 level

or above and must be selected from the approved list. This course must have as a prerequisite one of the humanities or social sciences courses already taken. Foreign language courses numbered 70 or 80 will be considered to satisfy this requirement. Students may receive humanities credit for foreign language courses in their native tongue only if the course is at the 300 level. All courses taken to satisfy the depth requirement must be taken after graduating from high school.

3) The remaining two courses are to be chosen from the list of approved humanities/social sciences courses and may include one communications course in addition to English 20.

4) Any specific departmental requirements in the general studies area must be satisfied.

5) Special topics and special problems and honors seminars are allowed only by petition to and approval by the student's department chairman.

The Mechanical Engineering program at Missouri S&T is characterized by its focus on the scientific basics of engineering and its innovative application; indeed, the underlying theme of this educational program is the application of the scientific basics to engineering practice through attention to problems and needs of the public. The necessary interrelations among the various topics, the engineering disciplines, and the other professions as they naturally come together in the solution of real world problems are emphasized as research, analysis, synthesis, and design are presented and discussed through classroom and laboratory instruction.

FREE ELECTIVES FOOTNOTE:

Free electives. Each student is required to take six hours of free electives in consultation with his/her academic advisor. Credits which do not count towards this requirement are deficiency courses (such as algebra and trigonometry), and extra credits in required courses. Any courses outside of Engineering and Science must be at least three credit hours.

FRESHMAN YEAR

First Semester	Credit
FE 10-Study and Careers in Engineering	.1
Chem 1-General Chemistry ^a	.4
Chem 2-General Chemistry Lab	.1
Math 14-Calculus I for Engineers ^{a, b}	.4
Engl 20-Exposition and Argumentation	.3
Hist-112, 175, 176, or Pol Sc 90	<u>.3</u>
	16
Second Semester	
IDE 20-Intro to Engineering Design	.3
Math 15-Calculus II for Engineers ^{a, b}	.4
Physics 23-Engineering Physics I ^a	.4
Econ-121 or 122	.3
Elective-Hum or Soc Sci ^f	<u>.3</u>
	17

SOPHOMORE YEAR

First Semester	Credit
Programming Elective ^{a, c}	.3
IDE 50-Eng Mech-Statics ^a	.3
Math 22-Calculus w/Analytic Geometry III ^a	.4

Physics 24-Eng Physics II ^a	.4
Mc Eng 153-Intro to Manufacturing Processes	<u>.3</u>
	17

Second Semester

Mc Eng 161-Intro to Design	.3
Mc Eng 219-Thermodynamics ^a	.3
Mc Eng 160-Dynamics ^a	.3
Math 204-Elementary Differential Equations ^a	.3
Mt Eng 121-Metallurgy for Engineers ^a	<u>.3</u>
	15

JUNIOR YEAR

First Semester	Credit
Mc Eng 213-Machine Dynamics	.3
Mc Eng 221-Applied Thermodynamics	.3
EI Eng 281-Electrical Circuits	.3
IDE 110-Mechanics of Materials ^a	.3
IDE 120-Material Lab	.1
Elective-Advanced Math/Stat or Cmp Sc ^e	<u>.3</u>
	16

Second Semester

Mc Eng 211-Modeling and Analysis of Dyn Sys ^a	.3
Mc Eng 208-Machine Design I	.3
Mc Eng 225-Heat Transfer	.3
Mc Eng 231-Thermofluid Mechanics I	.3
Mc Eng 240-Mechanical Instrumentation	.2
Elective-Communications ^d	<u>.3</u>
	17

SENIOR YEAR

First Semester	Credit
Mc Eng 242-Mech Engineering Systems	.2
Mc Eng 279-Automatic Control of Dynamic Systems	.3
Mc Eng technical elective ^g	.3
Free Elective ⁱ	.3
Literature elective ^f	.3
Elective-Advanced Hum or Soc Sci ^f	<u>.3</u>
	17

Second Semester

Eng Mg 124-Principles of Engineering Management	.1
Eng Mg 137-Economic Analysis of Engr Projects	.2
Mc Eng 261-Eng Design	.3
Mc Eng 280-Control Systems Lab	.1
Mc Eng 3xx technical elective ^g	.3
Free Elective ⁱ	<u>.3</u>
	13

NOTE: Students must satisfy the common engineering freshman year course requirements, and be admitted into the department, in addition to the sophomore, junior and senior year requirements listed above with a minimum of 128 hours

a) A grade of "C" or better is required in Chem 1, Math 14, 15, 22, 204, Phys 23, 24, programming elective, Met Eng 121, IDE 50, 110, Mc Eng 219, 160, and 211, both as prerequisite for follow-up courses in the curriculum and for graduation.

b) Math 8 and 21 may be substituted for Math 14 and 15, respectively.

c) The programming elective consists of a lecture and lab combination, and may be selected from Cmp Sc 73/77, 74/78, or 53/54. Note that Cmp Sc 53/54

requires one more credit hour than the other options.

- d) This course must be selected from the following: English 60, 160 or SP&M S 85, or the complete four course sequence in Advanced ROTC (Mil Sc 105, 106, 207 and 208 or Aerosp S 350,351,380 and 381.)
- e) This course must be selected from the following: Cmp Sc 228, Math 203, 208, Stat 213, 215 or any 300-level math or computer science course approved by the student's advisor.
- f) All electives must be approved by the student's advisor. Students must comply with the general education requirements with respect to selection and depth of study. These requirements are specified in the current catalog.
- g) Electives must be approved by the student's advisor. Six hours of technical electives, which may not include Ae Eng/EMech/Mc Eng 202, 300 or 390, must be in the Department of Mechanical and Aerospace Engineering. At least three of these technical elective hours in the Department must be at the 300 level. Honors students have special requirements for technical electives.
- h) All Mechanical Engineering students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade on this examination is not required to earn a B.S. degree, however, it is the first step toward becoming a registered professional engineer. This requirement is part of the Missouri S&T assessment process as described in Assessment Requirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.
- i) Each student is required to take six hours of free electives in consultation with his/her academic advisor. Credits which do not count towards this requirement are deficiency courses (such as algebra and trigonometry), and extra credits in required courses. Any courses outside of Engineering and Science must be at least three credit hours.

Energy Conversion Emphasis Area for Mechanical Engineering

Students desiring to obtain a Bachelor of Science degree in Mechanical Engineering with an Emphasis Area in Energy Conversion must satisfy all the requirements of the Bachelor of Science degree in Mechanical Engineering, with the additional stipulation that four courses must be taken as follows:

- a. Two courses from the following list: Mc Eng/Ae Eng 327, Mc Eng 333, Mc Eng 366, Mc Eng 371, Mc Eng 375, Ae Eng 369, Ae Eng 335.
- b. One course from the following list: Mc Eng/Ae Eng 319, Mc Eng/Ae Eng 325, Mc Eng/Ae Eng 331, Mc Eng/Ae Eng 339

- c. One additional course from either list "a" or list "b", or from the following list: Econ 345, El Eng 352, Env Eng 367, Nu Eng 317

Note: By using the free electives and technical electives to satisfy the above requirements, this emphasis area requires the same total number of credit hours as the BSME degree. A change of major form should be submitted to designate the Energy Conversion Emphasis Area

Manufacturing Processes Emphasis Area for Mechanical Engineering

Students desiring to obtain a Bachelor of Science in Mechanical Engineering with an Emphasis Area in Manufacturing Processes must satisfy all requirements of the Bachelor of Science in Mechanical Engineering with the following modifications:

- a. Mc Eng 253 is required.
- b. One of the Mc Eng technical electives must be from the following Manufacturing/Automation courses: Mc Eng 353, 355, 349, and 306.
- c. One of the Mc Eng technical electives must be from the following Design courses: Mc Eng 363, 308, 356, and 302.
- d. Two courses 1) Mc Eng 357 or Mc Eng 308, and 2) Mc Eng 358 are required in lieu of Mc Eng 261.
- e. The Math/Stat elective must be either Stat 213 or 215.

A suggested sequence for the Junior and Senior years is given below. Note that by using the free electives and technical electives to satisfy the above requirements, this emphasis area requires the same total number of credit hours as the BSME degree. A change of major form should be submitted to designate the Manufacturing Processes Emphasis Area.

JUNIOR YEAR

First Semester	Credit
Mc Eng 213-Machine Dynamics	3
El Eng 281-Electrical Circuits	3
Mc Eng 221-Applied Thermodynamics	3
IDE 110-Mechanics of Materials ^a	3
IDE 120-Materials Lab	1
Stat 213-Stat Meth in Eng or Stat 215-Eng Stat	3
	16

Second Semester	
Mc Eng 211-Modeling and Analysis of Dyn Sys ^a	3
Mc Eng 231-Thermofluid Mechanics	3
Mc Eng 225-Heat Transfer	3
Mc Eng 240-Mechanical Instrumentation	2
Mc Eng 253-Manufacturing	3
Elective-Communications ^d	3
	17

SENIOR YEAR

First Semester	Credit
Mc Eng 242-Mech Eng Systems	2
Mc Eng 279-Auto Control of Dynamic Systems	3
Mc Eng 208-Machine Design I	3

Mc Eng 357-Integrated Prod & Proc Design3
 or Mc Eng 308-Rapid Product Design
 Mc Eng Technical Elective^f3
 Elective Literature^e3
 17

Second Semester

Eng Mg 124-Principles of Engineering Management . . .1
 Eng Mg 137-Economic Analysis of Engr Projects2
 Mc Eng 358-Integrated Product Dev3
 Mc Eng 280-Control System Lab1
 Mc Eng Technical Elective^f3
 Electives-Hum or Soc Sci^e3
 13

NOTES:

- a) A grade of "C" or better is required in Chem 1, Math 14, 15, 22, 204, Physics 23, 24, programming elective, Met Eng 121, IDE 50, 110, Mc Eng 219, 160 and 211, both as prerequisite for follow-up courses in the curriculum and for graduation.
- b) Math 8 and 21 may be substituted for Math 14 and 15, respectively.
- c) The programming elective consists of a lecture and lab combination, and may be selected from Cmp Sc 73/77, 74/78, or 53/54. Note that Cmp Sc 53/54 requires one more credit hour than the other options.
- d) This course must be selected from the following: English 60, 160 or SP&M S 85, or the complete four course sequence in Advanced ROTC (Mil Sc 105, 106, 107 and 108 or Aerosp S 350, 351, 380 and 381.)
- e) To include at least one course in literature. All electives must be approved by the student's advisor. Students must comply with the general education requirements with respect to selection and depth of study. These requirements are specified in the current catalog.
- f) One of the technical electives must be from the following Manufacturing/Automation courses: Mc Eng 353, Mc Eng 355, Mc Eng 349, Mc Eng 306. One of the technical electives must be from the following Design courses: Mc Eng 363, Mc Eng 308, Mc Eng 356, Mc Eng 302.
- g) All Mechanical Engineering students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade on this examination is not required to earn a B.S. degree, however, it is the first step toward becoming a registered professional engineer. This requirement is part of the Missouri S&T assessment process as described in Assessment Requirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

Mechanical Design and Analysis Emphasis Area

Students desiring to obtain a Bachelor of Science in Mechanical Engineering with an Emphasis Area in Mechanical Design and Analysis must satisfy all

requirements of the Bachelor of Science in Mechanical Engineering, with the additional stipulation that four courses must be taken as follows:

- a. One design course from the following list: Mc Eng 209, 302, 304, 308, 315, 356, 357, 360, 363, IDE 220.
- b. One analysis course from the following list: Mc Eng 307, 311, 312, 313, 322, 338, 349, 378.
- c. Two additional courses from either of the previous lists.

Note that by using the free electives and technical electives to satisfy the above requirements, this emphasis area requires the same total number of credit hours as the BSME degree. A change of major form should be submitted to designate the Mechanical Design and Analysis Emphasis Area.

Mechanical Engineering Courses

- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 153 Introduction To Manufacturing Processes** (LEC 2.0 and LAB 1.0) Introduction into the fundamentals of manufacturing processes. Welding, joining, casting, forming, powder metallurgy and material removal are covered. The material is presented in a descriptive fashion with emphasis on the fundamental working of the processes, their capabilities, applications, advantages and limitations. Prerequisite: IDE 20.
- 160 Dynamics** (LEC 3.0) The principles of mechanics are used to model engineering systems. Kinematics of particle motion, kinematics of plane- and three-dimensional motions of rigid bodies. Kinetics of particles and of rigid bodies. Energy and momentum methods. Prerequisite: Grade of "C" or better in each of IDE 50, Math 22. (Co-listed with Aero Eng 160)
- 161 Introduction To Design** (LEC 2.0 and LAB 1.0) Introduces the process of design with emphasis on creativity and design visualization. Solid modeling is presented as a design tool. The solid modeling environment will also be used to reinforce the concepts of tolerancing, dimensioning, and multiview representation. Concurrent engineering will be introduced in a group design project. Prerequisites: IDE 20, Mech Eng 153, preceded or accompanied by IDE 50; a grade of "C" or better in each of Math 14 (or 8), Physics 23.
- 201 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 202 Cooperative Engineering Training** (IND 0.0-6.0) On-the-job experience gained through cooperative education with industry, with credit arranged through departmental cooperative advisor. Grade received depends on quality of reports submitted and work supervisor's evaluation.
- 208 Machine Design I** (LEC 3.0) Analysis of machine elements such as shafts, springs, screws, belts,

bearings, and gears; analytical methods for the study of fatigue; comprehensive treatment of failure, safety, and reliability. Introduction to finite element methods in mechanical design. Prerequisites: Mech Eng 153, accompanied or preceded by Mech Eng 161, and a grade of "C" or better in each of IDE 110, Met Eng 121.

209 Machine Design II (LEC 3.0) A continuation of the study of machine elements; bearings, spur, bevel, worm, and helical gearing, and indeterminate machine elements; impact and shrink stresses. Prerequisite: Mc Eng 208.

210 Seminar (LEC 1.0) Discussion of current topics.

211 Modeling and Analysis of Dynamic Systems (LEC 3.0) Concepts of modeling mechanical systems as linear systems are studied and applied to hydraulic, pneumatic, and electromechanical systems. Analysis techniques described include matrix formulations, Laplace transforms, and time domain response methods. Prerequisites: A grade of "C" or better in each of Comp Sci 53 or 73 or 74, Mech Eng 160 (or Aero Eng 160), Math 14 (or 8), 15 (or 21), 22, 204, Physics 23, 24.

213 Machine Dynamics (LEC 3.0) Motion analysis using vector methods is considered for machine elements including linkages, cams, and gears. Dynamic force analysis methods are applied to balancing, flywheels, and single and multicylinder engines. Prerequisites: A grade of "C" or better in each of Comp Sci 53 or 73 or 74, Mech Eng 160 (or Aero Eng 160), Math 14 (or 8), 15 (or 21), 22, and Physics 23.

