School of Engineering

- Aerospace Engineering
- Architectural Engineering
- Basic Engineering
- Engineering Graphics
- Chemical Engineering
- Civil Engineering
- Environmental Engineering
- Computer Engineering
- Electrical Engineering
- Engineering Management
- Engineering Mechanics
- Freshman Engineering
- Mechanical Engineering

Aerospace Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy

The Aerospace Engineering program is offered in the Department of Mechanical and Aerospace Engineering and Engineering Mechanics. In aerospace engineering, you will apply the laws of physics and mathematics to problems of aircraft flight and space vehicles in planetary atmospheres and adjoining regions of space. Maybe you will design space shuttles, rockets, or missiles. Possibly you might design military, transport, and general aviation aircraft, or a V/STOL (vertical/short take-off and landing) aircraft. You could design a spacecraft to travel to Mars or a more distant planet.

You'll be able to tackle problems in the environmental pollution of air and water and in the natural wind effects on buildings and structures. Designing all types of transportation systems, including high speed vehicles, urban rapid transit systems, and undersea craft, might be some of the challenges you will undertake.

Your professional training in aerospace engineering will be directed generally toward the analysis and design of aerospace vehicles, including aircraft, missiles, and spacecraft with special emphasis on the fundamental treatment of aerospace science. You will accomplish your goals through your basic training in gas dynamics, stability control dynamics, structures, propulsion, and aerodynamics including cross-lineage between these areas. You will use this knowledge to design, build, and flight test aerospace systems during the sophomore and senior years.

Your studies at UMR will include both basic science and engineering science, mathematics, and liberal arts courses as well as advanced aerospace engineering courses. Within aerospace engineering, you can choose nine hours of technical electives in a special interest area such as aerodynamics, dynamics structures, composites, flight dynamics, controls, propulsion, and aeroelasticity.

Your design courses will be integrated with UMR's computer graphics system to unify the graphical capabilities of the computer into your design experience. The Mechanical and Aerospace Engineering and Engineering Mechanics Department also has a departmental honors program. This program provides enhanced 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. Undergraduate departmental research opportunities are also available through the NASA Space Grant Consortium and the OURE program.

Classes and laboratories are held in the Mechanical Engineering Building. There is a Mach 1.5 to 4 supersonic blow down wind tunnel with a five-inch diameter jet which has continuous run-time duration's of up to five minutes. There is instrumentation for Schlieren photography, pressure, temperature, and turbulence measurements. A large subsonic wind tunnel, capable of speeds of up to 300 miles per hour, has a test section 4 feet wide by 2.7 feet high by 11 feet long and is complemented by a three-component balance system. Other facilities include flight simulation laboratory, space systems engineering laboratory, aerospace structural test equipment, propulsion component analysis systems, and shock tubes.

Mission Statement

To build and enhance the excellent public program that the Department of Mechanical and Aerospace Engineering and Engineering Mechanics 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.

UMR Aerospace Engineering graduates will have:

1) A solid foundation of principles of science and engineering with strong background in mathematics and physics to serve as foundation for life-long learning.
2) A solid technical knowledge in the areas of aerodynamics, materials, structures, stability and control, propulsion, and aerothermochemistry including cross-linkage among the areas.
3) The ability to apply engineering knowledge and skills to engineering analysis, solve open-ended problems, design projects, and develop useful products and processes.
4) The ability to work in team environment, create group synergy in pursuing a given goal, and communicate technical information in written, oral, visual and graphical formats.
5) An awareness and understanding of their moral, ethical, and professional obligations to protect human health and the environment.

Aerospace Program Outcomes:

Aerospace graduates will be able to:
A) Apply knowledge of mathematics, science, and engineering.
B) Design and conduct experiments, as well as to analyze and interpret data.
C) Design a system, component, or process to meet desired needs.
D) Function on multi-disciplinary teams.
E) Identify, formulate, and solve engineering problems.
F) Understand professional and ethical responsibility.
G) Communicate effectively.
H) Understand the impact of engineering solutions in a global and societal context.
I) Engage in life-long learning
J) Handle contemporary issues.

K) Use the techniques, skills, and modern engineering tools necessary for engineering practice.

Faculty

Professors:

S.N. Balakrishnan, Ph.D., University of Texas,at Austin
K. Chandrashekhara, Ph.D., Virginia Polytechnic Institute and State University
Donald Cronin Ph.D., California Institute of Technology
L. R. Dharani, Ph.D., Clemson
Walter Eversman[1] (Curators'), Ph.D., Stanford
Fathi Finaish (Associate Chair), Ph.D., University of Colorado
K.M.Isaac, Ph.D., Virginia Polytechnic Institute and State University
Leslie R. Koval, Ph.D., Cornell
H. Frederick Nelson[1], Ph.D., Purdue
David W. Riggins, Ph.D., Virginia Polytechnic Institute and State University

Associate Professors:

Gearoid MacSithigh, Ph.D., Minnesota
Henry J. Pernicka, Ph.D., Purdue

Emeritus Professors:

Donald Cronin (Emeritus), Ph.D., California Institute of Technology
Leslie R. Koval (Emeritus), Ph.D., Cornell
Shen Ching Lee[1] (Emeritus), Ph.D., Washington
Terry Lehnhoff[1] (Emeritus), Ph.D., Illinois
Robert Oetting[1] (Emeritus), Ph.D., Maryland
Bruce Selberg (Emeritus), Aerospace Engineer, University of Michigan

[1]Registered Professional Engineer

Bachelor of Science Aerospace Engineering

FRESHMAN YEAR

First Semester	Credit
Basic Engineering 10	1
Chemistry 5[1]	5
English 20	3
Math 14[4]	4
H/SS History elective[2]	3
	16
Second Semester	
Basic Engineering 20	3
Math 15[4]	4
Physics 23[4]	4
H/SS Economics elective[3]	3
	14

SOPHOMORE YEAR

First Semester	Credit
Cmp Sc 73 or 74-Basic Sci Prog	2
Cmp Sc 77 or 78-Comp Prog Lab	1
Bas Eng 50 or 51-Eng Mech-Statics	3
Math 22-Calc/Analy Geom III[4]	4
Physics 24-Eng Physics II	4
Ae Eng 161-Aero Vehicle Performance	3
	17
Second Semester	
Ae Eng 180-Intro to Aerospace Design	2
EMech 160-Eng Mech-Dyn[5]	3
Mc Eng 219-Thermodynamics[4,5]	3
Math 204-Elem Diff Equations	3
Bas Eng 110-Mech of Materials	3
Elective/Literature	3
	17

JUNIOR YEAR

First Semester	Credit
Ae Eng 213-Aerospace Mech I[4]	3
Ae Eng 231-Aerodynamics I[4,5]	3
Ae Eng 377-Princ of Eng Materials	3
El Eng 281-Electrical Circuits	3
Electives-Advanced Math/Cmp Sc[6]	3
	15
Second Semester	
Ae Eng 251-Aerospace Structures I[4]	3
Ae Eng 261-Flight Dynamics and Control	3
Ae Eng 271-Aerodynamics II	3
Ae Eng 282-Exp Methods in Ae Eng I	2
Elective/Free[10]	3
Elective/Communications[8]	3
	17

SENIOR YEAR

First Semester	Credit
Ae Eng 210-Seminar	1
Ae Eng 235-Aircraft & Space Vehicle Propulsion	3
Ae Eng 253-Aerospace Structures II	3
Ae Eng 280 or 380-	2
Ae Eng 283-Experimental Methods in Ae Eng II	2
Electives-Technical[7]	3
Electives/Hum/Soc Sci[9]	3
	17
Second Semester	
Ae Eng 281 or 382-Aero Sys Design II	3
Electives-Technical[7]	3
Electives-Technical[7]	3
Electives Free[10]	3
Electives-Hum/Soc Sci[9]	3
	15

List of Notes:

1) Chemistry 1 and 2 or Chemistry 5, depending on placement and Chemistry 4 or an equivalent training program approved by UMR.
2) Must be one of the following: Political Science 90, History 112, History 175, or History 176.
3) Must be one of the following: Economics 121 or Economics 122.
4) A grade of "C" or better in Math 14, 15, 22, and Physics 23 is required both for enrollment in ME 219, AE 213, AE 231, or AE 251 and for graduation.
5) A grade of "C" or better in EM 160 and ME 219 is required both for enrollment in any courses which require either EM 160 or ME 219 as prerequisites and for graduation.
6) Must be one of the following: Comp Sc 228, Math 203, Math 208, or any 300-level math or computer science course approved by the student's advisor.
7) Electives must be approved by the student's advisor. Nine hours of technical electives must be in the Mechanical and Aerospace Engineering and Engineering Mechanics department. Three hours of departmental technical electives must be at the 300-level.

Honors students have special requirements for technical electives.

[8)] This course can be selected from English 60, 160, SP&MS 85, or the complete four-course sequence in Advanced ROTC (Mil Sc 105, 106, 107, and 108 or Aerospace Studies 350, 351, 380, and 381).

[9)] All electives must be approved by the student's advisor. Students must comply with the School of Engineering general education requirements with respect to selection and depth of study. These requirements are specified in the current catalog.

[10)] 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.