219 Thermodynamics (LEC 3.0) Energy transformations and the relation of energy to the status of matter. Fundamental laws, concepts, and modes of analysis which underlie all applications of energy conversion in engineering. Prerequisites: A grade of "C" or better in each of Comp Sci 53 or 73 or 74, Math 14 (or 8), 15 (or 21), 22, and Physics 23.

221 Applied Thermodynamics (LEC 3.0) Extended study of the laws and concepts of thermodynamics with emphasis on applications to power and refrigeration cycles, gas mixtures, psychrometrics, behavior of real gases and combustion processes. Prerequisite: A grade of "C" or better in Mech Eng 219.

225 Heat Transfer (LEC 3.0) Fundamental principles of heat transmission by radiation, conduction and convection; application of these principles to the solution of engineering problems. Prerequisites: A grade of "C" or better each of Comp Sci 53 or 73 or 74, Math 204, Mech Eng 219.

227 Thermal Analysis (LEC 3.0) Basic principles of thermodynamics and heat transfer. First and second laws of thermodynamics and applications to engineering systems. Fundamentals of heat transfer by conduction, convection, and radiation with applications. Not for mechanical engineering majors. Prerequisites: Math 15 (or 21), Physics 23.

231 Thermofluid Mechanics I (LEC 3.0) Principles of viscous and inviscid flow in ducts, nozzles, diffusers, blade passages and application to design; dimensional analysis and laws of similarity; external flows; compressible flows. Prerequisite: A grade of "C" or better in Mc Eng 219.

235 Fluid Machinery (LEC 3.0) Fundamental investigation of positive displacement and turbomachinery including pumps, fans, compressors, turbines, and oil hydraulic systems. Operating characteristics, selection, and comparison of types are studied. Prerequisite: Mc Eng 231 or Ae Eng 231.

240 Mechanical Instrumentation (LAB 2.0) A basic course in the theory and application of instrumentation to typical measurement problems in mechanical and aerospace engineering. Experiments employing basic devices to measure quantities such as strain, pressure, force, temperature, motion, flow, sound level are performed. Accepted procedures for recording, interpretation, and presentation of experimental results are illustrated. Prerequisites: A grade of "C" or better each of Math 204, Mech Eng 219, Physics 24.

242 Mechanical Engineering Systems (LAB 2.0) A laboratory course focusing on experimental design and evaluation of complete mechanical engineering systems. Analysis of both mechanical and thermodynamic systems is included. Emphasis is on evaluating system performance and improving student written and oral communication skills. Prerequisites: Mech Eng 240, 221, 231, 225, 213.

253 Manufacturing (LEC 3.0) Advanced analytical study of metal forming and machining processes such as forging, rolling, extrusion, wire drawing and deep drawing; mechanics of metal cutting - orthogonal, turning, milling, cutting temperature, cutting tool materials, tool wear and tool life, and abrasive processes. Prerequisites: Mech Eng 153, and a grade of "C" or better in IDE 110.

256 Materials Handling And Plant Layout (LEC 2.0 and LAB 1.0) The design and objectives of materials handling equipment including diversity of application in industry from the viewpoint of efficient movement of materials and products from the receiving areas to the shipping areas. The layout of a plant to include materials handling equipment is considered throughout. Cost comparison of various systems will be made. (Co-listed with Eng Mg 257)

261 Engineering Design (LEC 1.0 and LAB 2.0) Real-life design projects emphasize problem definition, conceptualization, modeling, approximation techniques and optimization. Teamwork, communication, leadership and group discussions are encouraged. Student group and professional expert presentations bring awareness to diverse design issues and methodology, and professional engineering

- practice. Prerequisites: Preceded or accompanied each of Mech Eng 208, 225, 231, 279.
- 279 Automatic Control Of Dynamic Systems** (LEC 3.0) Use of classical control methods to analyze mechanical systems. Topics include root locus, Bode plots, and Nyquist diagrams. Applications to design situations are examined. Prerequisite: A grade of "C" or better in Mech Eng 211.
- 280 Control System Laboratory** (LAB 1.0) Experiments dealing with data acquisition, manipulation, and control of systems with particular emphasis on computer data acquisition and control applied to mechanical engineering systems. Microcomputer systems are used as measurement and control devices. Prerequisites: Preceded or accompanied by Mech Eng 279.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 302 Synthesis Of Mechanisms** (LEC 3.0) Synthesis of planar mechanisms for function generation, path generation, and motion generation. Emphasis is on analytical methods for synthesis. Prerequisite: Mc Eng 213.
- 304 Compliant Mechanism Design** (LEC 3.0) Introduction to compliant mechanisms; review of rigid-body mechanism analysis and synthesis methods; synthesis of planar mechanisms with force/energy constraints using graphical and analytical methods; pseudo-rigid-body models; force-deflection relationships; compliant mechanism synthesis methods; and special topics, e.g. bistable mechanisms, constant-force mechanisms, parallel mechanisms, and chain algorithm in design. Emphasis will be on applying the assimilated knowledge through a project on compliant mechanisms design. Prerequisites: Mech Eng 213, IDE 110.
- 305 Lubrication** (LEC 3.0) Development of basic principles of bearing analysis including manufacture and properties of lubricants, hydrodynamics and hydrostatic lubrication, journal and thrust bearings, ball and roller bearings, boundary considerations, and bearing materials. Prerequisite: Mc Eng 231.
- 306 Material Processing By High-Pressure Water Jet** (LEC 3.0) Methods of generating high pressure water jets; standard equipment, existing techniques, and basic calculations. Application of water jets to materials cutting and mineral processing. Safety rules. The course will be supported by laboratory demonstrations. Prerequisite: Mc Eng 231 or undergraduate fluids course. (Co-listed with Mi Eng 306)
- 307 Vibrations I** (LEC 3.0) Equations of motion, free and forced vibration of single degree of freedom systems and multidegree of freedom systems. Natural frequencies, resonance, modes of vibration and energy dissipation are studied. The vibration of continuous systems is introduced. Prerequisites: Mc Eng 211 and 213, or Ae Eng 213 and Math 204. (Co-listed with Aero Eng 307)
- 308 Rapid Product Design And Optimization** (LEC 3.0) Product Life cycle design; Finding design solutions using optimization technique; Rapid product realization using rapid prototyping and virtual prototyping techniques. Prerequisite: Mc Eng 208.
- 309 Engineering Acoustics I** (LEC 3.0) Introduction to acoustical theory and measurement with emphasis on mechanical and aerospace engineering applications. Plane and spherical wave propagation, resonators and filters, absorption, room acoustics, human response to noise, noise legislation, noise control. Use of common instrumentation in several projects. Prerequisites: Mc Eng 211 and 213, or Ae Eng 213 and Math 204. (Co-listed with Ae Eng 309)
- 311 Introduction To Continuum Mechanics** (LEC 3.0) Introductory cartesian tensor analysis to aid in the development of the theory of a continuum. Kinematics of deformation, stress tensor, equations of motion, equations of mass and energy balance. Examples from specific material theories in solid and fluid mechanics. Prerequisites: IDE 110, Math 204.
- 312 Introduction to Finite Element Analysis** (LEC 3.0) Variational formulation of the governing equations. Finite element model, interpolation functions, numerical integration, assembly of elements and solution procedures. Applications to solid mechanics, fluid mechanics and heat transfer problems. Two-dimensional problems. Computer implementation and use of commercial finite element codes. Prerequisite: Mech Eng 208 or Aero Eng 253 or consent of instructor for majors that do not require either of these courses. (Co-listed with Aero Eng 352)
- 313 Intermediate Dynamics Of Mechanical And Aerospace Systems** (LEC 3.0) Principles of dynamics are applied to problems in the design of mechanical and aerospace systems; basic concepts in kinematics and dynamics; dynamics of systems of particles; dynamics of rigid bodies, three-dimensional effects in machine elements; dynamic stability, theory and applications; methods of analytical dynamics. Prerequisite: Mc Eng 213 or Ae Eng 213. (Co-listed with Ae Eng 313)
- 314 Applications Of Numerical Methods To Mechanics Problems** (LEC 3.0) Numerical solutions of statics, vibrations, and stability problems. Direct stiffness formulations are developed and user-oriented computer codes are used to solve practical structures problems. Computer graphics techniques are utilized to prepare data and display results. Prerequisites: IDE 110; Mech Eng 160 or Aero Eng 160.
- 315 Concurrent Engineering I** (LEC 3.0) Students will be introduced to the concurrent engineering approach to product development. They will learn

to set up quantitative requirements and then use a quantitative rating process to identify the critical requirements relating to the desired product. The interaction between design, manufacturing, assembly, cost, and supportability will be covered. The students will form teams and practice the concurrent engineering process for simple products. Prerequisites: Mech Eng 213 or Aero Eng 231, and IDE 110. (Co-listed with Aero Eng 315)

- 316 Concurrent Engineering II** (LAB 3.0) Students will form groups and then using the electronic data based approach apply the concurrent engineering process to develop products. Areas to be covered are the customer, design, manufacturing, assembly, cost and supportability. Prerequisite: Ae Eng 315 or Mc Eng 315. (Co-listed with Ae Eng 316)
- 319 Advanced Thermodynamics** (LEC 3.0) After a short review of classical thermodynamics, the elements of chemical reactions, chemical equilibrium, statistical thermodynamics, and the basic concepts of kinetic theory are presented. Prerequisite: Mech Eng 219. (Co-listed with Ae Eng 319)
- 320 Advanced Mechanics of Materials** (LEC 3.0) Comprehensive insight into mechanics of materials. Topics to include: theories of failure, torsion of noncircular sections, shear flow and shear center, unsymmetric bending, bending of curved members, beams on elastic foundation and pressurization of thick walled cylinders. Prerequisites: IDE 110, Math 204. (Co-listed with Aero Eng 320)
- 322 Introduction To Solid Mechanics** (LEC 3.0) Review of basic concepts in continuum mechanics. Finite elasticity: some universal solutions for isotropic materials, application of special mechanical models. Linear elasticity: compatibility, stress functions, superposition, special examples such as extension, torsion, bending, and plane problems. Elements of plasticity. Prerequisite: E Mech 311. (Co-listed with Ae Eng 322)
- 323 Transport Phenomena In Manufacturing Processes** (LEC 3.0) A study of the important role that transport phenomena (heat and mass transfer and fluid flow) play during various manufacturing processes including metal casting, joining and welding extrusion, forging, crystal growth, chemical deposition, and thermal spray deposition. Prerequisites: Mc Eng 225 and 231.
- 325 Intermediate Heat Transfer** (LEC 3.0) Analytical study of conduction; theory of thermal radiation and applications; energy and momentum equations in convective heat transfer and review of empirical relations. Current topics are included. Prerequisite: Mc Eng 225. (Co-listed with Ae Eng 325)
- 327 Combustion Processes** (LEC 3.0) Application of chemical, thermodynamic, and gas dynamic principles to the combustion of solid, liquid, and

gaseous fuels. Includes stoichiometry, thermochemistry, reaction mechanism, reaction velocity, temperature levels, and combustion waves. Prerequisite: Mc Eng 221. (Co-listed with Ae Eng 327)

- 329 Smart Materials And Sensors** (LEC 2.0 and LAB 1.0) Smart structures with fiber reinforced polymer (FRP) composites and advanced sensors. Multi-disciplinary topics include characterization, performance, and fabrication of composite structures; fiber optic, resistance, and piezoelectric systems for strain sensing; and applications of smart composite structures. Laboratory and team activities involve manufacturing, measurement systems, instrumented structures, and performance tests on a large-scale smart composite bridge. Prerequisites: Senior standing and Math 204. (Co-listed with Aero Eng 329, Elec Eng 329 and Civ Eng 318)
- 330 Applied Computational Methods** (LEC 3.0) Detailed study of computational methods for efficient solution of selected fluids, structures, thermodynamics, and controls problems in aerospace and mechanical engineering. Besides basic numerical techniques, topics covered include gradient-based optimization and uncertainty quantification. Prerequisite: Comp Sci 53 or 73 or 78; Math 204. (Co-listed with Aero Eng 330)
- 331 Intermediate Thermofluid Mechanics** (LEC 3.0) Derivation of Navier-Stokes equations, analytical solutions of viscous flows; flow in pipes, flow networks; intermediate treatment of boundary layer theory; micro-fluidics and MEMS; introduction to numerical methods for solving fluid flows; and, preliminary treatise on turbulence. Prerequisite: Mc Eng 231 or Ae Eng 231. (Co-listed with Ae Eng 331)
- 333 Internal Combustion Engines** (LEC 3.0) A course dealing primarily with spark ignition and compression ignition engines. Topics include: thermodynamics, air and fuel metering, emissions and their control, performance, fuels, and matching engine and load. Significant lecture material drawn from current publications. Prerequisite: Mc Eng 221.
- 334 Stability Of Engineering Structures** (LEC 3.0) Solution of stability problems with applications to columns, plates and shell structures. Torsional and lateral buckling of columns. Buckling under high temperatures. Effect of imperfections introduced by a technological process on stability. Design issues related to stability requirements. Prerequisites: IDE 110; Math 204; and IDE 150 or Mech Eng 160 or Aero Eng 160. (Co-listed with Aero Eng 334)
- 335 Applied Energy Conversion** (LEC 3.0) The study of the principles of energy conversion. Specific applications include fuel cells and other direct energy conversion devices used in plug-in

hybrid electric vehicles. Prerequisite: Mech Eng 221.