NOTE: All Aerospace 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 UMR assessment process as described in Assessment Requirements found elsewhere in the catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

Requirements for a Minor in Aerospace Engineering

A student who receives a bachelor of science degree in an accredited engineering program from UMR may receive a minor in aerospace engineering by completing the 15 hours of courses listed below. Students must satisfy the prerequisite requirements for each course. The department granting the bachelor of science degree shall determine whether or not courses taken for the minor may also be used to fulfill the requirements of the B.S. degree.

- Ae Eng 161-Aerospace Vehicle Performance
- Ae Eng 213-Aerospace Mechanics I
- Ae Eng 231-Aerodynamics I
- Ae Eng 251-Aerospace Structures I
- Ae Eng 200 level 3-hour lecture course (student choice)

Aerospace Engineering Courses

060 Introduction to Aviation (Lect 3.0) A general introduction to aviation and preparation for the Federal Aviation Administration private pilot written examination. Areas of study include theory of flight, communication procedures, use of the flight computer, aviation weather, visual and radio navigation, federal aviation regulations. Prerequisite: (Entrance requirements).

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

161 Aerospace Vehicle Performance (Lect 3.0) Aerospace Vehicle Performance (Lect 3.0) Nature and theory of lift, drag, performance, and stability and control of aerospace vehicles. Prerequisite: Physics 23..

180 Introduction to Aerospace Design (Lab 2.0) Introduction to Aerospace Design (Lab 2.0) Introduction to methodology of aerospace vehicle design and principles of layout to meet a given specification, mission objective, component sizing, design iteration and building & performance testing of models. Prerequisite: Ae Eng 161..

200 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

202 Cooperative Engineering Training (Variable) Cooperative Engineering Training (Variable) On-the-job experience gained through cooperative education with industry with credit arranged through departmental co-op adviser. Grade received depends on quality of reports submitted and work supervisor's evaluation.

210 Seminar in Aerospace Engineering (Lect 1.0) Discussion of current topics.

213 Aerospace Mechanics I (Lect 3.0) Aerospace Mechanics I (Lect 3.0) Introduction to celestial mechanics and an analytical study of space flight. Emphasis is placed on satellite orbits and general theory of gyrodynamics. Prerequisites: E Mech 160 and a grade of "C" or better in Math 14 (or 8), 15 (or 21), 22, and Physics 23.

231 Aerodynamics I (Lect 3.0)3.0) A study of the fundamental concepts of fluid mechanics as applied to aerodynamic applications with both differential and control volume analysis. Theory and application of viscous and inviscid incompressible flow including boundary layer theory and two dimensional airfoil theory. Prerequisites: Accompanied or preceded by Ae Eng 161 and a grade of "C" or better in Math 14 (or 8), 15 (or 21), 22, Physics 23, and Mc Eng 219.

235 Aircraft and Space Vehicle Propulsion (Lect 3.0) Analysis of aircraft and missile propulsion systems; fundamentals of jet propulsion including air breathing and rocket engines. Introduction to advanced propulsion systems for space flights such as nuclear, thermonuclear, and plasma jets. Prerequisite: Mc Eng 231, or Ae Eng 271.

251 Aerospace Structures I (Lect 3.0) An introduction to various loads on aerospace vehicles. Basic theory and analysis of typical aerospace and related vehicle structures subjected to steady loading. An overview of various failure theories including yielding, buckling, fracture and fatigue. Design of thin walled structures. Introduction to advanced composite materials. Prerequisites: Bas En 110 and a grade of "C" or better in Math 14 (or 8), 15 (or 21), 22, and Physics 23.

253 Aerospace Structures II (Lect 3.0) Introduction to the finite element method for static and dynamic analysis of aerospace structures. Analysis of beams, trusses and frames. Plane stress and plane strain analysis. Isoparametric elements and numerical integration. Free vibration and time dependent problems.

261 Flight Dynamics and Control (Lect 3.0) Static stability and control of conventional aircraft and implications in aircraft design. Six degrees of freedom time dependent equations of motion and their linearized solutions. Consideration of stability vs maneuverability, and the dynamic modes of motion of the aircraft. Prerequisites: Ae Eng 213, Ae Eng 231, and accompanied or preceded by Ae Eng 180.

271 Aerodynamics II (Lect 3.0) Three dimensional incompressible wing theory. Compressible one dimensional flow with normal and oblique shock waves, heat addition, and friction. Compressible transonic, and supersonic linearized flow theory. Supersonic wings and wing/fuselage configurations. Prerequisite: Ae Eng 231.

273 Aerodynamics Applied to Current Problems (Lect 3.0) Applications of aerodynamic principles to current problems including such topics as V/STOL aerodynamics, transonic and hypersonic aerodynamics, sonic boom, rarefied gas dynamics, reactive aerodynamics. Additional topics in diffusion and dispersion processes of micro-, macro-, meso-, and global-scale aerodynamics. Prerequisite: Ae Eng 271.

280 Aerospace Systems Design I (Lect 2.0) Consideration of the creative design process with emphasis on aeronautical-aerospace systems. Short design problems to illustrate the process. Selection of design projects for AE 281. Information gathering for the design projects which will be completed in Aerospace Systems Design II. Fall semester. Prerequisites: Ae Eng 251, 261, 271.

281 Aerospace Systems Design II (Lab 3.0) Preliminary design of aerospace systems. Project to integrate the knowledge of different aerospace engineering areas through synthesis and analysis. The creative design will include a consideration of such factors as performance reliability, cost, human factors, energy and ecology. Spring semester. Prerequisites: Ae Eng 235, 253, 280.

282 Experimental Methods in Aerospace Engineering I (Lab 2.0) Introduction to experimental methods in low-speed aerodynamics, flight simulation, and aircraft structures. Measurements of drag, boundary layer flows, and aerodynamic forces and moments. Flight simulations, and structural testing of aircraft components. Statistical methods and probability.

283 Experimental Methods in Aerospace Engineering II (Lab 2.0) Laboratory investigations related to aerospace engineering. Investigations include high-speed aerodynamics, flow visualization measurements in turbulent flow, aircraft vibration and flutter, propeller acoustics, flight simulation, propulsion systems, flame measurements, and control experiments. Statistical error analysis. Prerequisites: Ae Eng 251, 261, 271, & 282.

300 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

307 Vibrations I (Lect 3.0) Equations of motion, free and forced vibration of single degree of freedom systems. Natural frequencies, resonance, modes of vibration and energy dissipation are studied. The vibration of continuous systems is introduced. Prerequisites: Mc Eng 211 and 213, or Ae Eng 213 and Math 204. (Co-listed with Mc Eng 307, E Mech 361).

309 Engineering Acoustics I (Lect 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 & 213, or Ae Eng 213 & Math 204. (Co-listed with Mc Eng 309).

311 Introduction to Composite Materials & Structures (Lect 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: Bas En 110. (Co-listed with E Mech 381 and Mc Eng 382).

313 Intermediate Dynamics of Mechanical and Aerospace Systems (Lect 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 Mc Eng 313)

314 Spaceflight Mechanics (Lect 3.0) Further topics in orbital mechanics. Time equations, Lambert's problem, patched-conic method, orbital maneuvers, orbit determination, orbit design, re-entry problem. Prerequisite: Ae Eng 213.

315 Concurrent Engineering I (Lect 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: Mc Eng 213 or Ae Eng 231, and Bas En 110. (Co-listed with Mc 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 Mc Eng 316).

319 Advanced Thermodynamics (Lect 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: Ae Eng 233. (Co-listed with Mc Eng 319).

321 Aerodynamics CAD design (Lab 3.0) Aircraft fuselages, wings, and fuselage-wing configurations will be constructed with a 3D CAD package, UNIGRAPHICS. These configurations will then be analyzed with an aerodynamics paneling program. Emphasis will be placed on the designing of these shapes for maximizing the aerodynamic performance. Prerequisite: Ae Eng 231.

322 Introduction to Solid Mechanics (Lect 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 E Mech 322, Mc Eng 322).

325 Intermediate Heat Transfer (Lect 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 Mc Eng 325).

327 Combustion Processes (Lect 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 Mc Eng 327)

329 Smart Materials and Sensors (Lect 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 Mc Eng, E Mech, El Eng 329 and Cv Eng 318).

331 Thermofluid Mechanics II (Lect 3.0) Derivation of Navier-Stokes equations, exact solutions of some simple flows. Superposition methods for inviscid flows. Intermediate treatment of boundary layer theory, and gas dynamics. Introduction to turbulence and kinetic theory. Prerequisite: Mc Eng 231 or Ae Eng 231. (Co-listed with Mc Eng 331)

334 Stability of Engineering Structures (Lect 3.0) Formulation of stability concepts associated with columns, beams, and frames. Applications to some engineering problems utilizing numerical methods. Prerequisites: Bas En 110; Math 204 & either Bas En 150 or E Mech 160. (Co-listed with Mc Eng 334, E Mech 334).

335 Aerospace Propulsion Systems (Lect 3.0) Study of atmospheric and space propulsion systems with emphasis on topics of particular current interest. Mission analysis in space as it affects the propulsion system. Power generation in space including direct and indirect energy conversion schemes. Prerequisite: Ae Eng 235.

336 Fracture Mechanics (Lect 3.0) Linear elastic and plastic mathematical models for stresses around cracks; concept of stress intensity; strain energy release rates; correlation of models with experiment; determination of plane stress and plane strain parameters; application to design. Prerequisite: Bas En 110. (Co-listed with Mc Eng 336, E Mech 336).