- 336 Fracture Mechanics** (LEC 3.0) Linear elastic and plastic mathematical models for stresses around cracks; concepts of stress intensity; strain energy release rates; correlation of models with experiment; determination of plane stress and plane strain parameters; application to design. Prerequisite: IDE 110. (Co-listed with Aero Eng 336)
- 338 Fatigue Analysis** (LEC 3.0) The mechanism of fatigue, fatigue strength of metals, fracture mechanics, influence of stress conditions on fatigue strength, stress concentrations, surface treatment effects, corrosion fatigue and fretting corrosion, fatigue of joints, components and structures, design to prevent fatigue. Prerequisite: IDE 110. (Co-listed with Aero Eng 344)
- 339 Computational Fluid Dynamics** (LEC 3.0) Introduction to the numerical solution of the Navier-Stokes equations, by finite difference methods, in both stream function-vorticity and primitive variable formulations. Course format emphasizes student development of complete computer programs utilizing a variety of solution methods. Prerequisites: Comp Sci 53 or 73 or 74; one course in fluid mechanics. (Co-listed with Ae Eng 339)
- 342 Experimental Stress Analysis II** (LEC 2.0 and LAB 1.0) Acquaints the student with some techniques of experimental stress analysis. Topics include principal stresses, strain to stress conversion, transmission and reflection photoelastic methods, Moire fringe methods, and analogies. Prerequisites: IDE 110, Eng Mech 321. (Co-listed with Eng Mech 342, Aero Eng 342)
- 344 Interdisciplinary Problems In Manufacturing Automation** (LEC 2.0 and LAB 1.0) The course will cover material necessary to design a product and the fixtures required to manufacture the product. Participants will gain experience with CAD/CAM software while carrying out an actual manufacturing design project. (Co-listed with Ch Eng 384, Eng Mg 344)
- 349 Robotic Manipulators And Mechanisms** (LEC 2.0 and LAB 1.0) Overview of industrial applications, manipulator systems and geometry. Manipulator kinematics; hand location, velocity and acceleration. Basic formulation of manipulator dynamics and control. Introduction to machine vision. Projects include robot programming, vision-aided inspection and guidance, and system integration. Prerequisites: Cmp Sc 73, Mc Eng 213. (Co-listed with Ae Eng 349)
- 353 Computer Numerical Control Of Manufacturing Processes** (LEC 2.0 and LAB 1.0) Fundamental theory and application of computer numerical controlled machine tools from the viewpoint of design principles, machine structural elements, control systems, and programming. Projects include manual and computer assisted part programming and machining. Prerequisite: Mc Eng 253.
- 354 Variational Formulations Of Mechanics Problems** (LEC 3.0) Introduction and study of variational problems in classical dynamics and solid mechanics emphasizing the concepts of virtual work, minimum potential energy, and complementary energy. Variational inequalities. Prerequisites: IDE 110; Math 204; and IDE 150 or Mech Eng 160 or Aero Eng 160. (Co-listed with Eng Mech 354)
- 355 Manufacturing Equipment Automation** (LEC 2.0 and LAB 1.0) Manufacturing automation at the equipment level. Topics include sensors, actuators, and computer interfacing for manufacturing equipment, dynamic modeling and control of manufacturing equipment, interpolation, coordinated motion control, kinematic and geometric error modeling, and runout. Prerequisite: Mech Eng 279.
- 356 Design For Manufacture** (LEC 3.0) Course covers the approach of concurrent product and process design. Topics includes: principle of DFM, New product design process, process capabilities and limitations, Taguchi method, tolerancing and system design, design for assembly and AI techniques for DFM. Prerequisites: Mc Eng 208, Mc Eng 253.
- 357 Integrated Product And Process Design** (LEC 3.0) Emphasize design policies of concurrent engineering and teamwork, and documenting of design process knowledge. Integration of various product realization activities covering important aspects of a product life cycle such as "customer" needs analysis, concept generation, concept selection, product modeling, process development, DFX strategies, and end-of-product life options. Prerequisite: Eng Mgt 253 or Mech Eng 253. (Co-listed with Eng Mgt 354)
- 358 Integrated Product Development** (LEC 1.0 and LAB 2.0) Students in design teams will simulate the industrial concurrent engineering development process. Areas covered will be design, manufacturing, assembly, process quality, cost, supply chain management, and product support. Students will produce a final engineering product at the end of the project. Prerequisite: Eng Mgt 354 or Mech Eng 357 or Mech Eng 253 or Mech Eng 308. (Co-listed with Eng Mgt 358)
- 360 Probabilistic Engineering Design** (LEC 3.0) The course deals with uncertainties in engineering analysis and design at three levels - uncertainty modeling, uncertainty analysis, and design under uncertainty. It covers physics-based reliability analysis and reliability-based design, robustness assessment and robust design, their integration with design simulations, and their engineering applications. Prerequisite: Mech Eng 208 or Aero Eng 261. (Co-listed with Aero Eng 360)
- 361 Engineering Design Methodology** (LEC 3.0) This course examines structured engineering

design theory and methodologies for conceptual design and redesign of products. Topical coverage includes customer needs gathering, functional modeling, engineering specifications creation (OFD), concept generation, selection and design embodiment. Team work/hands-on projects emphasized. Prerequisite: At least Senior standing in engineering. (Co-listed with IDE 220)

363 Principles And Practice Of Computer Aided Design (LEC 2.0 and LAB 1.0) Fundamentals of computer-aided design including geometric modeling, CAD data exchange, graphics concepts, and finite element analysis. Projects include basic graphics, matrix algebra, automated drafting, freeform curve and surface modeling, solid modeling, assembly modeling, and finite element modeling, using educational and commercial software packages including Unigraphics and Matlab. Prerequisites: Cmp Sc 73, 77, Mc Eng 211, 208.

364 Introduction to Decision Analysis (LEC 3.0) This course is an introduction to decision analysis, a decision-making method under uncertainty. The course topics include probability theory, influence diagram, decision tree, subjective probability, sensitivity analysis, value of information, risk attitude, and utility models. Prerequisite: Stat 211 or Stat 213 or Stat 215 or Stat 217.

366 Solar Energy Technology (LEC 3.0) Introduction to the nature of solar radiation and associated thermal energy transfers. Methods of collecting and storing solar energy. Analysis and design of systems for utilizing solar energy, including heating and cooling. Prerequisite: Mech Eng 225, or consent of instructor for non-ME majors.

367 Heat Pump And Refrigeration Systems (LEC 3.0) The various methods used in the thermal design and analysis of both refrigeration and heat pumps systems are investigated. Various methods of producing heating and cooling are examined including vapor compression, absorption, air cycle, steam jet, and thermoelectric systems. Prerequisites: Mc Eng 221, 225.

371 Environmental Controls (LEC 3.0) Theory and applications of principles of heating, ventilating, and air conditioning equipment and systems; design problems. Physiological and psychological factors relating to environmental control. Prerequisites: Mech Eng 221 and accompanied or preceded by Mech Eng 225; or Mech Eng 227 and Civ Eng 230. (Co-listed with Arch Eng 371)

375 Mechanical Systems For Environmental Control (LEC 3.0) Analysis of refrigeration, heating, and air-distribution systems. Synthesis of environmental control systems. Prerequisites: Mech Eng 221 and 225; or Mech Eng 227 and Civ Eng 230.

378 Mechatronics (LEC 2.0 and LAB 1.0) This course will introduce students to the basics of mechatronics (i.e., the integration of mechanical,

electrical, computer, and control systems). Students will learn the fundamentals of sensors and actuators for mechanical systems, computer interfacing, microcontrollers, real-time software, and control. Prerequisite: Mech Eng 279 or equivalent. (Co-listed with Aero Eng 378, Elec Eng 378 and Comp Eng 378)

381 Mechanical And Aerospace Control Systems (LEC 3.0) Synthesis of mechanical and aerospace systems to perform specific control functions. Response and stability are studied. Singular value analysis for stability margins is introduced. Prerequisite: Mc Eng 279 or Ae Eng 361. (Co-listed with Ae Eng 381)

382 Introduction To Composite Materials & Structures (LEC 3.0) Introduction to fiber-reinforced composite materials and structures with emphasis on analysis and design. Composite micromechanics, lamination theory and failure criteria. Design procedures for structures made of composite materials. An overview of fabrication and experimental characterization. Prerequisite: IDE 110. (Co-listed with Aero Eng 311)

383 Industrial Applications Of Composite Materials Technology (LEC 3.0) Composite materials-industrial applications. Fibers and matrices. Fabrication and NDI. Lamination theory overview. Composite joints. Postbuckling. Fatigue and environmental effects. Testing and certification of composite structures. A majority of the presentations will be made by engineers in the industry. Prerequisite: IDE 110. (Co-listed with Eng Mech 303)

390 Undergraduate Research (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

390 Undergraduate Research (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

Metallurgical Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy

Metallurgical engineering is one of two B.S. degrees offered by the Materials Science & Engineering Department. Metallurgical engineering is a broad discipline that studies metals production and recycling, the manufacturing of components from metals and alloys, the processing and treatment of metals to achieve improved properties, and the design of metallic materials for specific applications. Missouri S&T has one of the largest and most comprehensive metallurgical engineering departments in the United States. It is the only such department in Missouri or in any of the surrounding states.

The field of metallurgical engineering starts with the production and recycling of metals such as aluminum, steel, copper, magnesium and titanium. Once these metals are made, metallurgical engineers design forming and processing techniques to transform these metals into useful shapes with the properties required for their application. For example, light-weight magnesium is cast to make cell phones, zinc-coated steel is stamped to make corrosion resistant auto bodies, aluminum is formed to make the strong but lightweight wings of jet aircraft, tungsten powder is consolidated and drawn into filaments for incandescent light bulbs, and steel I-beams are hot-rolled for the construction of skyscrapers. Metallurgical engineers control the properties of metallic materials by altering the microscopic structure with alloying additions and special treatments. This approach leads to products such as corrosion-resistant stainless steels, ultra-lightweight alloys for aircraft, wear-resistant alloys for engines, and shape-memory alloys for space structures. In addition, investigating material failures and monitoring service life are tasks that are performed by metallurgists.

Although all metallurgical engineering students take the same basic required courses in metallurgical engineering, students can select several technical electives to emphasize their particular area of interest. Students are also encouraged to undertake summer and cooperative training employment to supplement both their academic studies and incomes. The department has also introduced a materials minor program for students from other engineering disciplines with an interest in materials.

The department is housed in McNutt Hall and has outstanding facilities for both classroom and laboratory learning. There are several optical and electron microscopes, a well equipped metals casting and joining laboratory, and comprehensive metal testing facilities. The department continuously upgrades its facilities for classroom and laboratory learning. The department has also enhanced its computer applications laboratory with

the addition of new software and computers, and improved network access. Additional information is available at <http://mse.mst.edu/>.

Mission Statement

The mission of the department is to provide a quality, comprehensive undergraduate and graduate education in the traditional areas of metallurgical engineering. The major program goal is to produce a Bachelor of Science graduate with a sound fundamental knowledge and extensive hands-on technical, communication, and leadership skills, capable of contributing in any technical area associated with metallurgy. The department is also committed to a strong graduate program, which ensures significant research activity, an active and involved faculty, and a robust, healthy environment for education. The provision of service course work for students in other engineering disciplines is also an important goal, as is interaction with professional societies and industry to promote continuing education, research, and technical information transfer. The utilization of the departmental resources to assist the state agencies and industry of Missouri and the Mid-west is an integral part of the departmental mission.

The program educational objectives of the metallurgical engineering program:

- Our graduates will be leaders in the science, technology, and management of metallurgical engineering;
- Our graduates will serve their profession and society;
- Our graduates will continually enhance their professional skills and educational background;

The specific outcomes of the metallurgical engineering program are:

- Ability to apply mathematical, science and engineering principles to metallurgical systems;
- An ability to utilize experimental, statistical and computational methods to solve metallurgical problems;
- Ability to design a system, component, or process to meet desired needs;
- Ability to function on diverse teams;
- Ability to identify, formulate, and solve engineering problems;
- Understanding of professional and ethical responsibility;
- Ability to communicate effectively;
- The broad education necessary to understand the impact of engineering solutions in a global and societal context;
- Recognition of the need for, and an ability to engage in life-long learning;
- knowledge and understanding of contemporary issues;
- Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice;
- Integrated understanding of scientific and engineering principles of metals structure;
- Integrated understanding of scientific and engineering principles of metals properties;

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- Integrated understanding of scientific and engineering principles of metals processing;
- Integrated understanding of scientific and engineering principles of metals performance;
- Ability to apply and integrate knowledge of structure, properties, processing and performance to metals selection and process design;

Faculty

Professors:

Wayne Huebner, (Department Chair of Materials Science and Engineering), Ph.D., University of Missouri-Rolla

Ronald A. Kohser, Ph.D., Lehigh University

Rajiv S. Mishra, Ph.D., University of Sheffield

Matthew J. O'Keefe, Ph.D., University of Illinois at Urbana-Champaign

Kent D. Peaslee¹, Ph.D., University of Missouri-Rolla

David G. C. Robertson², (Emeritus), Ph.D., University of New South Wales

Mark E. Schlesinger¹, Ph.D., University of Arizona

David C. Van Aken¹, Ph.D., University of Illinois at Urbana-Champaign

Associate Professors:

Joseph W. Newkirk, Ph.D., University of Virginia

Von L. Richards, Ph.D., University of Michigan

Assistant Professor:

Lifeng Zhang, Ph.D., University of Science & Technology, Beijing

Associate Teaching Professor:

F. Scott Miller, Ph.D., University of Missouri-Rolla

¹ Registered Professional Engineer

² Chartered Engineer, United Kingdom

Bachelor of Science Metallurgical Engineering

Entering freshmen desiring to study Metallurgical Engineering will be admitted to the Freshman Engineering Program. They will be permitted to state a Metallurgical Engineering preference, which will be used as a consideration for available freshman departmental scholarships. The focus of the Freshman Engineering program is on enhanced advising and career counseling, with the goal of providing to the student the information necessary to make an informed decision regarding the choice of a major.

For the Bachelor of Science degree in Metallurgical Engineering a minimum of 128 credit hours is required. These requirements are in addition to credit received for algebra, trigonometry, and basic ROTC courses. A student must maintain at least two grade points per credit hour for all courses taken in the student's major department, and an average of at least two grade points per credit hour must be maintained in Metallurgical Engineering.

The Metallurgical Engineering curriculum contains a required number of hours in humanities and social sciences as specified by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. Each student's program of study must

contain a minimum of 16 credit hours of course work from the humanities and the social sciences areas and should be chosen according to the following rules:

1) All students are required to take one American history course and one economics course. The history course is to be selected from History 112, 175, History 176, or Political Science 90. The economics course may be either Economics 121 or 122.

2) Of the remaining hours, six credit hours must be taken in humanities or social sciences at the 100 level or above and must be selected from the approved lists. Each of these courses must have as a prerequisite one of the humanities or social sciences courses already taken. Foreign language courses numbered 70 to 80 can be considered to be one of these courses. (Students may receive humanities credit for foreign language courses in their native tongue only if the course is at the 300 level.)

3) Skill courses are not allowed to meet humanities and social sciences requirements except in foreign languages or on approved HSS list.

4) Special topics, special problems courses and honors seminars are allowed only by petition to and approval by the student's department chairman.