339 Computational Fluid Mechanics (Lect 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: Cmp Sc 73, one course in fluid mechanics. (Co-listed with Mc Eng 339).

341 Experimental Stress Analysis I (Lect 2.0 and Lab 1.0) Acquaints the student with some techniques of experimental stress analysis. Principal stresses, strain to stress conversion, mechanical and optical strain gages, electrical resistance strain gages, transducers, and brittle coatings. Prerequisite: Bas En 110. (Co-listed with Mc Eng 341, E Mech 341).

342 Experimental Stress Analysis II (Lect 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: Bas En 110, E Mech 321. (Co-listed with Mc Eng 342, E Mech 342).

343 Photographic Systems for Engineering Applications (Lect 2.0 and Lab 1.0) Study of photographic techniques applied to engineering uses including observations of events, recording and storage of data, and communication and dissemination of information. Both conventional and special photo-optical systems are covered. Prerequisite: Senior standing. (Co-listed with Mc Eng 343)

344 Fatigue Analysis (Lect 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: Bas En 110. (Co-listed with E Mech 337, Mc Eng 338).

349 Robotic Manipulators & Mechanisms (Lect 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, Ae Eng 213. (Co-listed with Mc Eng 349).

350 Integrated Product Development (Lect 2.0 and Lab 1.0) Students in design teams will simulate the industrial concurrent engineering development process. Areas covered will be design, manufacturing, assembly, cost, and product support. Using a 3-D solid modeling program, students will design, analyze, and send the data base to the automated machine shop where the parts will be manufactured. The parts will then be assembled, tested and analyzed for their performance. Prerequisites: Ae Eng 251 or Mc Eng 208 for Design; Mc Eng 213 for Assembly; Accompanied or preceded by Mc Eng 353 for Manufacturing; Eng Mg 375 or 385 for Cost/Product Support.

351 Intermediate Aerospace (Lect 3.0) Discussion of the finite element method for static and dynamic analysis of complex aerospace structures. Solution of basic problems using established finite element computer programs. Prerequisite: Ae Eng 253 or Mc Eng 212. (Co-listed with Mc Eng 351).

352 Finite Element Approximation I—An Introduction (Lect 3.0) Variational statement of a problem. Galerkin Approximation, finite element basis functions and calculations, element assembly, solution of equations boundary conditions, interpretation of the approximation solution, development of a finite element program, two-dimensional problems. Prerequisite: Math 204. (Co-listed with Mc Eng 312, E Mech 307).

353 Aeroelasticity (Lect 3.0) Study of phenomena involving interactions among inertial, aerodynamic, and elastic forces and the influence of these interactions on aircraft and space vehicle design. Some aeroelastic phenomena are: divergence, control effectiveness, control reversal, flutter, buffeting, dynamic response to rapidly applied loads, aeroelastic effects on load distribution, and static and dynamic stability. Prerequisites: Ae Eng 251 and 271.

361 Flight Dynamics-Stability and and Control (Lect 3.0) Review of static stability, dynamic equations of motion, linearized solutions, classical control design and analysis techniques, introduction to modern control. Prerequisite: Ae Eng 261.

362 Experimental Vibration Analysis (Lect 2.0 and Lab 1.0) Methods for measuring and analyzing motion and strain response of dynamically excited structures. Includes frequency-response testing of elementary beam, torsion bar, plate and shell structures. Experiments on the effectiveness of isolators and dynamic absorbers. Prerequisite: E Mech 361 or Mc Eng 307 or Ae Eng 307. (Co-listed with Mc Eng 362, E Mech 362).

369 Introduction to Hypersonic (Lect 3.0) A study of the basic principles of hypersonic flow. Invisvid and viscous hypersonic flow. Application of numerical methods. High temperature flow. Consideration of real gas and rarefied flow. Applications in aero-dynamic heating and atmospheric entry. Prerequisite: Ae Eng 271 or Mc Eng or Ae Eng 331.

371 V/STOL Aerodynamics (Lect 3.0) Basic concepts of V/STOL flight. Take-off transition and landing performance, thrust vectoring. Propeller and helicopter aerodynamics. Unblown and blown flaps. Boundary layer control. Lift fans and ducted propellers. Wing-propeller interaction and thrust augmentation. Prerequisite: Ae Eng 271.

377 Principles of Engineering (Lect 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 Ch Eng 347, Physics 377, Mt Eng 377, Cr Eng 377).

380 Spacecraft Design I (Lect 3.0) Fundamentals of spacecraft design. Systems engineering, subsystem analysis and design. Gantt charts, organizational charts. Oral presentations and technical documentation. Term project to involve design and development of actual flight hardware, continuing into Spacecraft Design II. Prerequisites: Ae Eng 251, 261, and 271 for Ae Eng majors; consent of instructor for non-Ae Eng majors.

381 Mechanical and Aerospace Control Systems (Lect 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 Mc Eng 381).

381 Spacecraft Design II (Lab 3.0) As a continuation of Ae Eng 380, detailed spacecraft design is performed, leading to procurement of components. As schedules permit, spacecraft fabrication and test commence. Development of labs to facilitate spacecraft test, operation, and data analysis continues. Prerequisites: Ae Eng 235, 253, and 380 for Ae Eng majors; consent of instructor for non-Ae Eng majors.

390 Undergraduate Research (Variable) 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.

Architectural Engineering

Bachelor of Science

Emphasis areas include structural engineering, construction engineering and project management, environmental systems for buildings, and construction materials.

Architectural engineers plan, design, and supervise construction of many essential facilities and structures for residential commercial, industrial and institutional buildings. These building systems include electrical, communications and control, lighting, heating, ventilating, air conditioning, fire protection, plumbing, and structural systems. Architectural engineers are problem solvers ... applying the latest in high-tech equipment and sophisticated procedures to address challenges concerning our environment and infrastructure. The diversity of architectural engineers complements the use of multiple systems to the intent and purpose of the project's design.

The Bachelor of Science in Architectural Engineering (BSAE) degree requires satisfactory completion of 138 credit hours. In your first two years, you will complete mathematics, physics, English, architectural design and other prerequisite courses. In your third and fourth years, most of your course work will be in engineering sciences. Also in your fourth year you will complete engineering design courses in general and specific areas.

Courses in structural, electrical, mechanical and lighting design are directed toward providing reliable and economical structures such as stadiums, retail complexes, office buildings and airports. Courses in construction engineering include studies in construction techniques, cost estimating, quality control/quality assurance, and contract administration. History, architectural design and humanities provide the necessary tools to appreciably coexist in the fabric of society.

Architectural engineering is a broad field of endeavor. Because of this breadth, courses are required in each of the above areas. Although you, as a architectural engineer, may specialize within a given area, by the very nature of the profession you will be required to interact with specialists in the other areas. You will find that you will be working with architects and engineers in the other disciplines in the planning, design, and construction of complex facilities.

Architectural engineers also must be effective in communicating with the public. You may be expected to work with property owners, concerned citizens, city officials, attorneys, and even medical doctors for concerns related to public health measures. The results of your work as a architectural engineer will be seen everywhere. Projects in which you will become involved must be economical, appreciable to self and community, and provide a reasonable life expectancy. Use of computer hardware and software is a key component of the BSAE program of study.

Mission Statement

The Architectural Engineering Program will provide students with the tools necessary to solve architectural engineering problems critical to our society's well-being. This will be accomplished through a comprehensive, forward-looking and broad-based architectural engineering curriculum emphasizing fundamentals, practical applications, oral and written communication skills, computer applications skills, and professional practice issues and ethics. The Program will prepare graduates for entry into the architectural engineering profession, for life-long learning, and to function as architectural engineers in a global society.

BSAE Program Objectives

Our graduates will have:

1) a strong fundamental scientific and technical knowledge base which they will be able to apply to experimental design, and analysis and interpretation of data in conducting experiments;

2) an ability to apply engineering skills and work in multi-disciplinary teams to identify and formulate solutions for architectural engineering problems, and to analyze and design architectural engineering projects;

3) a recognition of the professional and personal value of the continuing acquisition of knowledge;

4) competence in the use of the latest tools and techniques in architectural engineering practice and the ability to effectively communicate resulting technical and professional information in written, oral, and visual formats; and,

5) an awareness and understanding of the ethical, legal and professional obligations needed to function as part of a professional enterprise and to protect human health and welfare, and the environment in a global society.