FRESHMAN YEAR

First Semester	Credit
FE 10-Study and Careers in Engineering	.1
Chem 1-General Chemistry	.4
Chem 2-General Chemistry Lab	.1
Math 14-Calculus for Engineers I	.4
Engl 20-Exposition and Argumentation	.3
Hum/Soc Sci Elective ¹	.3
	16

Second Semester	
Met 125-Chemistry of Materials ²	.3
Math 15-Calculus for Engineers II	.4
Physics 23-Engineering Physics I	.4
History Elective (Government) ¹	.3
IDE 20-Intro to Engr Design	.3
	17

SOPHOMORE YEAR

First Semester	Credit
Physics 24-Engineering Physics II	.4
Math 22-Calculus w/Analytic Geometry III	.4
Mt Eng 121-Metallurgy for Engineers	.3
IDE 50-Statics	.3
Econ-Principles of Micro or Macro ¹	.3
	17

Second Semester	
Cer Eng 259-Thermodynamics of Materials	.3
IDE 110-Mechanics of Materials	.3
Mt Eng 217-Metals Microstructure Development	.3
Mt Eng 218-Metals Structures and Properties Lab	.1
Mt Eng 221-Principles of Metals Processing	.3
Mt Eng 222-Metals Processing Lab	.1
Hum/Soc Sci Elective ¹	.3
	17

JUNIOR YEAR

First Semester	Credit
Mt Eng 204-Transport Phenomena in Metallurgy	.3
Math 204-Differential Equations or Statistics ³	.3

Mt Eng 215-Fundamentals of Materials Behavior	3
Mt Eng 216-Metals Characterization Lab	1
Mt Eng 307-Metal Casting	3
Communication Elective ¹	3
	16

Second Semester

Eng Mgt 124-Principles of Engineering Mgmt	1
Eng Mgt 137-Economic Analysis of Eng Projects	2
Mt Eng 202-Extractive Met Lab	1
Mt Eng 203-Intro to Extractive Metallurgy	3
Cer Eng 291-Characterization of Inorganic Solids	3
Out of Department Technical Elective ⁴	3
Core Elective I ⁵	3
	16

SENIOR YEAR

First Semester	Credit
Mt Eng 261-Materials Senior Design I	1
Statistics Course ³	3
Mt Eng 355-Process Metallurgy Applications	3
Core Elective II ⁵	3
Technical Elective ⁶	3
Free Elective ⁷	2
	15

Second Semester

Mt Eng 262-Materials Senior Design II	2
Hum/Soc Sci Electives ¹	3
Core Elective III ⁵	3
Technical Elective ⁶	3
Free Elective ⁷	3
	14

NOTES:

¹⁾ Eighteen hours of required H/SS electives of which three hours must be history (Hist 112, 175, 176, or Pol Sci 90), three hours of economics (Econ 121 or Econ 122) and three hours communications (Engl 60, Engl 160, or SpM 85)

²⁾ Chem 3 can be substituted for Met 125

³⁾ All metallurgical engineering students must either take Math 204 and one statistics course (Stat 213 or Stat 215) or an introductory statistics course (Stat 213 or Stat 215) plus an advanced statistics elective (EMgt 385, Stat 320, 346, or Stat 353)

⁴⁾ Cer 251 or 364 or 392, ChE 346, Chem 221 or 237 or 241, EE 151&152 or EE 281, Geo 113, Math 204 (if two stat courses taken³) or 303 or 325, ME 312 or 320 or 329 or 336 or 338 or 382, Mining 241, Physics 107 or 207

⁵⁾ Met Core Electives (9 hours) Core Elective I - Particulate Materials (Met 367) or Corrosion (Met 381) Core Elective II - Steelmaking (Met 358) or Steels and their treatment (Met 331) Core Elective III - Materials selection course (Met 329 or MSE 325)

⁶⁾ Technical Electives (Met Eng or Approved listing)

⁷⁾ Free Electives (5 hours)-algebra, trigonometry, basic ROTC, and courses considered remedial excluded

NOTE: All Metallurgical Engineering students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade on this examination is not required to earn a B.S. degree; however, it is the first step toward becoming a registered professional engineer. This requirement, together with the department's Senior Assessment, is part of the Missouri

S&T assessment process as described in Assessment Requirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

Materials Minor Curriculum

A Materials Minor is available to any Missouri S&T student. The minor requires a total of 15 hours of materials related course work and must include Mt Eng 121 or Mt Eng 377 and Mt Eng 221 or ME 153. An additional 3 hours must come from either Metallurgical or Ceramic Engineering courses. The remaining 6 hours may be from any combination of materials related courses approved by Materials Science and Engineering Department.

Approved Materials related courses:

Approved courses in Metallurgical, Ceramic, or Materials Science & Engineering

Additional hours may come from any 100, 200 or 300 level courses (other than Met 121, Met 221, Met 377, or ME 153).

Approved courses in Chemistry

Chem 381-Chemistry and Inherent Properties of Polymers

Approved courses in Aerospace Engineering

AE 311-Introduction to Composite Materials and Structures
 AE 329-Smart Materials and Sensors
 AE 336-Fracture Mechanics
 AE 344-Fatigue Analysis

Approved courses in Chemical Engineering

Ch Eng 349-Structure and Properties of Polymers
 Ch Eng 381-Corrosion and Its Prevention

Approved course in Electrical Engineering

EE 329-Smart Materials and Sensors

Approved courses in Mechanical Engineering

ME 329-Smart Materials and Sensors
 ME 336-Fracture Mechanics
 ME 338-Fatigue Analysis
 ME 382-Introduction to Composite Materials and Structures

Metallurgical Engineering Courses

- 1 Introduction To Metallurgical Engineering** (LEC 1.0) Introduction to the field of metallurgical engineering with specific reference to the emphasis areas of extractive, manufacturing and physical metallurgy. The course will include lectures, videos and field trips to local industry.
- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity
- 121 Metallurgy For Engineers** (LEC 3.0) Introduction to the structure and properties of metals and alloys and to processes used to modify the structure and properties of metallic materials,

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- including alloying, deformation and heat treating. Prerequisite: Preceded or accompanied by Chem 1, prior or concurrent.
- 125 Chemistry Of Materials** (LEC 3.0) Basic Inorganic Chemistry of Materials. Topics will include chemical properties, structure and bonding of solids, energy, enthalpy, entropy, thermochemistry, kinetics and rate processes. Application of chemistry principles to materials engineering through flowsheeting, reactor design, materials/metals processing and the environment. Prerequisite: Chem 1.
- 126 Computer Application In Metallurgical Engineering** (LEC 2.0 and LAB 1.0) Introduction to the use of microcomputers for simulation, data analysis including statistics, data acquisition from laboratory instruments, and automatic process control systems. The course will provide instruction in programming and software usage, and the laboratory will enable students to fully utilize the potential of microcomputer in later courses.
- 200 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 201 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 202 Extractive Metallurgy Laboratory** (LAB 1.0) A series of laboratory experiments designed to illustrate the principles of pyrometallurgy, hydrometallurgy, and electrometallurgy. Prerequisites: Preceded or accompanied by Mt Eng 203; preceded or accompanied by Chem 4 or an equivalent training program approved by S&T.
- 203 Introduction To Extractive Metallurgy** (LEC 3.0) Production and refining of metals by pyrometallurgy, hydrometallurgy, and electrometallurgy. Emphasis on heat and mass balance calculations for the unit processes of metals extraction. Introduction to the principles of combustion, heat utilization and recovery. Prerequisite: Mt Eng 281 or Cr Eng 259 or Ch Eng 143.
- 204 Transport Phenomena In Metallurgy** (LEC 3.0) The application of the principles of fluid flow and heat transfer to the solution of practical problems in metallurgical engineering. Prerequisite: IDE 50.
- 212 Cooperative Training** (IND 1.0-2.0) On-the-job experience gained through cooperative education in the field of metallurgical engineering with credit arranged through department cooperative advisor. A pass/fail grade will be given based on the quality of reports submitted and work supervisor's evaluation.
- 215 Fundamentals Of Materials Behavior** (LEC 3.0) An introduction to crystal defects and deformation; mechanical testing; creep; fracture mechanics and fatigue. Prerequisites: Met Eng 121 and IDE 110.
- 216 Mechanical Testing of Materials** (LAB 1.0) Deformation of materials and mechanical testing of materials; tensile testing, creep; impact testing; fracture mechanics and fatigue. Prerequisites: Met Eng 121, accompanied by Met Eng 215.
- 217 Metals Microstructural Development** (LEC 3.0) Fundamentals of microstructural developments as relating to solid solutions, solidification and transformations; phase diagrams; case studies. Prerequisite: Met Eng 121.
- 218 Microstructural Development Laboratory** (LAB 1.0) Investigation of the relationships between microstructures, and processing for various materials. Prerequisites: Met Eng 121, accompanied by Met Eng 217.
- 221 Principles Of Materials Processing** (LEC 3.0) An introduction to various methods of processing of metals and influences of processing on design. Includes: casting, welding, shaping, inspection and testing. Prerequisite: Mt Eng 121.
- 222 Metals Processing** (LAB 1.0) Laboratory study of the methods of processing of metals. Prerequisite: Accompanied or preceded by Mt Eng 221.
- 261 Materials Senior Design I** (LAB 1.0) Students working in groups will be assigned a capstone design project related to a specific materials technology. This course will focus on project plan and all aspects of product and process design. Prerequisite: Senior standing. (Co-listed with Cer Eng 261)
- 262 Materials Senior Design II** (LAB 2.0) A continuation of the Materials Senior Design I. Students working in groups will complete a capstone design project including process and product simulation and/or fabrication, safety aspects, environmental impact and capital and operating economics. Prerequisite: Cer Eng 261 or Met Eng 261. (Co-listed with Cer Eng 262)
- 281 Metallurgical Thermodynamics I** (LEC 3.0) Thermodynamic laws and thermodynamic functions and their relation to problems of metallurgical interest, thermochemistry, thermophysics, and chemical or phase equilibria. Prerequisite: Met Eng 125 or Chem 3.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 303 Metals Refining and Recycling of Materials** (LEC 3.0) Survey of selected modern processes for the production of metals, the treatment of wastes, and recycling of metal values. Processes are studied with respect to raw materials, chemical reactions, energy consumption, process intensity, yield and environmental impact. Prerequisite: Cer Eng 259.

- 305 Nondestructive Testing** (LEC 3.0) Principles and applications of various means of non-destructive testing of metallic materials. Radiological inspection methods, ultrasonic testing, magnetic methods, electrical and eddy current methods and others. Prerequisite: Physics 24 or 25. (Co-listed with Elec Eng 375)
- 306 Nondestructive Testing Laboratory** (LAB 1.0) Application of radiological and ultrasonic methods of nondestructive testing of metallic materials. A radiographic X-ray units and ultrasonic equipment are used in the inspection of a variety of materials and manufactured parts. Prerequisite: Accompanied or preceded by Mt Eng 305.
- 307 Metals Casting** (LEC 3.0) An advanced course in the materials and methods used in modern metals casting processes. Application of metallurgical principles to the casting of metals. Design of castings and metals casting mold features using commercial casting process simulation software. Prerequisite: Met Eng 221 or Mech Eng 153.
- 308 Metals Casting Laboratory** (LAB 1.0) An advanced laboratory study of mold materials, metal flow, and cast metals. Emphasis is given to design of gating, risering, and ladle treatment techniques required for economical, highquality castings. Prerequisite: Accompanied or preceded by Mt Eng 307.
- 310 Seminar** (IND 0.0-3.0) Discussion of current topics.
- 311 Metals Joining** (LEC 2.0) Metals joining processes such as welding and brazing. Effects of welding on materials. Treatment and properties of welded joints. Welding defects and quality control. Prerequisite: Mt Eng 121 or 221.
- 313 Scanning Electron Microscopy** (LEC 2.0 and LAB 1.0) A course in the theory and application of scanning electron microscopy and x-ray microanalysis. Topics considered are electron optics, image formation and analysis; x-ray generation, detection and analysis; and characterization of fracture surfaces. Prerequisites: Met Eng 217 and 218 or course in optical microscopy - consent of instructor required.
- 315 Metallurgical Process Design Principles** (LEC 2.0) Application of mass, component and energy balances for metallurgical design. The fundamentals of engineering economic analysis will be examined and experimental design techniques will be introduced. Students will be prepared for the selection and planning of the subsequent design project. Prerequisite: Senior standing in Mt Eng.
- 316 Metallurgical Design Project** (LAB 2.0) Student groups will undertake selected projects, which will represent a capstone design experience utilizing skills, understanding and data from previous courses. The faculty supervised open-ended design projects will involve a variety of tasks appropriate to the metallurgical engineer. Prerequisite: Mt Eng 315.
- 318 Principles for Microstructural Design** (LEC 2.0) This course will introduce the basics of microstructural principles that can be used to design advanced materials. It will help students learn about the basic principles and microstructural design approaches. Prerequisites: At least junior standing, Met Eng 215; Met Eng 217 or equivalent.
- 321 Metal Deformation Processes** (LEC 3.0) An introduction to metal deformation concepts followed by a study of various forming processes from both the analytical and applied viewpoints. Processes to include: forging, wire drawing, extrusion, rolling, sheet metal forming, and others. Prerequisite: Mt Eng 221.
- 329 Material Selection, Fabrication, And Failure** (LEC 3.0) Factors governing the selection of materials for specific needs, fabrication, heat treatment, surface treatment, and other aspects in the production of a satisfactory component. Failure analysis and remedies. Lecture plus assigned problems. Prerequisites: Mt Eng 217, 218, 221.
- 331 Steels And Their Treatment** (LEC 3.0) Industrially important ferrous alloys are described and classified. The selection of proper heat treatments to facilitate fabrication and to yield required service properties in steels suitable for various applications is considered. Prerequisites: Met Eng 217 and Met Eng 218.
- 332 Metals Treatment Laboratory** (LAB 1.0) The students plan and perform experiments that illustrate heat treating processes and their effects on the properties and structure of commercial alloys. Prerequisite: Accompanied or preceded by Mt Eng 331.
- 333 Nonferrous Alloys** (LEC 3.0) Structure and properties of nonferrous alloys (Al, Ti, Mg, Ni and Cu) are described. The role of processing and microstructure in the development of mechanical properties is emphasized. Prerequisites: Mt Eng 217 or Mt Eng 377.
- 340 Biomaterials I** (LEC 3.0) This course will introduce senior undergraduate students to a broad array of topics in biomaterials, including ceramic, metallic, and polymeric biomaterials for in vivo use, basic concepts related to cells and tissues, host reactions to biomaterials, biomaterials-tissue compatibility, and degradation of biomaterials. Prerequisite: Senior undergraduate standing. (Co-listed with Cer Eng 340, Bio Sci 340, Chem Eng 340)
- 341 Nuclear Materials I** (LEC 3.0) Fundamentals of materials selection for components in nuclear applications. Design and fabrication of UO₂ fuel; reactor fuel element performance; mechanical properties of UO₂; radiation damage and effects, including computer modeling; corrosion of materials in nuclear reactor systems. Prerequisites: IDE 110; Nuc Eng 205; Nuc Eng 223; Met Eng 121.(Co-listed with Nuc Eng 341)