Faculty

Professors:

Abdeldjelil Belarbi, Ph.D., Houston

Walter Eversman[1] (Curators'), Ph.D., Stanford

Roger LaBoube[1] (Distinguished Teaching Professor), Ph.D., Missouri-Rolla

Antonio Nanni[1] (Vernon and Maralee Jones Professor), Ph.D., Miami
Thomas M. Petry[1], Ph.D., Oklahoma State
Harry Sauer[1], Ph.D., Kansas State
William Schonberg[1] , Ph.D., Northwestern
E. Keith Stanek[1] (Fred Finley Distinguished Professor), Ph.D., Illinois Institute of Technology
Richard Stephenson[1], Ph.D., Oklahoma State

Associate Professors:
Jerry Bayless[1] (Associate Dean of Engineering),M.S., Missouri-Rolla
Genda Chen[1], Ph.D., Suny-Buffalo
Rodney Lentz[1], Ph.D., Michigan State
Ronaldo Luna[1], Ph.D., Georgia Tech.
David Richardson[1], Ph.D., Missouri-Rolla

Assistant Professors:
John Myers[1], Ph.D., Texas-Austin
William Eric Showalter, Ph.D., Purdue
Pedro F. Siva[1], Ph.D., California, San Diego
Stuart Baur[2], Ph.D., Missouri - Rolla
Jeff Schramm, Ph. D., Lehigh

[1]Registered Professional Engineer
[2]Registered Architect

Bachelor of Science Architectural Engineering

FRESHMAN YEAR

First Semester	Credit
Chem 1 & 2-Gen Chem for Eng	5
Math 14-Calc for Engr I	4
English 20-Expos & Argumentation	3
General Ed Elective[1]	3
	15
Second Semester	
BE 10-Study & Careers in Eng[2]	1
BE 20-Eng Design w/Comp Appl	3
Math 15-Calc for Eng II	4
Phy 23-Eng Physics I	4
General Ed Elective[1]	3
	15

SOPHOMORE YEAR

First Semester	Credit
CE 001-Fund Survey & Intro to CE[2]	3
BE 50-Eng Mc/Statics[2]	3
Math 22-Calc/Analytic Geom III	4
Physics 24-Eng Physics II	4
ArchE 003-Eng Communication	2
	16
Second Semester	
BE 150 - Engr Mech/Dynamics	2
Stat 213 - Probability & Statistics	3
BE 110-Mech of Materials[2]	3
BE 120-Materials Testing Lab	1
ArchE 103-Mat & Meth of Const	2
Art 203- Arch Design I	3
Math 204-Diff Equations	3
	17

JUNIOR YEAR

First Semester	Credit
ArchE 217-Structural Analysis[2]	3
CE 230 - Elementary Fluid Mech[2]	3
El Eng 281-Elec Circuits	3
ME 227-Thermal Analysis	3
ArchE 204- Arch Design II	3
CE 215 - Elementary Soil Mechanics	3
	18
Second Semester	
ArchE 241 - Econ of Engr Design[2]	2
ArchE 223 - Reinf Concrete Design	3
ME 371 - Environmental Controls	3
CE 216-Construction Materials	3
His 270 - History of Technolgy	3
ArchE 248 - Contracts & Construction Engng	3
	17

SENIOR YEAR

First Semester	Credit
ArchE 210-Senior Seminar	1
ArchE 221-Struct Design Metals	3
ArchE 205-Illumination of Bldgs.	2
History 274-Recent American Art & Tech	3
ArchE Technical Elective[3,4]	3
General Ed Elective[1]	3
	15
Second Semester	
ArchE 298-Senior Design Project	3
ArchE Technical Elective[3,4]	3
CE 229-Foundation/Pavement Eng	3
Free Elective[5]	3
Free Elective[5]	3
	15

1) All general education electives must be approved by the student's advisor. Students must comply with the School of Engineering general education requirements with respect to selection and depth of study. These requirements are specified in the current catalog.
2) A grade of 'C' or better required to satisfy graduation requirements.
3) A grade of 'C' or better may be required in ArchE technical elective prerequisite courses. Refer to the UMR undergraduate catalog for this prerequisite information.
4) Choose technical electives from approved lists under Emphasis Areas for Architectural Engineering Students.
5) 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.

Note: All Architectural 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 UMR assessment process as described in Assessment Re-

quirements found elsewhere in this catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

Emphasis Areas and Course Listings by Area for Architectural Engineering Students

Area I, Structural Engineering

ArchE 301	Structural Analysis II
ArchE 319	Applied Mechanics in Structural Engr
ArchE 322	Analysis and Design of Wood Structures
ArchE 323	Classical and Matrix Meth Strucl Analy
ArchE 326	Advanced Steel Structures Design
ArchE 327	Advanced Concrete Structures Design
ArchE 328	Prestressed Concrete Design
ArchE 329	Foundation Engineering II
Arch E 3XX	Masonry Engineering

Area II, Construction Engineering and Project Management

ArchE 345	Construction Methods
ArchE 346	Management of Construction Costs
ArchE 349	Eng and Construc Contract Specs
ArchE 3XX	Project Delivery System
ArchE 3XX	Construction Project Management
Eng Mg 211	Managing Engineering and Technology
Eng Mg 252	Financial Management
Eng Mg 313	Human Relations in Technical Management
Eng Mg 364	Value Analysis
Eng Mg 375	Total Quality Management

Area III, Environmental Systems for Buildings

Mechanical Emphasis Courses

Mc Eng 309	Engineering Acoustics I
Mc Eng 365	Solar Heating and Cooling
Mc Eng 375	Mech Systems for Environ Control

Electrical Emphasis Courses

El Eng 235	Controllers for Factory Automation
El Eng 282	Electronic Circuits and Machines
El Eng 283	Electronics for Instrumentation
Cp Eng 111/112	Intro to Computer Eng

Area IV, Construction Materials

ArchE 319	Applied Mechanics in Structural Eng
Cv Eng 313	Composition & Properties of Concrete
Cv Eng 317	Pavement Design
Arch E 3XX	Special Concretes
Ch Eng 381	Corrosion and Its Prevention

Architectural Engineering Courses

ArchE 103	Materials and Methods of Construction
ArchE 203	Architectural Design I
ArchE 204	Intro to Architectural Design II
ArchE 205	Illumination of Buildings

(to be developed in AY2003/2004)

ArchE 3xx	Masonry Engineering
ArchE 3xx	Special Concretes

Architectural Engineering Courses (cross–list with existing civil engineering courses)

ArchE 001	Fundamentals of Surveying
ArchE 003	Engineering Communication
ArchE 101	Special Topics
ArchE 200	Special Problems
ArchE 201	Special Topics
ArchE 202	Co-operative Eng Training
ArchE 210	Senior Seminar
ArchE 217	Structural Analysis I
ArchE 221	Structural Design in Metals
ArchE 223	Reinforced Concrete Design
ArchE 241	Economy of Engineering Design
ArchE 242	Building Systems
ArchE 247	Ethical, Legal, and Prof Eng Prac
ArchE 248	Fund of Contracts & Construction Eng
ArchE 298	Senior Design
ArchE 300	Special Problems
ArchE 301	Special Topics
ArchE 310	Seminar
ArchE 320	Intermediate Structural Analysis
ArchE 322	Analysis & Design of Wood Struct
ArchE 323	Classical and Matrix Meth Struct Analy
ArchE 324	Numerical Methods of Structural Analysis
ArchE 326	Advanced Steel Structures Design
ArchE 327	Advanced Concrete Structures Design
ArchE 328	Prestressed Concrete Design
ArchE 345	Construction Methods
ArchE 346	Management of Construction Costs
ArchE 349	Eng & Construction Contract Spec
ArchE 390	Undergraduate Research

Civil Engineering Courses (required courses, emphasis area, and/or technical electives)

Cv Eng 215	Elementary Soil Mechanics
Cv Eng 216	Const Materials, Prop, & Test
Cv Eng 229	Foundation/Pavement Eng
Cv Eng 230	Elementary Fluid Mechanics
Cv Eng 313	Composition and Properties of Concrete
Cv Eng 317	Pavement Design
Cv Eng 329	Foundation Engineering II
Cv Eng 341	Professional Aspects of Eng Practice
Cv Eng 345	Construction Methods
Cv Eng 346	Management of Construction Costs
Cv Eng 349	Eng & Construction Contract Spec

Architectural Engineering Courses

003 Engineering Communications (Lect 1.0 and Lab 1.0) Introduction to programming concepts and software tools (computer aided design drafting, computer mathematics, word processing, spreadsheets, and presentation software) with application to written and oral communication in professional civil and architectural engineering practice. Prerequisite: Sophomore standing. (Co-listed with Cv Eng 003).

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

103 Architectural Materials and Methods of Construction (Lect 2.0) A study of the origin and properties of construction materials, methods of construction, and installation. Materials include mineral based, wood, steel, concrete, masonry, asphalt, and gypsum as components of architectural engineering. Prerequisites: Chem 1, Chem 2 and Sophomore standing.

201 Special Topics (Variable) This course is

designed to give the department an opportunity to test a new course. Variable title.

203 Introduction to Architectural Design I (Lect 1.0 and Lab 2.0) Introduction to the interaction between architecture and the engineering disciplines. Theories of building and site design, technology as an integral component of design, plan and spatial organization, structural clarity, formal composition, and environmental context are considered as principle form determinants. Prerequisite: Sophomore standing

204 Architectural Design II (Lect 1.0 and Lab 2.0) A continuation of Architectural Engineering Design I with an increased focus on problems and models associated with detail development, principles of acoustic design and building construction as a form determinant. Prerequisite: ArchE 203.

205 Illumination for Buildings (Lect 3.0) Design and specification of interior and exterior building illumination systems, including lighting loads, branch circuits and switching. Work includes study of applicable NFPA 70 (NEC) and related building codes. Prerequisites: El Eng 281 and Arch Eng 204.

210 Senior Seminar: Engineering in a Global Society (Lect 1.0) Discussion of contemporary issues: public safety, health, and welfare; the principles of sustainable development; lifelong learning; impact of engineering solutions in a global and societal and political context; relationships with owners, contractors, and the public; public service; the Code of Ethics; and the Missouri licensing Statutes and Board Rules. Prerequisite: Senior standing. (Co-listed with Cv Eng and Env En 210).