205 — Metallurgical Engineering

- 343 Nuclear Materials II** (LEC 3.0) Extractive metallurgy of uranium, thorium, and zirconium. Equation of state of UO₂ and fuel chemistry. LMFBR fuel and interaction of sodium and stainless steel. Materials for fusion and other advanced nuclear applications. Reprocessing of spent fuel and disposal. Prerequisite: Mt Eng 341.
- 350 Composites** (LEC 3.0) An introduction to the structure, properties and fabrication of fiber and particulate composites. Prerequisites: Mt Eng 215 & 211 or Cr Eng 102 & 242.
- 352 International Engineering and Design** (LEC 3.0) A multi-disciplinary engineering course focused on sustainable design and technology transfer to developing countries. Course includes elements of traditional capstone design classes. Experiential learning through competitions and/or field work is a major component of the class. Prerequisite: Senior standing, instructor approval. (Co-listed with Geo Eng 352 and Cer Eng 352)
- 353 Mineral Processing II** (Mechanics and Design) (LEC 2.0 and LAB 1.0) Mineral particle mechanics of comminution, sizing, classification, concentration, filtering and thickening. Mill and equipment selection and design including flowsheet, development and plant assessment. Prerequisite: Min Eng 241. (Co-listed with Min Eng 353)
- 354 Electrical Systems and Controls for Materials** (LEC 2.0 and LAB 1.0) This course will cover analysis of alternating and direct current circuits as experienced in the materials industry. Current, voltage, and power relationships in single and three-phase electrical power systems. Introduction to continuous and batch instrumentation including programmable logic controllers (PLCs) and computer interfacing for materials applications. Prerequisite: Physics 24.
- 355 Process Metallurgy Applications** (LEC 3.0) Application of thermodynamics to process metallurgy. Equilibrium calculations with stoichiometry and heat balance restrictions, phase transformations, and solution thermodynamics. Use of thermodynamic software to solve complex equilibria in metallurgical applications. Prerequisite: Cer Eng 259.
- 358 Steelmaking** (LEC 3.0) Introduction to the fundamentals and unit processes used to turn impure iron and scrap into steel. Includes desulfurization, BOF and electric furnace operations, ladle metallurgy, casting, and stainless steel manufacture. Prerequisite: Cer Eng 259.
- 359 Environmental Aspects Of Metals Manufacturing** (LEC 3.0) Introduction to environmental aspects of metal extraction, melting, casting, forming, and finishing. Subjects include history of environmental movement and regulations permitting, risk analysis, disposal and recycling of metal manufacturing residues, environmental ethics, environmental technologies and case studies. Prerequisite: Junior/Senior standing.
- 361 Alloying Principles** (LEC 3.0) Basis for alloy design and property control. Predictions of phase stability, alloy properties and metastable phase possibilities; interfaces in solids and their role in phase transformations. Prerequisites: Mt Eng 217, 218.
- 363 Metal Coating Processes** (LEC 3.0) Introduction to the current technologies used to enhance metal performance, particularly corrosion resistance, by overlay coatings. Deposition processes are emphasized and the fundamentals of the behavior of the films in high technology and electronic materials applications is discussed. Prerequisite: Senior or Graduate Standing.
- 365 Microfabrication Materials And Processes** (LEC 3.0) An overview course on the materials and processes used to fabricate integrated circuits, microelectromechanical systems (MEMS), interconnect substrates and other microelectronic components from starting material to final product. The emphasis will be on the influence of structure and processing on the electrical, mechanical, thermal, and optical properties. Prerequisites: Chem 1 or equivalent; Senior or Graduate Standing.
- 367 Introduction to Particulate Materials** (LEC 3.0) Powder metallurgy and ceramic components, filters, catalysts, nanomaterials, vitamins and more depend strongly on particulate, or powder, characteristics and processing. Aspects of powder fabrication, characterization, safety, handling, component fabrication, secondary processing, and applications will be covered. Prerequisite: Met Eng 121.
- 375 Metallurgical Failure Analysis** (LEC 3.0) Application of the principles of manufacturing and mechanical metallurgy for the analysis of failed components. Analytical techniques such as Scanning Electron Microscopy, Optical Metallography, and High Resolution Photography are used to characterize microstructure and fractographic features. In addition, appropriate methods to gather data, assimilate it, and draw conclusions from the data such that it will stand up in a court of law will be addressed. Prerequisite: Senior or Graduate Student standing.
- 377 Principles Of Engineering Materials** (LEC 3.0) Examination of engineering materials with emphasis on selection and application of materials in industry. Particular attention is given to properties and applications of materials in extreme temperature and chemical environments. A discipline specific design project is required. (Not a technical elective for undergraduate metallurgy or ceramic majors) (Co-listed with Ae Eng 377, Ch Eng 347, Physics 377, Cr Eng 377)

381 Corrosion And Its Prevention (LEC 3.0) A study of the theories of corrosion and its application to corrosion and its prevention. Prerequisite: Chem 243 or Cer Eng 259. (Co-listed with Chem Eng 381)

385 Mechanical Metallurgy (LEC 3.0) Elastic and plastic behavior of metallic single crystals and polycrystalline aggregates. Resulting changes in mechanical properties are considered. Included are applications to metal fabrication. Prerequisites: Met Eng 215, 216, IDE 110.

390 Undergraduate Research (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

Military Science

Army ROTC

The Department of Military Science is responsible for the Army Reserve Officers' Training Corps Program. ROTC is a program of leadership and basic military skill training which prepares students to serve as officers in the Total Army—the Active Army, the Army Reserve, and the Army National Guard—after graduation. Army ROTC can help you succeed during college and after graduation. You can gain the confidence and self-discipline needed to meet the academic challenge of Missouri S&T through Military Science courses and can acquire the leadership skills, which will impress employers when you enter the work force.

The Army ROTC program is flexible, and allows students to participate in the first two years of the program without obligation. Alternate entry programs for students with prior military service, transfer students, and students serving in the Army Reserve or National Guard are available. The Advanced Course, (Junior and Senior years), focuses on preparing cadets for officership, and requires a commitment to the ROTC program. Students who wish to take Military Science courses, but who do not wish to participate in Army ROTC, may do so with the approval of the Department Chairman.

Military Science classes are taught on the Missouri S&T campus and are supplemented by one weekend field training exercise at Fort Leonard Wood, MO. each semester for contracted ROTC cadets. The ROTC program concentrates on the whole person and includes physical training, leadership development, marksmanship, individual tactical skills, and essential knowledge of today's Army and its role in our society.

The minor in Military Science gives formal academic recognition for the leadership and management training received by those completing the entire Army ROTC program.

The Military Science program at Missouri S&T is described in detail in the Appendix/Army ROTC (Military Science) of this catalog. For more information on the Military Science Program, scholarships, qualification and

obligation, and extracurricular activities, contact the Department in 301 Harris Hall or phone (573) 341-4744.

Faculty

Professor:

LTC Brenden D. Burke, (Department Chair), MBA, Embry-Riddle Aeronautical University

Instructors:

CPT Markus Shawnee

SFC Michael Moore

Military Science Minor Curriculum

Required courses:

Mil Sc 105	Adaptive Tactical Leadership
Mil Sc 106	Leadership in Changing Enviro
Mil Sc 207	Developing Adaptive Leaders
Mil Sc 208	Leadership in a Complex World

Elective courses:

History	(select one course)
History 280	The American Military Experience
History 329	Contemporary Europe
History 348	Recent United States History
Human Behavior	(select one course)
Psychology 050	General Psychology
Philosophy 015	Introduction to Logic
Philosophy 025	Ethics of Engineering Practice
Sociology 081	General Sociology

Military Science Courses

10 Ranger Operations (LEC 1.0) Learn about one of the world's most elite fighting forces -the U. S. Army Rangers. Get some hands-on training with actual army equipment. Learn rappelling, land navigation, orienteering and combat patrolling.

15 Leadership and Personal Development (LEC 1.0) Introduces cadets to the personal challenges and competencies that are critical for effective leadership. Cadets learn how the personal development of life skills such as critical thinking, goal setting, time management, physical fitness, and stress management relate to leadership, officership, and the Army profession.

20 Rifle Marksmanship (LEC 1.0) The course teaches basic rifle marksmanship and firearm safety. Students will be required to learn common rules of firearms safety and fire airguns using standard firing positions. Targets will be scored. Students will also become familiar with military marksmanship techniques and weapons.

25 Introduction to Tactical Leadership (LEC 1.0) Overviews leadership fundamentals such as setting direction, problem-solving, listening, presenting briefs, providing feedback, and using effective writing skills. Cadets explore dimensions of leadership values, attributes, skills, and actions in the context of practical, hands-on, and interactive exercises.

30 Wilderness Survival And Life-Saving Techniques (LEC 1.0) Basic life-saving techniques that will enable the student to assist an injured person or himself in an emergency, and

survival techniques that will help the student survive in the wilderness.

- 35 Innovative Team Leadership** (LEC 3.0) Develop knowledge of self, self-confidence and individual leadership techniques through problem solving and critical thinking skills. Apply communication, feedback, and conflict resolution skills.
- 40 Foundations of Tactical Leadership** (LEC 3.0) Examines the challenges of leading tactical teams in the complex contemporary operating environment (COE). The course highlights dimensions of terrain analysis, patrolling, and operation orders. Further study of the theoretical basis of the Army leadership framework explores the dynamics of adaptive leadership in the context of military operations.
- 50 Army Physical Readiness Program** (LAB 1.0) Course instruction includes planning, implementing and managing the Army physical fitness program; the conducting of an Army physical fitness test; physical fitness training to include conditioning, calisthenics, and cross-country running. Fundamentals of drills and ceremony will also be taught.
- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course.
- 102 Basic Leadership Laboratory** (LAB 1.0) Hands-on experience in basic military leadership skills, supplementing, but not duplicating classroom instruction in MSI and MSII courses. Training is conducted at squad (8 person group) level with emphasis on leadership development at that level. Topics include oral communication and presentations, decision making, drill and ceremonies, squad tactics, land nav, and the tactical bivouac. Prerequisite: To accompany Mil Sc 40.
- 105 Adaptive Tactical Leadership** (LEC 2.0 and LAB 1.0) Challenges cadets to study, practice, and evaluate adaptive leadership skills as they are presented with scenarios related to squad operations. Cadets receive systematic and specific feedback on their leadership attributes and actions. Based on such feedback and self-evaluations, cadets continue to develop their leadership and critical thinking abilities. Prerequisites: Mil Sc 15, 25, 35, 40 - Exceptions to be made by Dept Chair Only In Accordance with Army (Cadet Command) Policies.
- 106 Leadership in Changing Environments** (LEC 2.0 and LAB 1.0) Uses increasingly intense situational leadership challenges to build cadet awareness and skills in leading tactical operations up to platoon level. Cadets review aspects of combat, stability, and support operations. They also conduct military briefings and develop proficiency in garrison operation orders. Prerequisites: Mil Sc 105 - Exceptions to be made by Department Chair Only In Accordance With Army (Cadet Command) Policies.

200 Special Problems (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required. Prerequisites: Mil Sc 207 and 208 - Exceptions to be made by Dept Chair Only in accordance with Army (Cadet Command) policies.

207 Developing Adaptive Leaders (LEC 2.0 and LAB 1.0) Develops cadet proficiency in planning, executing, and assessing operations, functioning as a member of a staff, and providing performance feedback to subordinates. Cadets assess risk, make ethical decisions, and lead fellow ROTC cadets. Lessons on military justice and personnel processes prepare cadets to make the transition to Army officers. Prerequisites: Mil Sc 105 and 106 - Exceptions to be made by Dept Chair Only in accordance with Army (Cadet Command) policies.

208 Leadership in a Complex World (LEC 2.0 and LAB 1.0) Explores the dynamics of leading current military operations in the contemporary operating environment. Cadets examine differences in customs, military law, principles of war, and rules of engagement in terrorism. They also explore aspects of interacting with non-government organizations, civilians on the battlefield, and host nation support. Prerequisite: Mil Sc 207 - Exceptions to be made by Department Chair Only In Accordance With Army (Cadet Command) Policies.

Mining Engineering

Bachelor of Science

Master of Science

Doctor of Philosophy

Master of Engineering

Emphasis areas at the bachelor level in explosives engineering, mining health and safety, quarry engineering, coal, mining and the environment, and sustainable development.

The Mining and Explosives Engineering programs are offered under the Department of Mining and Nuclear Engineering. The overall objectives of the Mining Engineering program are to provide a broad engineering education with strong expertise in Mining Engineering, a cultural foundation for the mining industry and a strong basis for future growth and development. These objectives are achieved at the B.S. level by providing education in basic sciences, engineering sciences and design, core Mining Engineering, humanities and social sciences.

ABET Educational Objectives:

The objectives establish broad career and professional attributes that the Mining Engineering program prepares students to achieve in industry. The PEOs include:

1. Graduates will become frontline supervisors and middle level managers within three to five years in industry.
2. Graduates will have a vital interest and a passion to remain and promote industry growth.
3. Graduates will be capable of solving industrial problems toward growth and competitiveness of their respective companies.
4. Graduates will become functional and effective leaders or members of industrial teams for carrying out the mission of their respective companies.
5. Graduates will communicate effectively the technical, social and economic aspects of the job requirements to subordinates, peers and superiors.
6. Graduates will carry out their functional responsibilities with supreme understanding of safety and health, environment and ethics.
7. Graduates will cultivate and maintain an interest in life-long learning through professional development and memberships in professional societies.
8. Graduates will continue to grow in the knowledge of relevant technologies, skills and tools for modern mining engineering practice.

ABET Program Outcomes

Consistent with the definition of ABET POs, the Mining Engineering Program is designed and delivered to allow students opportunities to acquire the following skills, knowledge and behaviors by the time of graduation.

1. Become proficient in the basic sciences, including mathematics, statistics, physics and chemistry and their applications in solving mining engineering problems (ABET Outcome a).
2. Understand fundamental engineering principles in statics and dynamics, mechanics of rock structures, electrical circuits, thermodynamics, fluid mechanics and engineering design and their applications in solving mining engineering problems (ABET Outcome a).
3. Become knowledgeable in the humanities, social sciences and management for understanding the non-technical aspects of the mining engineering profession, including environmental, socio-economic, and the health and safety impacts exemplified by the knowledge of the regulatory regime (ABET Outcome h).
4. Become proficient in core mining engineering subjects required to carry out the professional duties of an entry level mining engineer upon graduation (ABET Outcome a).
5. Understand geological and mineral processing dimensions for comprehensive mine design, extraction and mineral beneficiation (ABET Outcome a).
6. Understand geomechanics, geometric and computer-aided mine design, and optimization of flow processes for designing mine layouts to maximize health and safety, economics and production efficiency, and to minimize environmental impacts (ABET Outcome c).
7. Have the ability to outline and conduct experiments, with relevant input data and information, analysis and interpretation to draw inferences for

making decisions on maintenance, improvement, or modification of an operating system (ABET Outcome b).

8. Function effectively on a team by understanding team dynamics, communication, social norms and conflict management (ABET Outcome d).