217 Structural Analysis I (Lect 2.0 and Lab 1.0) Loads on Structures. Analysis of statically determinate and indeterminate beams, frames and trusses. Influence lines and moving loads. Computation of deflections. Development and use of theorems of displacement methods including slope-deflection and moment distribution to analyze statically indeterminate structures. Computer solutions. Prerequisites: Bas En 50, Bas En 110 each with a grade of "C" or better. (Co-listed with Cv Eng 217).

221 Structural Design in Metals (Lect 2.0 and Lab 1.0) The analysis and design of structural elements and connections for buildings, bridges and specialized structures utilizing structural metals. Both elastic and plastic designs are considered. Prerequisite: Arch Eng 217 with grade of "C" or better. (Co-listed with Cv Eng 221).

223 Reinforced Concrete Design (Lect 2.0 and Lab 1.0) The analysis and design of reinforced concrete beams, slabs, columns, retaining walls and footings by the elastic and ultimate strength methods including and introduction to the design of prestressed concrete. Introduction to use of computers as a design aid tool. Prerequisite: Arch Eng 217 with grade of "C" or better. (Co-listed with Cv Eng 223).

241 Economy of Engineering Design (Lect 1.0 and Lab 1.0) Engineering decision-making procedures with emphasis on time value of money principles. Includes topics such as present, annual, and future worth analysis; rate of return and benefit/cost ratio methods; effects of taxes, depreciation, and inflation on project viability; sensitivity analysis; design component optimization; project financing costs; and applications. Prerequisite: Preceded or accompanied by Stat 213. (Co-listed with Cv Eng 241).

242 Introduction To Building Systems (Lect 3.0) An introduction to life support systems and technology of interest to civil and architectural engineers in the planning and operation of large buildings. Topics include building climate and human comfort; awareness of national building code requirements; fundamentals of building HVAC systems and interior air quality; the principles of plumbing and waste systems; fundamentals of electric power distribution, equipment, and wiring systems; principles of building illumination; building transportation equipment; and the fundamentals of architectural acoustics. Prerequisites: Physics 24, Math 204 and Junior standing. (Co-listed with Cv Eng 242).

247 Ethical, Legal and Professional Engineering Practice (Lect 2.0) Discussions of law concerning contracts, torts, agencies, real property, partnerships and corporations. The purposes and implications of the engineering registration law, the effect of legal, ethical and marketing considerations of the practice of Architectural Engineering. Prerequisite: Junior standing. (Co-listed with Cv Eng 247).

248 Fundamentals of Contracts and Construction Engineering (Lect 3.0) A study of the concepts and techniques used in large construction projects for the preparation of engineer service contracts, the development of a project manuel, detailed and conceptual cost estimating, and construction scheduling analysis. Prerequisite: Junior Standing. (Co-listed with Cv Eng 248).

298 Architectural Engineering Design Project (Lect 1.0 and Lab 2.0) Open-ended building design project involving one or more areas of architectural engineering. Planning design projects, philosophy of design, and the application of architectural engineering principles to design problems. Prerequisite: Arch Eng 248/To be taken final semester.

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

319 Applied Mechanics in Structural Engineering (Lect 3.0) A study of basic relationships involved in the mechanics of structures. Topic include basic elasticity, failure criteria, fundamental theories of bending and buckling of plates and cylindrical shells for practical application in analysis and design of bridge building floors and shell roofs. Prerequisite: Cv Eng 217 with grade of "C"

or better. Co-listed with: Cv Eng 319

322 Analysis and Design of Wood Structures (Lect 3.0) A critical review of theory and practice in design of modern wood structures. Effect of plant origin and physical structure of wood on its mechanical strength; fasteners and their significance in design; development of design criteria and their application to plane and three dimensional structures. Prerequisite: Arch Eng 217 with a grade of "C" or better. Co-listed with: Cv Eng 322

323 Classical and Matrix Methods of Structural Analysis (Lect 3.0) Classical displacement and force methods applied to structures of advanced design. Displacement matrix methods and computer techniques applied to continuous beams, frames, and trusses, plane grid and three dimensional frames. Prerequisite: Arch Eng 217 with grade of "C" or better. Co-listed with: Cv Eng 323

326 Advanced Steel Structures Design (Lect 3.0) The design of structural steel systems into a final integrated structure. Plate girders, composite systems, stability, connections, rigid frames, single and multistory buildings, and similar type problems of interest to the student. Use of the computer as a tool aid in the design will be emphasized. Prerequisite: Arch Eng 221 with a grade of "C" or better. Co-listed with: Cv Eng 326

327 Advanced Concrete Structures Design (Lect 3.0) The design of structural concrete systems into a final integrated structure. Two-way slabs, long columns, connections, and discontinuity regions, deflections and cracking of beams and slabs, ACI design criteria, and similar type problems of interest to the student. Use of the computer as a tool to aid in the design will be emphasized. Prerequisite: Arch Eng 223 with a grade of "C" or better. Co-listed with: Cv Eng 327

328 Prestressed Concrete Design (Lect 3.0) Behavior of steel and concrete under sustained load. Analysis and design of pre-tensioned and post-tensioned reinforced concrete members and the combining of such members into an integral structure. Prerequisite: Arch Eng 223 with a grade of "C" or better. Co-listed with: Cv Eng 328

329 Foundation Engineering II (Lect 3.0) Classical earth pressure theories. Analysis of shallow and deep foundations to include bearing capacity and settlement of footings, rafts, piles and drilled piers. Analysis of stability and design of retaining walls and anchored bulkheads. Prerequisite: Arch Eng 229 with a grade of "C" or better. Co-listed with: Cv Eng 329

345 Construction Methods (Lect 3.0) Introduction to construction planning selection of equipment and familiarization with standard methods for horizontal and vertical construction. Application of network analysis and schedules to project control. Prerequisite: Arch Eng 248 with a grade of "C" or better. Co-listed with: Cv Eng 345

346 Management of Construction Costs (Lect 3.0) Management of construction projects from inception to completion: estimates, role of network preplanning, project monitoring and control. Prerequisite: Arch Eng 248 with agrade of "C" or better. Co-listed with: Cv Eng 346

349 Engineering and Construction Contract Specifications (Lect 3.0) Legal and business aspects of contracts and contracting procedure in the construction industry to include contracts for engineering services and for construction. Analysis, study of precedents, and application of the more important provisions, including changes, differing site conditions, liability, arbitration, termination, disputes, appeal procedure, payments, insurance, inspection, liquidated damages, and technical provisions. Prerequisite: Arch Eng 248 with a grade of "C" or better. (Co-listed with Cv Eng 349).

374 Infrastructure Strengthening with Composites (Lect 2.0 and Lab 1.0) This course presents composites materials and includes principles of reinforcing and strengthening for flexure, shear and ductility enhancement. It covers the design of new concrete members reinforced with composites as well as existing members strengthened with externally bonded laminates or near surface mounted composite. Case studies are discussed and substantial laboratory exposure is provided. Prerequisites: Cv Eng 217 and Cv Eng 223. (Co-listed with Cv Eng 374).

Basic Engineering

The department of basic engineering is a service department dedicated to high quality teaching and advising. The department has responsibility for the Freshman Engineering Program, which is a program of enhanced advising and career information designed to increase the likelihood of success of freshman students, as well as for instruction in engineering graphics and fundamental engineering mechanics courses taken by most engineering students as part of their required undergraduate curriculum. An engineering design and computer applications course is taken by all freshman students in engineering and provides a basis for further design activity in many engineering fields. The fundamental engineering mechanics courses are taken primarily by sophomores and juniors in engineering. The department has excellent computer and materials testing laboratories and is dedicated to providing course work which provides students a sound foundation upon which to build further competence in their chosen engineering fields.

The basic engineering department also houses the Instructional Software Development Center (ISDC). The ISDC is charged with helping faculty evaluate and develop software for use in their classes, the goal being to enhance learning effectiveness and productivity. Several faculty within basic engineering have participated in the development of instructional software for the courses they teach, but the ISDC provides a supportive environment for faculty from other campus departments, as well.

Mission Statement

The mission of the Basic Engineering Department is to provide first-rate academic advising for freshman students in engineering; to provide high quality instruction in basic engineering courses taken by a wide range of engineering students in preparation for advanced study in their fields or in support of establishing breadth of knowledge in engineering; and to develop and evaluate innovative teaching tools and processes, especially as they pertain to technology-based methods.

Faculty

Professors:

Douglas R. Carroll[1], Ph.D., UMR
Archie W. Culp, Jr. (Emeritus), Ph.D., University of Missouri-Columbia
Robert L. Davis[1] (Emeritus), Ph.D., University of Maryland
D. Ronald Fannin[1] (Department Chair; Director of Freshman Engineering Program), Ph.D., Texas Tech University
Peter G. Hansen (Emeritus), Ph.D., Washington University
David B. Oglesby (Emeritus), D.Sc., University of Virginia

Associate Professors:

Ralph E. Flori, Jr., Ph.D., UMR
Edward E. Hornsey[1], (Emeritus), Ph.D., UMR
Nancy E. Hubing, Ph.D., North Carolina State University
Myron G. Parry (Emeritus), Ph.D., University of Illinois
Robert B. Stone, Ph.D., University of Texas-Austin
George Swancutt (Emeritus), M.S., Colorado State University
Daniel R. White, Ph.D., UMR

Assistant Professors:

Kenneth B. Oster[1] (Emeritus), Ph.D., UMR
Timothy A. Philpot[1], Ph.D., Purdue University

Lecturers:

Edward M. Raney[1], Ph.D., UMR
Jeffery S. Thomas[1], M.S., UMR
Kristy L. Wolfe, M.S., UMR

[1]Registered Professional Engineer

Basic Engineering Courses

010 Study and Careers in Engineering (Lect 1.0) Examination of fields of engineering and career opportunities in engineering. Professional expectations. Introduction to campus resources for assisting student success.