9. Have the ability to identify, formulate and solve closed and open-ended problems in science, engineering, humanities, social sciences, and management from verbal and/or written statements (ABET Outcome e).

10. Understand engineering code of ethics and its impact on professional engineering practice, especially in mine design, mine health and safety, and quality control (ABET Outcome c and f).

11. Develop creative abilities for effective oral and written communication of both technical and non-technical materials for presentations to peers, superiors and subordinates with proficiency (ABET Outcome g).

12. Know contemporary engineering issues through general education requirements, involvement in professional societies, participation in student activities, and reading of professional journals (ABET Outcome j).

13. Develop leadership skills in competitive environments, project teams and organizational units through student chapter organizations, mine rescue, mine design and mucking competitions, student-initiated and student-led field trips, fund raising and community involvement (Program Core Value).

14. Have the desire and motivation toward a life-long learning process via the online Master of Engineering program, preparation toward professional engineering certification, opportunities for conference attendance and research exposure (ABET Outcome i).

15. Acquire the knowledge of the Mining Engineering profession through cooperative and summer internships, field trips and practical working laboratories in the Missouri S&T Experimental Mine (Program Core Value).

16. Acquire the knowledge and familiarity of the complex relationships among technology, government, society, investors, and the environment and their impact on tomorrow's mining industry through guest lectures, in-class presentations, general education subjects and community involvement (ABET Outcome k).

17. Understand global mining issues by participating in exchange programs, internships, and in-class presentations (Program Core Value).

18. Develop a sense of responsibility and appreciation for the continuous well-being of the Mining Engineering Program and Missouri S&T (Program Core Value).

General Program Information

The mining engineering courses provide students with the knowledge necessary to enter a variety of segments of the mining industry. Graduate mining engineers, who satisfactorily complete the program criteria, usually obtain employment in one or more of the following areas: mine engineering, operations management, extraction or processing, base metals,

precious metals, industrial minerals, quarry industry, explosives industry, construction or demolition, mining equipment suppliers and mining/geotechnical consulting firms.

The Mining Engineering profession deals with location, extraction, and use of mineral resources and mineral policy. Lunar and ocean mining constitute new frontiers. The mining engineer is concerned with all phases of mineral recovery, including exploration, evaluation, development, extraction, mine evaluation, reclamation, processing, and marketing of minerals. In addition to engineering, science and liberal arts courses, appropriate courses are taken in explosives engineering, geology, mineral beneficiation, coal mine development and production, mining of metallic and aggregate minerals, mine systems design, mining economics and law, mine hygiene and safety, mine management, mine ventilation, rock mechanics, ground support, and reclamation.

The mining engineer relies upon geologic knowledge and highly sensitive instruments for the location and evaluation of mineral deposits. Problems involved in the development, exploitation and the beneficiation of minerals and marketing of valuable constituents must be determined in advance. Mining must be carried out efficiently, safely, and economically, with the welfare of the public as a primary consideration. Land must be restored to a useful condition after mining ceases and pollution controls must be designed to prevent harmful environmental effects.

Intensive research programs are conducted at Missouri S&T in surface and underground mining, heavy mining machinery, explosives engineering, mine health and safety, oil sands recovery, waterjet excavation, mineral economics, mine operations and design, mine atmospheric control and ventilation, minerals transportation, rock mechanics and applied geophysics. Appropriate research by faculty and graduate students ensures program relevance to industry.

An Experimental Mine and the Rock Mechanics and Explosives Research Center are located close to the campus and provide facilities for laboratory instruction and research. Trips to coal, metal, and industrial mineral operations supplement classroom activities. Summer employment and co-op training provide valuable practical mining and engineering expertise.

Program Mission and Core Values

The Mining Engineering Programs at Missouri S&T will continue to provide superb education and training to undergraduate and graduate students in Mining Engineering for the mining and construction industries of Missouri, U.S. and those global mining companies with strategic interests in the U.S. To this end, Missouri S&T will maintain outstanding faculty, experimental mine facilities, intensive explosive engineering programs, waterjet research facilities, program emphases (explosives, health and safety, coal, sustainable development environment, and quarrying), teaching laboratories, strong industry and alumni networks, and a very supportive administration. The programs will provide students with total quality

education and research capabilities. From its humble beginnings in 1870, Missouri S&T has continued its tradition of excellence in educating mining engineers, who make a difference in industry and society, with scientific, technological and practical knowledge, leadership skills and professional ethics.

Excellence: The efforts of faculty and staff and the network of established alumni, industry and related organizations create an environment that promotes excellence in teaching and research.

Hands-on Experience: Through its experimental mining facilities, summer employment, cooperative education and field trips, Mining Engineering students at Missouri S&T receive hands-on experience, which is vital to the practice of the Mining Engineering profession.

Depth and Quality: Missouri S&T prides itself with depth and quality in its Mining Engineering education, a testimony born by the performance and leadership of its alumni and the mining industry.

Hard Work: One of the defining attributes of Missouri S&T students in Mining Engineering is hard work. This attribute is attained in the classroom, on the field and in various intercollegiate competitions, where our students continue to distinguish themselves as champions.

Leadership: Leadership is ingrained in the students throughout their education at Missouri S&T. Mining Engineering students are given opportunities to lead various societies, such as, SME, NSSGA, WIM, and ISEE and competitions like the mine design, mucking and mine rescue competitions.

Unique Education: The availability of the experimental mine, intensive explosive engineering programs, the rock mechanics and explosive research facility, industrial training opportunities, attendance of conferences, and a supportive environment provides an excellent opportunity for students to obtain a unique education in Mining Engineering at Missouri S&T.

Outreach: Through its Development Board of industry executives, strong networks of alumni, research and professional societies, Missouri S&T Mining Engineering reaches out to global frontiers.

Faculty

Professors:

Richard Bullock¹ (Emeritus), D. Eng., UMR
Samuel Frimpong² (Robert Quenon Chair and Department Chair), Ph.D., University of Alberta
Stewart D. Gillies, Ph.D., (Union Pacific-Rocky Mountain Energy), Queensland
Tad Golosinski¹ (Emeritus), Ph.D., University of Mining and Metallurgy, Cracow
R. Larry Grayson¹ (Emeritus), Ph.D., West Virginia University
Charles J. Haas (Emeritus), D.Sc., Colorado School of Mines
Lee W. Saperstein¹ (Emeritus), D. Phil, Oxford University
David A. Summers³, (Curators'), Ph.D., University of Leeds

John W. Wilson (Emeritus), Ph.D., University of Witwatersrand

Paul N. Worsey³, Ph.D., University of Newcastle-Upon-Tyne

Associate Professors:

Jason Baird, Ph.D., UMR

Grzegorz Galecki, Ph.D. (Research), Technical University of Wroclaw

Maochen Ge, Ph.D., Penn State University

Jerry C. Tien¹, Ph.D., UMR

Assistant Professor:

Awuah-Offei, Kwame, Ph.D., UMR

Adjunct Assistant Professor:

R. Karl Zipf, Ph.D. (Adjunct), Penn State University

Leslie Gertsch, Ph.D. (Adjunct), Colorado School of Mines

¹ Registered Professional Engineer

² Registered Professional Engineer of Canada

³ Chattered Engineer of UK

**Bachelor of Science
Mining Engineering**

Entering freshmen desiring to study Mining Engineering will be admitted to the Freshman Engineering Program. They will, however, be permitted, if they wish, to state a Mining Engineering preference, which will be used as a consideration for available freshman departmental scholarships. The focus of the Freshman Engineering program is on enhanced advising and career counseling, with the goal of providing to the student the information necessary to make an informed decision regarding the choice of a major.

For the Bachelor of Science degree in Mining Engineering a minimum of 128 credit hours is required. These requirements are in addition to credit received for algebra, trigonometry, and basic ROTC courses. A student must maintain at least two grade points per credit hour for all courses taken in the student's major department, and an average of at least two grade points per credit hour must be maintained in Mining Engineering.

The Mining Engineering curriculum contains a required number of hours in humanities and social sciences as specified by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. Each student's program of study must contain a minimum of 16 credit hours of course work from the humanities and the social sciences areas and should be chosen according to the following rules:

1. All students are required to take one American history course and one economics course. The history course is to be selected from History 112, 175, History 176, or Political Science 90. The economics course may be either Economics 121 or 122. Some disciplines require one humanities course to be selected from the approved lists for art, English, foreign languages, music, philosophy, speech and media studies, or theater.

2. Of the remaining hours, six credit hours must be taken in humanities or social sciences at the 100 level or above and must be selected from the approved lists.

Each of these courses must have as a prerequisite one of the humanities or social sciences courses already taken. Foreign language courses numbered 70 to 80 can be considered to be one of these courses. (Students may receive humanities credit for foreign language courses in their native tongue only if the course is at the 300 level.)

3. Some departments list specific requirements; e.g., a psychology course, a literature course, and /or a second semester of economics. Selections should be made to ensure that these requirements are met.

4. Skill courses are not allowed to meet humanities and social sciences requirements except in foreign languages. Students who select the foreign language option are urged to take more than one course.

5. Special topics, special problems courses and honors seminars are allowed only by petition to and approval by the student's department chairman.

The Mining Engineering program at Missouri S&T is characterized by its focus on the scientific basics of engineering and its innovative application; indeed, the underlying theme of this educational program is the application of the scientific basics to engineering practice through attention to problems and needs of the public. The necessary interrelations among the various topics, the engineering disciplines, and the other professions as they naturally come together in the solution of real world problems are emphasized as research, analysis, synthesis, and design are presented and discussed through classroom and laboratory instruction.

FRESHMAN YEAR

First Semester	Credit
Chem 001-General Chemistry I	4
Chem 002-General Chemistry I Lab	1
Chem 004-Lab Safety	1
Math 014-Calculus for Engineers I	4
FE 010-Study & Careers in Eng	1
Ge Eng 050-Geology for Engineers	3
Hist 112, 175, 176 or Pol Sc 90	3
	17

Second Semester	Credit
Math 015-Calculus for Engineers II	4
Physics 023-Engineering Physics	4
IDE 020-Eng Design w Comp Appl	3
<i>Mi Eng 003-Principles of Mi Eng</i> ⁸	1
Min Eng 151-Intro to Mining Safety	1
Geo 125-Physical Mineralogy and Petrology	3
	16

SOPHOMORE YEAR

First Semester	Credit
Mi Eng 110-Surveying for Mineral Engineers	2
Mi Eng 215-Mat Handling in Mines	3
Math 022-Calculus & Analytic Geometry III	4
Geo 220-Structural Geology	4
Econ 121-Prin of Micro or Econ 122-Prin of Macro . . .	3
Mi Eng 225-Surface Mine Design	3
	19

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Second Semester

English 20-Exposition and Argumentation	3
Physics 024-Engineering Physics II	4
IDE 140-Statics & Dynamics ¹	3
Math 204-Elem Differential Equations	3
Mi Eng 235-Underground Mine Design	3
	<u>16</u>

JUNIOR YEAR

First Semester	Credit
Mi Eng 221-Mining Exploration	3
English 65-Tech Writer in Bus & Industry	3
Cv Eng 230-Elementary Fluid Mechanics	3
Stat 213-Applied Engineering Statistics	3
Human/Soc Sc ¹	3
	<u>15</u>

Second Semester

Mi Eng 324-U/G Mi Methods & Equip	3
Mi Eng 326-Surface Mining Methods & Equip	3
Mi Eng 241-Principles of Mineral Processing	3
Mi Eng 331-Rock Mechanics I	3
Mi Eng 318-Mine Atmos. Control	3
Human/Soc Sc ¹	3
	<u>18</u>

SENIOR YEAR

First Semester	Credit
Mi Eng 317-Mine Power and Drainage	3
Mi Eng 322- <i>Mine Management</i> ⁹	2
Mi Eng 307-Principles of Explosives Engr.	3
Mi Eng 332-Soils and Overburden Materials	2
Mi Eng 392-Mine Design Project I ⁸	1
Technical Elective ^{2,3,4,5,6,7}	3
	<u>14</u>

Second Semester

Mi Eng 376-Environmental Aspects of Mining	3
Mi Eng 393- <i>Mine Design Project II</i> ⁹	4
Human/Soc Sc ¹	3
Technical Elective ^{2,3,4,5,6,7}	3
	<u>13</u>

Notes:

- The curriculum contains a total of 21 general education credit hours. The three HSS electives must be from the approved list with at least one course (3 or more hours) that builds on depth and at least one course (3 or more hours) that focuses on the economics of a large enterprise, such as the mining industry, e.g. Econ 340 or Econ 345. The latter also satisfies the depth requirement.
- Explosives Engineering Emphasis: Mi Eng 350 (Blasting Tech) and either Mi Eng 301, 390 (Special Topics and Mining Research, both in an explosives area), Ge Eng 371 (Rock Engineering) or Mi Eng 383 (Tunneling/Construction) have to be taken as Technical Electives.
- Quarrying Emphasis: Cv Eng 216 (Construction Materials) and Mi Eng 304 (Advanced Aggregate and Quarrying) have to be taken as Technical Electives.
- Coal Emphasis: Mi Eng 343 (Coal Mine Development and Production), Mi Eng 311 (Mine Plant Management) or an approved substitute course have to be taken as Technical Electives.

- Mining and the Environment Emphasis: Geol Eng 235 (Environmental Geoscience), Geol Eng 333 (Risk Assessment in Environmental Studies), or approved substitute courses have to be taken as Technical Electives.
- Mining Health and Safety Emphasis: Mi Eng 202 (Mine Rescue), Eng Mgt 311 (Human Factors), or other approved substitute courses have to be taken as Technical Electives.
- Sustainable Development Emphasis: Pol Sci 315 (Public Policy Analysis), Econ 340 (Environmental and Natural Resource Economics), or other approved substitute courses have to be taken as Technical Electives.
- Mining courses in *italics* offered every semester.

Mining engineering students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade on this examination is not required to earn a B.S. degree; however, it is the first step toward becoming a registered professional engineer. This requirement is part of the Missouri S&T assessment process as described in Assessment Requirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

Minor in Mining Engineering

A student who receives a Bachelor of Science degree in an accredited engineering program from Missouri S&T may receive the Minor in Mining Engineering by completing 15 credit hours from the courses listed below. Non-engineering students who have a strong background in mathematics and the physical sciences may also qualify for the Minor in Mining Engineering or Explosives Engineering with the approval of the Department and based on an individually designed program of study. Students will need to consult with the Chair of the Mining Engineering Program to determine pre-requisite requirements for each course. The program granting the Bachelor of Science degree shall determine whether or not courses taken for the Mining Engineering Minor or Explosives Engineering Minor may also be used to fulfill the requirements of the B.S. degree from that program.

The following courses are required for the Minor in Mining Engineering:

- Mi Eng 221-Mining Exploration
- Mi Eng 324-Underground Mining Methods & Equipment
- Mi Eng 326-Surface Mining Methods & Equipment

Two other Mi Eng 200- or 300- level lecture courses (3 credit hours), or relevant courses from other disciplines, as approved, must be taken to match the student's area of emphasis in Mining Engineering. The following areas of emphasis may be pursued:

Explosives Engineering; Quarrying; Mineral Economics; Mining-Environmental; Mining-Equipment; Mining-Geo-technical; Mining-Health and Safety; Mining Operations Management; Mining-Tunneling; Sustainable Development; Surface Mining; Underground Mining.

The Minor in Mining Engineering is not accredited by the Accreditation Board of Engineering and Technology (ABET).

Minor in Mineral Process Engineering

The Minor in Mineral Process Engineering provides an in-depth study of the fundamental theories and applications of mineral and coal processing and aggregate materials sizing and classification. Any student who receives a Bachelor of Science degree in an accredited engineering program from Missouri S&T may also receive the Minor in Mineral Process Engineering by completing 15 credit hours in this specialty. The B.S. degree granting program shall determine whether or not courses taken for the Minor in Mineral Process Engineering may also be used to fulfill the requirements of the B.S. degree from that program.

The following courses are required for the Minor in Mineral Process Engineering:

- Mi Eng 241-Principles of Mineral Processing
- Mi Eng 344-Coal Preparation
- Mi Eng 303-Aggregate Materials Sizing and Classified
- Mi Eng 352-Mineral Processing I
- Mi Eng 353-Mineral Processing II

Minor in Explosives Engineering

The Department of Mining & Nuclear Engineering, Mining Engineering Program, realizing the attractiveness of Explosives Engineering to students, the potential for jobs in the area (post 9-11), and the use of over 6 billion pounds of explosives in mining, tunneling, construction, and other areas, is offering a Minor in Explosives Engineering so that students interested in Explosives Engineering have a chance to attain in-depth knowledge of the sub-discipline.

A student who received a Bachelor of Science degree in an accredited engineering program from Missouri S&T may receive the Minor in Explosives Engineering by completing 15 credit hours from the courses listed below. Non-engineering students who have a strong background in mathematics and the physical sciences may also qualify for the Minor in Explosives Engineering, with the approval of the Department and based on an individually designed program of study. Students need to consult with the Chair of the Mining Engineering Program to determine pre-requisite requirements for each course. The program granting the Bachelor of Science degree shall determine whether or not courses taken for the Explosives Engineering Minor may also be used to fulfill the requirements of the B.S. degree from that program.

The following courses are required for the Minor in Explosives Engineering:

- Mi Eng 307-Principles of Explosives Engineering
- Mi Eng 309-Commercial Pyrotechnics Operations
- Mi Eng 350-Drilling and Blasting
- Mi Eng 383-Tunneling and Underground Const.
- One other related course, as approved by program coordinator.

Min Eng 390-Research or Min Eng 301-Demolition of Building and Structures (permanent number coming

after two offerings), may be substituted for Min Eng 309 or Min Eng 383. The list of explosives courses will be expanded in the future in order to give students more flexibility in selecting courses.

The Minor in Explosives Engineering is not accredited by the Accreditation Board of Engineering and Technology (ABET).

Mining Health and Safety Emphasis

Junior and Senior Years

- A)** Mi Eng 202 (Mine Rescue) or approved substitute course in lieu of Technical Elective.
- B)** Eng Mgt 311 (Human Factors) or approved substitute course in lieu of Technical Elective.

Sustainable Development Emphasis

Junior and Senior Years

- A)** Pol Sci 315 (Public Policy Analysis) or approved substitute course in lieu of Technical Elective.
- B)** Econ 340 (Environmental and Natural Resource Economics) or approved substitute course in lieu of Technical Elective.

Quarrying Engineering Emphasis

Senior year

- A)** Cv Eng 216 (Construction Materials) in lieu of Technical Elective.
- B)** Mi Eng 304 (Advanced Aggregate and Quarrying) in lieu of Technical Elective.

Explosives Engineering Emphasis

Junior and Senior Years

- A)** Choose one of the following courses in lieu of Technical Elective in Junior year: Mi Eng 309 (Commercial Pyrotechnics Operations), 383 (Tunneling/Construction), Ge Eng 371 (Rock Engineering) or Mi Eng 300, 301, or 390 (Special Problems, Special Topics/Experimental Courses and Mining Research all in an explosives area).
- B)** Mi Eng 350 (Blasting Design & Technology) in lieu of Technical Elective in Senior Year

Coal Emphasis

Junior and Senior Years

- A)** Mi Eng 343 (Coal Mine Development and Production) in lieu of Technical Elective.
- B)** Mi Eng 311 (Mine Plant Management) or approved substitute course in lieu of Technical Elective.

Mining and the Environment Emphasis

Junior and Senior Years

- A)** Geol Eng 235 (Environmental Geoscience) or an approved substitute course in lieu of Technical Elective.
- B)** Geol Eng 333 (Risk Assessment in Environmental Studies) or an approved substitute course in lieu of Technical Elective.

Undergraduate Certificate in Explosives Engineering

This certificate program is designed to provide formalized education in the area of Explosives Engineering.

Students will be exposed to the theoretical and practical approaches of Explosives Engineering. Students will be exposed to the analysis and design of explosive-related systems and both natural and built structure effects.

The Explosives Engineering Certificate Program is open to all persons holding a High School Diploma who have a minimum of 12-months of post-H.S. professional employment or college experience.

Once admitted to the program, the student must take four designated courses as given below. In order to receive an undergraduate Certificate, the student must have an average cumulative grade of 2.0 or better in the certificate courses.

Students admitted 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 may apply to the B.S. Mining Engineering program if they so choose. The certificate credits taken by students admitted to the B.S. program may be eligible to count toward their bachelors degrees depending on the degree requirements. Prerequisite courses outside of those in this certificate program may be waived at the discretion of the administrative co-coordinators for persons that are not regular Missouri S&T students.

Once admitted to the program, a student will be given three years to complete the program so long as he/she maintains a 2.0 GPA in the courses taken.

Required courses:

- Mi Eng 307-Principles of Explosives Engineering
- Mi Eng 350-Blasting Design and Technology

Two of the following courses are required:

- Mi Eng 301-Demolition of Buildings & Structures
- Mi Eng 309-Commercial Pyrotechnics Operations
- Mi Eng 383-Tunneling & Underground Construction
- Mi Eng 390-Research
(Explosives Engineering related)
- Mi Eng 300-Special Problems
(1. Explosives Engineering related. 2. At discretion of coordinators)

Other courses approved by the Explosives Engineering faculty may be substituted for any of the above listed courses on a case-by-case basis.

Students with a GPA of 3.0 in the certificate program may take postgraduate explosives classes as electives.

Mining Engineering Courses

3 Principles Of Mining Engineering (LEC 1.0) Principles and definitions related to mining engineering including one or more field trips to familiarize the student with current mining ts associated with mining. Prerequisite: Accompanied or preceded by Mi Eng 3.

50 Computing In Mining Engineering (LAB 1.0) Basic software needed by mining engineers for computer applications in various phases of mine planning, development, and operations will be covered. The overarching goal is developing early familiarity with relevant software so it can be integrated across mining engineering courses.

110 Surveying For Mineral Engineers (LAB 2.0) Principles of surface and underground survey practice utilizing total station, engineer's level and GPS. Traversing and details, note taking and computations, balancing surveys and error analysis, staking-out new points, and map construction with AutoCAD. Prerequisite: Math 6, accompanied or preceded by Min Eng 3.

151 Introduction To Mining Safety (LAB 1.0) Instruction in the safety aspects of mining accordance with the MSHA Training Program required for all new miners. Subjects include self-rescue and respiratory protection, ground control, hazard recognition, mine gases, and legal aspects associated with mining. Prerequisite: Accompanied or preceded by Mi Eng 3.

200 Special Problems (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

201 Special Topics (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.

202 Mine Rescue (LEC 2.0 and LAB 1.0) Utilization of the principles of mine safety concerning mine gases, ventilation, explosives, fires, and first aid in the organization of mine rescue personnel and techniques. Training in the use of current mine rescue equipment, recognition and control of common recovery hazards, handling of survivors. Prerequisite: Mi Eng 151.

215 Materials Handling In Mines (LEC 2.0 and LAB 1.0) Mining applications of material transport and handling. Truck haulage and haulroads. Conveyors: belt, armored, and others; feeders; bins and bunkers; material stockpiling and homogenization; rail transport; water transport; slurry transport; mine hoists and hoisting. Prerequisite: Mi Eng 003.

221 Mining Exploration (LEC 3.0) Classification of mineral deposits. Orebody definition. Geology, geophysics, geochemistry, geobotany, and drilling in mineral exploration. Sampling methods, errors and mitigation. Resources/Reserves classification. Proven, probable and possible resources/reserves. Reserve estimation project. Prerequisites: Geology 125 and Min Eng 110.

225 Surface Mine Design (LEC 1.0 and LAB 2.0) Surface mining methods. Conventional methods for ore reserves estimation. Geomechanics, geometrics and computer-aided mine design, haul roads and waste dump design and layouts optimization. Materials scheduling and sequencing using a commercially available mine design software. Prerequisite: Min Eng 3.

- 232 Statics And Mechanics Of Rock Materials** (LEC 2.0 and LAB 1.0) Application of the principles of mechanics to engineering problems of equilibrium, strength, and stiffness concerning rock materials and mine support structures. This course extends the study of statics to rock materials in mines and covers rock-related and support structure-related mechanics of materials. The course is complemented by rock mechanics laboratory. Prerequisites: IDE 140; or IDE 50 and 150.
- 235 Underground Mine Design** (LEC 1.0 and LAB 2.0) Underground mining methods. Parametric statistics and introductory geostatistics. Geomechanics, geometrics and computer-aided mine design. Empirical and numerical methods for mine openings, pillar and roof span design; caving and ore drawing mechanics. Materials scheduling and sequencing using commercially available software. Prerequisite: Min Eng 225.
- 241 Principles Of Mineral Processing** (LEC 2.0 and LAB 1.0) Introduction to the principles of mineral processing including mineral resources; particle comminution, classification, separation and dewatering; flowsheet and equipment design.
- 270 Mining Industry Economics** (LEC 3.0) Importance of the mineral industry to national economy, uses, distribution, and trade of economic minerals, time value of money, mineral taxation, economic evaluation utilizing depreciation, depletion, and discounted cashflow concepts, social and economical significance of mineral resources. Prerequisite: Econ 121 or 122. (Co-listed with Econ 270)
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 302 Computer Applications In The Mining & Minerals Industry** (LEC 2.0 and LAB 1.0) History of computer technology usage in the mining industry. Exposure to the use of computers in mine planning, design, exploration, ventilation & environment, rock mechanics, open pit stability, simulation of mining systems and equipment selection.
- 303 Aggregate Materials Sizing and Characterization** (LEC 2.0 and LAB 1.0) Geological formation of aggregates; aggregate properties and their measurements; aggregates for specific end-user applications; specifications and standards; processing (crushing, screening, classification, and washing); plant design and flow sheet analysis; quality control and assurance. Prerequisite: Min Eng 241.
- 304 Advanced Aggregate and Quarrying** (LEC 3.0) Advanced coverage of topics on the stone and aggregate industry, including surface and underground operations, plant equipment, economics, marketing, transportation, and environmental topics. The course will include at least one field trip and a design project. Prerequisite: Min Eng 215, co-requisite: Civ Eng 216.
- 305 Explosives Handling And Safety** (LEC 3.0) Basic handling & safety for explosives, explosive devices and ordnance related to laboratory handling, testing, manufacturing & storage, for both civil and defense applications. For "credit offering" of the S&T Explosives Handling & Safety Industrial Short Course. Prerequisites: Min Eng 151, Min Eng 307, Successful background check. (Co-listed with Exp Eng 305)
- 306 Material Processing By High-Pressure Water Jet** (LEC 3.0) Methods of generating high pressure water jets; standard equipment, existing techniques and basic calculations. Applications of water jets to materials cutting and mineral processing. Safety rules. The course will be supported by laboratory demonstrations. (Co-listed with Mc Eng 306)
- 307 Principles Of Explosives Engineering** (LEC 2.0 and LAB 1.0) Theory and application of explosives in the mining industry; explosives, initiating systems, characteristics of explosive reactions and rock breakage, fundamentals of blast design, drilling and blasting, regulatory and safety considerations. Prerequisites: Min Eng 151; accompanied or preceded by Civ Eng 215 or Geology 220 or Geology 125; Successful background check. (Co-listed with Exp Eng 307)
- 309 Commercial Pyrotechnics Operations** (LEC 2.0 and LAB 1.0) Provide participants with basic pyrotechnic operator certification (with passing of PGI test) and advanced lead pyrotechnic operator training. Class work will be complemented by practical training in laboratory sessions, culminating in a full pyrotechnic show, from start to finish. Prerequisites: Chem 1. US Citizen or permanent resident (to fulfill the requirements of the SAFE EXPLOSIVES ACT 2003). Resident enrollment at Missouri S&T (e.g. not distance or internet). (Co-listed with Exp Eng 309)
- 311 Mine Plant Management** (LEC 2.0) Optimization of mine plant and equipment performance. Availability, utilization and reliability of equipment; matching equipment and plant to minesite specific conditions; maintenance planning, scheduling and control; parts and materials supply systems; mine information and management systems. Basics of mine automation and robotics. Prerequisite: Senior standing or consent of instructor.
- 312 Ore Reserve Analysis And Geostatistics** (LEC 2.0 and LAB 1.0) An introduction to principles of geostatistics, theory of spatially correlated random variables, variance and co-variances and their application on the evaluation of mineral resources, ore reserve estimation, strategic exploration, and production planning. Real case studies from mining industry will be presented. Prerequisites: Math 204, Stat 213.