020 Engineering Design with Computer Applications (Lect 1.0 and Lab 2.0) Introduction to software tools (computer aided design drafting, computer mathematics, word processing, spread sheets) with application to professional engineering practice. Principles of engineering design. A semester long group design project is an integral part of the course.

050 Engineering Mechanics-Statics (Lect 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.

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

110 Mechanics of Materials (Lect 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: Bas En 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 Bas En 110.

140 Statics and Dynamics (Lect 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 BE 110. Prerequisites: Physics 23 or 21; prec. or acc. by Math 22.

150 Engineering Mechanics-Dynamics (Lect 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: Bas En 50 and Math 22.

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

220 Engineering Design Methodology (Lect 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. Prerequisites: Junior standing in engineering and at least 12 hours major field credit.

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

342 Introduction to Solar Car Design (Lect 3.0) The course provides an introduction to designing and building a solar car for participating in national and international competitions. Topics include power management, race rules, solar array, batteries, electric motors, chassis structure, suspension, drive train, steering, brakes, signals, displays and controls, management structure, and race logistics. Prerequisite: Math 204 or 229.

390 Undergraduate Research (Variable) 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.

Engineering Graphics

200 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

212 Computer Aided Drafting (Lect 2.0 and Lab 1.0) Expanded use of the UMR computer workstation environments and the use and evaluation of several CAD/CAM software packages. Prerequisite: Eng Gr 10.

Chemical & Biological Engineering

Bachelor of Science in Chem. Eng.
Master of Science in Chem. Eng.
Doctor of Philosophy in Chem. Eng.
Doctor of Engineering in Chem. Eng.

Emphasis area at bachelor of science level in biochemical engineering

Chemical engineering is the branch of engineering which deals with changing the composition, energy content, and state of aggregation of materials. As a chemical engineering student, you will consider the fundamental properties and nature of matter (chemistry), the forces that act on matter (physics), and the precise expressions of the relationships between them (mathematics). Extensive use is made of computers in the application of these sciences to engineering problems.

As a chemical engineer, you may study ways in which pure water can be obtained from the sea; design processes to provide fertilizers, rubber, fibers, and fuels; or team up with other engineers and scientists in biomedical engineering to develop specialized polymeric materials for use in artificial arms, legs, and other human organs. You may be instrumental in finding supplemental food sources for man-such as protein from petroleum, wood, or the sea. You might help develop new processes for the application of biochemistry, energy conservation, or environmental control-such as reducing undesirable substances in the air. Or, you might have a hand in the creation of strong lightweight materials to be used in aircraft construction. Your opportunities will be unlimited.

At UMR, you will have laboratories available which offer training in qualitative and quantitative analysis, organic and physical chemistry, physics, unit operations, biochemical engineering, design, and automatic process control.

Your studies will give you a broad technical basis with an emphasis on material balances, energy balances, separation processes, rate processes, unit operations, and process economics and design.

Among its facilities, the department features digital data acquisition and control equipment for research and instruction which allows simultaneous utilization of the system by several people. A full complement of hardware exists for input and output of signals to and from process equipment and instrumentation. The departmental computer network makes available a wide variety of professional software. Also included is equipment to measure thermodynamic and physical properties, study biochemical engineering processes, polymers, surface phenomena, fluid mechanics, membranes, chemical kinetics, and diffusion.

Mission Statement

The department prepares chemical engineers for successful careers of leadership and innovation in chemical engineering and related fields; expands the knowledge base of chemical engineering through its scholarly pursuits; develops technology to serve societal needs; and benefits the public welfare through its service to the chemical engineering profession.

BSChE Program Objectives: Graduates Will Have:

1) A strong fundamental scientific and technical knowledge base and critical thinking skills which provide the foundation for design, experimentation, interpretation, and analysis, and for life-long learning.
2) The ability to apply science, mathematics and engineering skills and work in multi-functional teams to identify and formulate solutions for problems faced by practicing chemical engineers, and to design and analyze chemical engineering systems and processes.
3) The ability to effectively communicate technical and professional information in written oral, visual and graphical formats.
4) Awareness and understanding of the moral, ethical, legal and professional obligations needed to function as part of a professional enterprise, and to protect human health and welfare, and the environment in a global society.

Faculty

Professors:

David Azbel (Emeritus), Ph.D., Moscow Institute of Chemical Engineering, D.Sc., Mendelev Institute of Chemical Technology

Orrin Crosser[1], (Emeritus), Ph.D., Rice

Athanasios Liapis, Ph.D., Swiss Federal Institute of Technology

Douglas K. Ludlow, (Department Chair), Ph.D., Arizona State University

David Manley (Emeritus), Ph.D., University of Kansas

Nicholas Morosoff (Emeritus), Ph.D., Polytechnic Institute of Brooklyn

Partho Neogi, Ph.D., Carnegie-Mellon

Gary Patterson[1], (Emeritus), Ph.D., University of Missouri-Rolla
X B Reed, Jr. (Emeritus), Ph.D., Minnesota
Stephen L. Rosen, (Emeritus) Ph.D., Cornell
Mailand Strunk (Emeritus), Sc.D., Washington University
Raymond Waggoner[1], (Emeritus), Ph.D.,Texas A & M

Associate Professors:
Neil Book, Ph.D., Colorado
Daniel Forciniti, Ph.D., North Carolina State University
Oliver Sitton, Ph.D., University of Missouri-Rolla

Assistant Professors:
Jee-Ching Wang, Ph.D., Pennsylvania State University
Yangchuan Xing, Ph.D., Yale

Lecturer:
Robert Mollenkamp, Ph.D., Louisiana State University

[1]Registered Professional Engineer

Bachelor of Science Chemical Engineering

FRESHMAN YEAR

First Semester	Credit
Bas Eng 10-Study & Careers in Eng	1
Chem 1 - General Chemistry	4
Chem 2 - General Chemistry Lab	1
Engl 20 - Exposition & Argumentation	3
Hist - 112, 175, 176 or Pol Sci 90	3
Math 14 - Calculus I for Engineers	4
	16

Second Semester	Credit
BE 20-Eng Design w/Comp App	3
Ch Eng 20-Comp & Chem Eng or CmpSc73/77 or CmpSc74/78 or CmpSc 53/54	3
Chem 3-General Chemistry II	3
Math 15-Calculus II for Engineers	4
Physics 23-Engineering Physics I	4
	17

SOPHOMORE YEAR

First Semester	Credit
Ch Eng 120-Chem Eng Mat Balances[1]	3
Chem 221-Organic Chemistry I	3
Econ 121 or 122-Prin of Micro/Macro	3
Math 22-Calculus w/Analytic Geometry III	4
Physics 24-Eng Physics II	4
	17

Second Semester	
Ch Eng 141-Chemical Eng Thermodynamics I[1]	3
Ch Eng 145-Chem Process Materials	3
Humanities Electives[2]	3
Humanities or Social Science Elective[2]	3
Math 204-Elem Differential Equa	3
	15

JUNIOR YEAR

First Semester	Credit
Ch Eng 231-Chem Eng Fluid Flow	3
Ch Eng 233-Chem Eng Heat Transfer	2
Ch Eng 245-Chem Eng Thermo II[1]	3
Chem 241-Physical Chemistry I	3
General Ed Upper Level Elective[3]	3
Humanities or Social Science Upper Level Elective[2]	3
	17

Second Semester	
Ch Eng 234-Chem Eng Lab I[4]	2
Ch Eng 235-Staged Mass Transfer	3
Ch Eng 237-Cont Mass Transfer	3
Ch eng 247-Molecular Chem Eng	3
Chem & Lab Elective[5]	4
	15

SENIOR YEAR

First Semester	Credit
Ch Eng 211-Prof Prac & Ethics[6]	1
Ch Eng 236-Chem Eng Lab II[4]	3
Ch Eng 251-Chem Eng Proc Dyn & Cont	3
Ch Eng 252-Proc Dyn & Contr Lab	1
Ch Eng 281-Chem Eng Reactor Design	3
Ch Eng 3xx-Chem Eng Elective[7]	3
Free Electives[8]	3
	17

Second Semester	
Ch Eng 283-Chem Eng Econ[4]	2
Ch Eng 285-Chem Proc Safety[4]	3
Ch Eng 288-Chem Process Design[4]	3
Ch Eng 3xx-Chem Eng Elective[7]	3
Free Electives[8]	3
	14

Note: The minimum number of hours required for a degree in Chemical Engineering is 128.