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- 313 Stage Pyrotechnics and Special Effects** (LEC 1.0 and LAB 2.0) Use of energetic materials in close proximity to audiences. Provide participants with training preparing for Missouri Pyrotechnics Display Operators License. Covers: close proximity indoor and outdoor pyrotechnics and special effects. Working with stage crews and talent, safety and permitting. Prerequisites: Chem 1. US Citizen or permanent resident (to fulfill the requirements of the SAFE EXPLOSIVES ACT 2003). Successful background check. Resident enrollment at Missouri S&T (e.g., not distance or internet). (Co-listed with Exp Eng 313)
- 315 Advanced Mine Health and Safety** (LEC 3.0) A detailed study of health and safety principles, practices, analyses, regulations, issues and technology in the mining industry. Prerequisite: Min Eng 151.
- 317 Mine Power And Drainage** (LEC 2.0 and LAB 1.0) Engineering principles of mine power distribution and application and mine dewatering. Electric power: basics of electrical circuits, AC/DC power, transformers, electric meters, power distribution, power management. Fundamentals of thermodynamics. Hydraulic power systems. Compressed air in mines. Mine dewatering: passive and active systems. Controlling water inflow. Dewatering wells: horizontal and vertical. Water pumping and pumping systems.
- 318 Mine Atmosphere Control** (LEC 2.0 and LAB 1.0) Fundamentals of mine ventilation, including the principles of airflow, control of gases, dust, and temperature, methane drainage, mine fans, network theory, computer network simulation, and economics of airflow, with emphasis on analysis, systems design and practical application. Prerequisite: Cv Eng 230.
- 322 Mine Management** (LEC 2.0) Theory and practice of mine management, including basic managerial functions, management theories, communication skills, motivation, leadership, organization, maintenance management, managerial decision making, cost control, labor relations, government relations, ethics, with emphasis in presentation skills. Prerequisite: Completion of 100 credits in Mining Engineering curriculum.
- 324 Underground Mining Methods And Equipment** (LEC 3.0) Principles of planning, constructing, and operating economically viable underground mines. Cost effective mining methods: room-and-pillar, sublevel open stoping, VCR, shrinkage, sublevel caving, cut-and-fill, block caving, longwall. Selection of equipment for underground mining operations. Optimization of mine performance. Field Trip Required. Prerequisites: Min Eng 235, Min Eng 270; coreq. Min Eng 221; Min Eng 331.
- 326 Surface Mining Methods And Equipment** (LEC 3.0) Principles of planning, constructing, and operating economically viable surface mines. Cost effective mining methods: placer mining, strip mining, open pit mining, quarrying. Selection of equipment for surface mining operations. Optimization of mine performance. Field trip required. Prerequisites: Min Eng 215; Min Eng 225; Min Eng 270; coreq. Min Eng 331.
- 331 Rock Mechanics** (LEC 2.0 and LAB 1.0) Applications of the fundamental principles of mechanics to engineering problems of equilibrium, strength and stiffness of rock materials. Review of in-situ stresses, laboratory and field instrumentation, rock and rockmass properties, pillar design, roof span design, rock reinforcement, surface subsidence, slope stability, and violent failures. Field trip required. Prerequisites: IDE 140, or IDE 50 and 150; and Geology 220.
- 332 Soils and Overburden Materials for Mining Engineering** (LEC 2.0) Physical and mechanical properties of soils and overburden materials. Soils and overburden characterization for reclamation and mine closure and overburden blasting. Soil failure modes and slope stability for surface mine layouts, waste dumps, tailings and earth dams, and foundations for heavy mining machinery. Prerequisites: IDE 140, or IDE 50 and 150.
- 342 Environmental And Natural Resource Economics** (LEC 3.0) Optimum use of replenishable and non-replenishable resources, public goods and common resources, externalities, private vs. public costs, and quality of the environment; emphasis on public policy related to environmental and natural resource economics. Prerequisite: Econ 221. (Co-listed with Econ 340)
- 343 Coal Mine Development And Production** (LEC 3.0) An in-depth study of all aspects of coal mining, including an overview of coal industry, reserves and geology, planning and development of coal mines, surface and underground mechanized methods of face preparation, equipment, coal extraction, handling and preparation as practiced in the United States. Prerequisite: Accompanied or preceded by Mi Eng 217.
- 344 Coal Preparation** (LEC 2.0 and LAB 1.0) Coal properties, sampling, testing, breaking, sizing, cleaning and dewatering. Disposal of refuse. Prerequisites: Min Eng 241 and senior standing.
- 345 Strata Control** (LEC 3.0) A detailed review of artificial ground support, both above and below ground, including slope stabilization techniques and shaft and tunnel liner design. The use of shotcrete, roofbolts, and solid liners and the principles of underground longwall and room and pillar mine support. Longwall and hydraulic mining practice is covered. Prerequisite: Min Eng 331.
- 350 Blasting Design And Technology** (LEC 2.0 and LAB 1.0) Advanced theory and application of explosives in excavation; detailed underground blast design; specialized blasting including blast

casting, construction and pre-splitting. Introduction to blasting research. Examination of field applications. Prerequisites: Min Eng 307. Student must be at least 21 years of age. Successful background check. (Co-listed with Exp Eng 350)

351 Demolition of Buildings and Structures (LEC 2.0 and LAB 1.0) Provide participants with basics and solid grounding in the equipment, techniques and processes required for the demolition and remediation of mine plant and processing equipment sites and non-mining structures such as buildings, factories, bridges, etc. Field trip required. Prerequisites: Preceded or accompanied by IDE 50 or 140; US citizen or permanent resident; *Requirement due to Safe Explosives Act - January 2003; Successful background check. (Co-listed with Exp Eng 351)

352 Mineral Processing I (Flotation and Hydrometallurgy) (LEC 2.0 and LAB 1.0) Forth flotation including mineral surfaces, double layer theory, zeta potential, hydrophobicity, adsorption, collectors, frothers, modulation, kinetics, and sulphide and acid flotation systems. Hydrometallurgy including leaching, ion exchange and liquid/liquid extraction. Prerequisite: Min Eng 241.

353 Mineral Processing II (Mechanics and Design) (LEC 2.0 and LAB 1.0) Mineral particle mechanics of comminution, sizing, classification, concentration, filtering and thickening. Mill and equipment selection and design including flowsheet, development and plant assessment. Prerequisite: Min Eng 241. (Co-listed with Met Eng 353)

355 Energy Economics (LEC 3.0) Market structure. World resource development. Supply and demand analysis on energy production and consumption within domestic and global settings. Prerequisite: Econ 221. (Co-listed with Econ 355)

376 Environmental Aspects Of Mining (LEC 3.0) Permitting: the legal environment of reclamation and environmental impact assessment; post-mining land-use selection and mine planning for optimum reclamation of all mines: metal, nonmetal, and coal; unit operations of reclamation: drainage, backfill, soil replacement, revegetation, maintenance, etc. Prerequisites: Ge Eng 50; Mi Eng 324 and 326 or prereq./coreq. Cv Eng 215. (Co-listed with Ge Eng 376)

383 Tunneling & Underground Construction Techniques (LEC 2.0 and LAB 1.0) Cover both mechanical excavation and conventional excavation techniques to underground tunneling and construction. The emphasis will be on equipment selection and prediction of performance expected of the equipment. Ground control systems will be covered as technology emerges. Excavation methods and support of large caverns, often found in civil structures, will also be discussed. A limited focus will be on underground construction specifications and

underground advance rate and cost estimation techniques. Prerequisites: Min Eng 331, Min Eng 324 or Civ Eng 215, Civ Eng 216 or Geo Eng 371.

390 Undergraduate Research (IND 0.0-6.0) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

392 Mine Design Project I (LAB 1.0) Formation of mine design project teams and acquisition of project data from industry. Geostatistical methods for ore reserves estimation. Develop complete project schedule and milestones for executing the project tasks in MIn Eng 393 (Mine Design Project II). Set up database for Min Eng 393 and interact with selected mine design software packages.

393 Mine Design Project II (LEC 1.0 and LAB 3.0) Capstone project with written and oral presentations. Includes mine design and optimization, production plan, equipment and flowsheet design based on geology, resources/reserves, geotechnics, hydrology and hydro-geology. Project also incorporates markets, environmental and permitting, mine-mill organization, support facilities, economic and risk analyses. Prerequisite: Min Eng 392 and completion of 110 hours in the Mining Engineering Curriculum.

Multiculturalism & Diversity

Multiculturalism & Diversity Minor

The minor requires 15 hours in a minimum of 3 of 4 Humanities and Social Sciences (HSS) departments: the Departments of Arts, Languages & Philosophy; English & Technical Communication; History & Political Science; and Psychology. The academic home for this minor will be the HSS department in which the student takes the majority of their classes. Courses offered by these departments that can be included in the minor are listed below.

Arts, Languages & Philosophy:

One 3rd level basic study course in a foreign language (German, Spanish, French, or Russian)*, French 360 (French Culture and Civilization), Philosophy 340 (Social Ethics), Russian 360 (Russian Civilization), Speech 235 (Intercultural Communication)

English and Technical Communication:

English 102 (World Literature I), English 215 (Literature by Women), English 230 (Black American Literature), English 378 (The American Experience)

History and Political Science:

History 226 (Modern East Asia), History 355 (The History of Black America), History 360 (History of the American Family), Political Science 226 (International Relations), Political Science 350 (The Politics of the Third World)

Psychology:

Psychology 350 (Psychology of Women)
Psychology 380 (Cross-Cultural Psychology)

***Specific 3rd Level Language Courses**

French 80 (French Readings and Composition), 90 (Scientific French), 110 (Basic French Conversation), 170 (Masterpieces of French Literature), 180 (Basic French Composition), 311 (Advanced French Composition), 370 (Survey of French Literature I), 375 (Survey of French Literature II)

German 70 (Classic and Modern German Readings), 90 (Scientific German), 110 (Basic German Conversation), 170 (Masterpieces of German Literature), 180 (Basic German Composition), 311 (Advanced German Composition), 370 (Survey of German Literature I), 375 (Survey of German Literature I), 385 (The German Novelle)

Russian 80 (Readings in Science and Literature), 110 (Basic Russian Conversation), 170 (Masterpieces of Russian Literature), 180 (Basic Russian Composition), 311 (Advanced Russian Conversation), 370 (Survey of Russian Literature I), 375 (Survey of Russian Literature I)

Spanish 80 (Readings and Composition), 90 (Scientific Spanish), 110 (Basic Spanish Conversation), 160 (Hispanic Culture), 170 (Masterpieces of Hispanic Literature), 180 (Intermediate Spanish Composition), 311 (Advanced Spanish Conversation), 377 (Spanish-American Novel and Short Story), 378 (Novela Proletaria)

Music

At Missouri S&T, music offerings include bands, orchestras, choirs, and the Collegium Musicum. Credit may be earned by participating in these groups.

You can take courses in various areas of music appreciation, music history and theory, special projects courses in music, and private applied music instruction.

The music minor is available and you may elect this as a broadening aspect to your education.

Faculty

Professor:

David Oakley (Emeritus), D.M.E., Indiana

Assistant Professor:

Joel Kramme, (Emeritus) M.A., Iowa

Robert Cesario, D.M.A., University of Northern Colorado

Lecturer:

Lorie Francis, M.M., Colorado

Music Minor Curriculum

- 1) The following courses will be taken:
 - A) Eight hours of theory.
 - B) Six hours of music history and literature.
 - C) Six hours of applied private instruction (two years), culminating in an approved recital or other appearance.

- 2) The successful music minor will demonstrate adequate keyboard proficiency or take keyboard until proficiency is attained.
- 3) The music minor will participate in one or more major ensembles per semester (band, jazz, orchestra, vocal, opera).

Music Courses

- 11 **Individual Music Instruction I** (LAB 1.0-2.0) Individual music instruction in student's concentration area. Consent of instructor required.
- 21 **Individual Music Instruction II** (LAB 1.0-2.0) Individual music instruction in student's concentration area. Prerequisite: Consent of instructor.
- 30 **University Band** (LAB 2.0) Open to all students who play a band instrument. This ensemble is both the "Miner" Marching Band and the Missouri S&T Symphonic Band. Students assigned to the ensemble after satisfactory audition.
- 32 **University Orchestra** (LAB 2.0) Open to all students who play stringed, wind, percussion or keyboard instruments used in the symphony orchestra. Students assigned to the orchestra after satisfactory audition.
- 33 **Highland Pipe Band** (LAB 1.0) A musical unit of bagpipes and drums for performance at campus, military, and other functions. An elective not to satisfy humanities elective. Consent of instructor required.
- 34 **Instrumental Chamber Ensemble-Strings** (LAB 1.0) Open to all students who play violin, viola, cello or double bass. Students assigned to the ensemble after satisfactory audition.
- 35 **Wind And Percussion Ensemble** (LAB 1.0) Open to all students who play wind or percussion instruments.
- 36 **Jazz Ensemble** (LAB 1.0) A study of the various instrumental jazz forms. Students are assigned by audition to a jazz ensemble. Prerequisite: Consent of instructor.
- 40 **University Choir** (LAB 1.0) Open to any student of the university. Students assigned after satisfactory audition.
- 41 **Chamber Vocal Ensembles** (LAB 1.0) The members are selected by audition and organized into interest groups-madrigal, pops ensemble, and chamber choir.
- 42 **Collegium Musicum - King'S Musicke** (LAB 1.0) Study and performance of renaissance and early Baroque instrumental music using historical reproductions of period instruments and appropriate performance techniques. Performances on and off campus each semester. A skills course, not a humanities elective. Prerequisite: Consent of instructor and audition.
- 43 **Collegium Musicum - Madrigal Singers** (LAB 1.0) Study and performance of renaissance and early Baroque vocal music using performance techniques appropriate to the period. Performances on and off campus each semester.

A skills course, not a humanities elective.
Prerequisite: Consent of instructor and audition.

- 50 Music Understanding And Appreciation** (LEC 3.0) A study of the development of music with emphasis on understanding music forms and the role music has played in the various historical periods.
- 100 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 101 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 111 Individual Music Instruction III** (LAB 1.0-2.0) Individual music instruction in student's concentration area. Prerequisite: Consent of instructor.
- 121 Individual Music Instruction IV** (LAB 1.0-2.0) Individual music instruction in student's concentration area. Prerequisite: Consent of instructor.
- 161 Theory Of Music I** (LEC 3.0 and LAB 1.0) Basic musicianship. Notation, rhythm, meter, scales, intervals, triads, nonharmonic tones, major-minor seventh, modulations of common practice period. Strong emphasis on aural perception, sight-singing, and key-board performance of these materials. Applications of these materials in original composition and analysis of melodies and elementary homophonic form.
- 162 Theory Of Music II** (LEC 3.0 and LAB 1.0) A continuation of the requisite theory and fundamentals of music I. Prerequisite: Music 161.
- 200 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 201 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 210 Seminar** (IND 0.0-6.0) Discussion of current topics.
- 251 History And Analysis Of Music I** (LEC 3.0) General survey of history of music from Greek period to 18th century. Score reading required. Prerequisite: Music 162.
- 252 History And Analysis Of Music II** (LEC 3.0) General survey of history of music from the 18th century to the present. Score reading required. Prerequisite: Music 251.
- 300 Special Problems** (IND 0.0-6.0) Problems or readings on specific subjects or projects in the department. Consent of instructor required.
- 301 Special Topics** (Variable 0.0-6.0) This course is designed to give the department an opportunity to test a new course. Variable title.
- 310 Symphonic Bands** (LAB 1.0) An auditioned ensemble. Students perform music for wind ensemble and large bands. Music from 1400-present is performed in a concert setting. Prerequisite: Consent of instructor - audition only.