1) A grade of "C" or better is required in Ch Eng 120 and in Ch Eng 141 to enroll in Ch Eng 245
2) From approved list by School of Engineering
3) General Education Upper Level Elective -all Hu/SS upper level electives and also: Engl 60, Engl 160, Sp&M 85, and Sp&M 181
4) Writing emphasized course
5) Chemistry & Laboratory Electives:Chem 51(2), 52(2) or Chem 223(3), 224(1) or Chem 243(3), 242(1) or Chem 361(3), 362(1) or BioSci 211(4)
6) All Chemical Engineering students must take the Fundamentals of Engineering Exam 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 UMR assessment process as described in Assessment Requirements found elsewhere in this undergraduate catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.
7) Chemical Engineering Elective: Any Ch Eng 3xx class. But only one of Ch Eng 300, 390 or 390H can be used to fulfill this requirement.
8) 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. ECE 281 recommended for preparation for FE exam.

Chemical Engineering Biochemical Engineering Emphasis

FRESHMAN YEAR

First Semester	Credit
BE 10-Study & Careers in Eng	1
Chem 1-General Chemistry	4
Chem 2-General Chemistry Lab	1
Engl 20-Exposition & Argumentation	3
Hist-112, 175, 176 or Pol Sci-90	3
Math 14-Calculus I for Engineers	4
	16

Second Semester	Credit
BE 20-Eng Design w/ Comp Appl	3
Ch Eng 20-Comp & Ch Eng or CmpSc 73/77 or CmpSc 74/78 or CmpSc 53/54	3
Chem 3-General Chemistry II	3
Math 15-Calculus II for Engineers	4
Physics 23 - Engineering Physics I	4
	17

SOPHOMORE YEAR

First Semester	Credit
Bio 211-Cellular Biology	4
Ch Eng 120-Chem Eng Mat Bal[1]	3
Chem 221-Organic Chemistry I	3
Math 22-Calculus w/Analytic Geometry III	4
Physics 24-Eng Physics II	4
	18

Second Semester	Credit
Bio Sc 221-Microbiology	5
Ch Eng 141-Chem Eng Thermo[1]	3
Ch Eng 145-Chem Process Mat	3
Chem 223-Organic Chemistry II	3
Chem 224-Organic Chemistry Lab	1
Math 204-Elem Differential Equations	3
	18

JUNIOR YEAR

First Semester	Credit
Bi Sc 331-Molecular Genetics	3
Bio Sc 332-Molecular Genetics Lab	2
Ch Eng 231-Chem Eng Fluid Flow	3
Ch Eng 233-Chem Eng Heat Transfer	2
Ch Eng 245-Chem Eng Thermodynamics II[1]	3
Chem 241-Physical Chemistry	3
	16

Second Semester	
Ch Eng 235-Staged Mass Transfer	3
Ch eng 247-Molecular Chem Eng	3
Ch Eng 263-Biochem Separations	3
Econ 121 or 122-Prin of Micro/Macro	3
Humanities Elective[2]	3
	15

SENIOR YEAR

First Semester	Credit
Ch Eng 211-Prof Prac & Ethics[3]	1
Ch Eng 251-Proc Dyn & Control	3
Ch Eng 252-Proc Dyn & Contr Lab	1
Ch Eng 264-Biochemical Separations Lab[4]	2
Ch Eng 281-Chem Eng Reactor Design	3
General Ed Upper Level Electivies[5]	3
Humanities or Social Science Elective[2]	3
	16

Second Semester	
Cheng 283-Chem Eng Econ[4]	2
Ch Eng 265-Biochemical Reactors	3
Ch Eng 266-Bioreactor Lab[4]	3
Ch Eng 288-Chem Process Design[4]	3
Humanities or Social Science Upper Level Elective[2]	3
	14

NOTE: The minimum number of hours required for a degree in Chemical Engineering is 130.

1) A grade of "C" or better is required in Ch Eng 120 and in Ch Eng 141 to enroll in Ch Eng 245
2) From approved list by School of Engineering
3) All Biochemical Engineering Emphasis students must take the Fundamentals of Engineering Exam 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 UMR assessment process as described in Assessment Requirements found elsewhere in this undergraduate catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.
4) Writing emphasized course
5) General Education Upper Level Elective-all Hum/SS upper level electives and also: Engl 60, Engl 160, Sp&M 85, and Sp&M 181

Chemical Engineering Courses

020 Computers and Chemical Engineering (Lect 2.0 and Lab 1.0) Introduction to chemical engineering, both its intellectual and professional opportunities. Students are introduced to computer programming and software packages while performing meaningful chemical engineering calculations.

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

120 Chemical Engineering Material Balances (Lect 2.0 and Lab 1.0) The application of mathematics, physics and chemistry to industrial chemical processes. The use of equations of state, chemical reaction stoichiometry, and the conservation of mass to solve chemical engineering problems. Prerequisites: Preceded by Chem 3 or 5; preceded or accompanied by Math 15 (or 21), and preceded or accompanied by Ch Eng 20, or Cmp Sc 73 & 77, or Cmp Sc 74 & 78, or Cmp Sc 53 & 54.

141 Chemical Engineering Thermodynamics I (Lect 3.0) Development and application of the laws and fundamental relationships of thermodynamics to industrial chemical processes. Emphasis is placed on the estimation of thermophysical property values for applications in chemical process engineering. Prerequisites: Preceded or accompanied by Ch Eng 120 and Math 22.

145 Chemical Process Materials (Lect 3.0) Fundamentals of the chemistry of materials. Classifica-

tion, selection, and processing of engineering materials. Introduction to statics and mechanics of materials. Introduction to polymers, electronic materials, biomaterials, and nanomaterials. Generally offered winter semester only. Prerequisites: Math 15, Physics 23, preceded or accompanied by Chem 221.

200 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

202 Co-operative Engineering Training (Variable) On-the-job experience gained through cooperative education with industry, with credit arranged through departmental cooperative adivsor. Grade received depends on quality of reports submitted and work supervisors evaluation.

211 Professional Practice and Ethics (Lect 1.0) Preparation for post-graduate activities including resume writing and job searching. Professional attitudes, practice, licensure, and ethics in the chemical engineering profession. Discussions led by visiting industrialists and other invited speakers. Discussion of professional development including professional and graduate programs. Generally offered fall semester only. Prerequisite: To be taken in final academic year.

231 Chemical Engineering Fluid Flow (Lect 3.0) Mass, energy, and momentum balance concepts in fluid flow are studied to provide a basis for study of flow measurement, fluid behavior, turbulent flow, dimensional analysis of fluid flows, and the study of some practical flow processes-filtration, fluidization, compressible flow, pipe networks. Prerequisite: Ch Eng 141, accompanied or preceded by Math 204.

233 Chemical Engineering Heat Transfer (Lect 2.0) Process principles of heat transfer in the chemical process industry. Steady and unsteady state heat conduction and radiation heat transfer. Free and forced convection and condensation and boiling heat transfer. Practical heat exchanger design. Prerequisite: Accompanied or preceded by Ch Eng 231.

234 Chemical Engineering Laboratory I (Lect 1.0 and Lab 1.0) Experiments associated with the unit operations with fluid flow and heat transfer. Design of experiments and uncertainty analysis are introduced. Process equipment designs based on laboratory data stress the importance of creativity as well as the need for effective communication. This is a communication emphasized course. Generally offered winter semester only. Prerequisite: Ch Eng 233.

235 Staged Mass Transfer (Lect 3.0) Principles of equilibrium stage operations applied to distillation, liquid-liquid extraction, absorption, and leaching. Crystallization, fluidization, mechanical separations are also studied. Quantitative solutions to practical problems are stressed. Prerequisite: Accompanied or preceded by Ch Eng 237 or Ch Eng 263.

236 Chemical Engineering Laboratory II (Lect 1.0 and Lab 2.0) Experiments illustrating the unit operations of continuous and staged separation. Experimental design methods are extended to include the principles of regression and model building. Communication skills are stressed. This is a communication emphasized course. Prerequisites: Ch Eng 234 and Ch Eng 235.

237 Continuous Mass Transfer (Lect 3.0) Fundamentals of diffusion and mass transfer applied to absorption, extraction, humidification, drying and filtration. Design and rating of continuous chemical separators. Prerequisites: Ch Eng 233, 245 and preceded or accompanied by Chem 241.

245 Chemical Engineering Thermodynamics II (Lect 3.0) Physical, chemical and reaction equilibrium. Study of the thermophysical relationships of multicomponent, multiphase equilibrium. Application of equilibrium relationships to the design and operation of chemical mixers, separators and reactors. Prerequisites: Grade of "C" or better in Ch Eng 120 and 141, accompanied or preceded by Math 204.

247 Molecular Chemical Engineering (Lect 3.0) Introduction to the molecular aspects of chemical thermodynamics, transport processes, reaction dynamics, and statistical and quantum mechanics. Prerequisite: Ch Eng 245.

251 Chemical Engineering Process Dynamics and Control (Lect 3.0) Study of the dynamics of chemical processes and the instruments and software used to measure and control temperature, pressure, liquid level, flow, and composition. Generally offered fall semester only. Prerequisite: Accompanied by Ch Eng 252.

252 Process Dynamics and Control Laboratory (Lab 1.0) Application of the concepts of industrial process dynamics and control using experiments that demonstrate different control and sensing devices and software. Generally offered fall semester only. Prerequisites: Preceded or accompanied by Ch Eng 236, or Ch Eng 264; accompanied by Ch Eng 251.

263 Biochemical Separations (Lect 3.0) The fundamentals of mass transfer are introduced and applied to various unit operations employed in the separation of chemical and biochemical compounds. Prerequisites: Ch Eng 233, 245 and preceded or accompanied by Chem 241.

264 Biochemical Separations Laboratory (Lab 2.0) Introduction to the unit operations employed in the separation of chemicals and biochemicals. The experiments illustrate the stage and continuous separation systems are involved. This is a communication emphasized course. Prerequisite: Ch Eng 263.

265 Biochemical Reactors (Lect 3.0) Application of chemical engineering principles to biochemical reactors. Fermentation, enzyme catalysis, and biological transport phenomena, with emphasis on

food, chemicals, medicine and pharmaceuticals, fuels, and waste treatment are studied. Prerequisite: Ch Eng 263.

266 Biochemical Reactor Laboratory (Lab 3.0) Introduction to the unit operations involved with the production of biochemicals. The experiments emphasize enzymatic and whole-cell reactions and the ancillary processing steps used to produce useful products. This is a communication emphasized course. Prerequisite: Preceded or accompanied by Ch Eng 265.

281 Chemical Engineering Reactor Design (Lect 3.0) The study of chemical reaction kinetics and their application to the design and operation of chemical and catalytical reactors. Prerequisites: Ch Eng 237 or Ch Eng 263, preceded or accompanied by Ch Eng 247, preceded or accompanied by Advanced Biology/ Chemistry elective with laboratory.

283 Chemical Engineering Economics (Lect 2.0) Economic analysis of a chemical process including capital requirements, operating costs, earnings, and profits. The economic balance is applied to chemical engineering operations and processes. Optimization and scheduling techniques are applied to process evaluation. This is a communication emphasized course. Prerequisite: Ch Eng 235.

285 Chemical Process Safety (Lect 3.0) The identification and quantification of risks involved in the processing of hazardous and/or toxic materials are studied. Generally offered winter semester only. Prerequisite: Preceded or accompanied by Ch Eng 145 and Ch Eng 281.

288 Chemical Process Design (Lect 1.0 and Lab 2.0) Engineering principles involved in the design and layout of chemical process equipment. Material and energy balances, equipment selection and design, and preconstruction cost estimation are performed for a capstone design project. Communication emphasized course. Prerequisites: Ch Eng 281, preceded or accompanied by Ch Eng 251 and 283.

300 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

320 Chemical Process Flowsheeting (Lect 2.0 and Lab 1.0) The development, implementation, and evaluation of methods for determining the mathematical model of a chemical process, ordering the equations in the mathematical model, and solving the model. Prerequisite: Ch Eng 235 or graduate standing.

333 Intermediate Separation Processes (Lect 3.0) Fundamentals of separation operations such as extraction and distillation; rates of diffusion in equilibrium stages and continuous contactors; efficiencies; multistage contactors; performance of equipment; phase equilibrium data; multicomponent separation. Prerequisite: Ch Eng 235 or graduate standing.

335 Intermediate Transport Phenomena (Lect 3.0) The similarities of flow of momentum, heat and mass transfer and the applications of these underlying principles are stressed. Course is primarily for seniors and beginning graduate students. Prerequisite: Ch Eng 235 or graduate standing.

341 Physical Property Estimation (Lect 3.0) Study of techniques for estimating and correlating thermodynamic and transport properties of gases and liquids. Prerequisite: Ch Eng 235 or graduate standing.

347 Principles of Engineering Materials (Lect 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, Physics 377, Mt Eng 377, Cr Eng 377).

349 Structure and Properties of Polymers (Lect 3.0) A study of the parameters affecting structure and properties of polymers. Syntheses, mechanisms, and kinetic factors are emphasized from the standpoint of structural properties. Prerequisite: Ch Eng 235 or graduate standing.

351 Principles of Environmental Monitoring (Lect 3.0) This course provides an overview of environmental monitoring methodologies. Discussion covers thermodynamic and kinetic processes that affect chemical transport and fate in the environment. Federal environmental regulations and remediation technologies are also covered with specific examples. Prerequisites: Chem 51, 221, 223, and Physics 23, 24.

355 Intermediate Process Dynamics and Control (Lect 3.0) A study of the dynamic properties of engineering operations and the interrelationships which result when these operations are combined into processes. Formulation of equations to describe open-loop and closed-loop systems. Prerequisite: Ch Eng 251 or graduate standing.

359 Plantwide Process Control (Lect 3.0) Synthesis of control schemes for continuous and batch chemical plants from concept to implementation. Multiloop control, RGA, SVD, constraint control, multivariable model predictive control, control sequence descriptions. Design project involving a moderately complicated multivariable control problem. Prerequisite: Ch Eng 251 or graduate standing. (Co-listed with El Eng 332).

366 Chemical Process Simulation (Lab 1.0) Simulation of Engineering and chemical processes on digital and/or analog devices with application to pilot scale processes. Prerequisite: Ch Eng 262.

371 Environmental Chemodynamics (Lect 3.0) Interphase transport of chemicals and energy in the environment. Application of the process oriented

aspects of chemical engineering and science to situations found in the environment. Prerequisite: Ch Eng 235 or graduate standing.

373 Pollution Prevention via Process Engineering (Lect 3.0) To arrive at environmentally benign process design, each processing system will be considered as an inter-connection of elementary units. Systematic methods capitalizing on synergistic process integrations will be employed. Linear, nonlinear and integer optimization, mass/heat exchange networks, and reactor and reaction networks will be used. Prerequisite: Ch Eng 235 or graduate standing.

379 Industrial Pollution Control (Lect 3.0) The study of water, air, and thermal pollution control methods and the application of these methods to the solution of pollution problems in the chemical industry. Prerequisite: Ch Eng 235 or graduate standing.

381 Corrosion and its Prevention (Lect 3.0) A study of the theories of corrosion and its application to corrosion and its prevention. Prerequisite: Chem 243 or Mt Eng 281. Co-listed with: Mt Eng 381

383 Intermediate Chemical Reactor Design (Lect 3.0) A study of homogeneous and heterogeneous catalyzed and noncatalyzed reaction kinetics for flow and batch chemical reactors. Application to reactor design is stressed. Prerequisite: Ch Eng 281 or graduate standing.

384 Interdisciplinary Problems in Manufacturing Automation (Lect 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. Prerequisites: Senior standing and permission of instructor. (Co-listed with Mc Eng 344, Eng Mg 344)

387 Interfacial Phenomena in Chemical Engineering (Lect 3.0) The course deals with the effects of surfaces on transport phenomena and on the role of surface active agents. Topics include fundamentals of thermodynamics, momentum, heat and mass transfer at interfaces and of surfactants. Some applications are included. Prerequisites: Ch Eng 237, Math 204.

388 Intermediate Process Design (Lect 3.0) Study of newer unit operations, fluidization, chromatographic absorption, new developments in operations previously studied. Comparison of operations which might be selected for the same end result in an industrial process. Prerequisite: Ch Eng 235 or graduate standing.

389 Industrial Chemical Processes (Lect 3.0) Detailed study of various industrial chemical manufacturing processes including underlying chemistry, reaction pathways and separation processes. Prerequisite: Ch Eng 235 or Chem 221, or graduate standing. Co-listed with: Chem 325

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

Civil Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy
Doctor of Engineering

Emphasis areas at all levels in construction engineering, environmental engineering, water resources engineering, geotechnical engineering, structural engineering, materials engineering and transportation engineering.

Civil engineers plan, design, and supervise construction of many essential facilities and structures such as bridges, dams, interstate highways, and buildings. Service to the community, its development and improvement are fundamental aspects of a civil engineering career. Civil engineers are problem solvers...applying the latest in high-tech equipment and sophisticated procedures to address challenges concerning our environment and infrastructure.

Included in the study of civil engineering are courses in environmental engineering that are directly related to the solution of hazardous waste and pollution problems, to providing potable and economical water supply systems, and to maintaining a safe environment. Water resources engineering is related to hydraulic and hydrologic engineering, flood control, rainfall, and runoff prediction and the transport in flows. Studies in geotechnical engineering address the bearing capacities of soils, settlement of foundations, and the design of both deep and shallow foundations. Courses in structural analysis and design are directed toward providing reliable and economical structures such as bridges, buildings, port facilities, and intricate lock and dam facilities. The principles involved in this sequence of courses are also applicable to the design of automobiles, aircraft, spacecraft, and future space structures. Transportation engineering involves the movement of people and cargo from place to place, the design of airports and highways, and traffic studies to maintain efficient flows. Courses in construction engineering include studies in construction techniques, cost estimating, quality control/quality assurance, and contract administration. Materials engineering involves the production, quality control, use, and property analysis of construction materials such as asphalt, concrete, aggregate, wood, masonry, and steel.

Civil engineering is a broad field of endeavor. Because of this breadth, courses are required in each of the above areas. Although you, as a civil engineer, may specialize within a given area, by the very nature of the profession you will be required to interact with specialists in the other areas. You also may find that you will

work with engineers in other disciplines such as mechanical, electrical, or geological engineering in the planning, design, and construction of complex facilities.

Civil engineers also must be effective in communicating with the public. You may be expected to work with property owners, concerned citizens, city officials, attorneys, and even medical doctors for concerns related to public health measures.

The results of your work as a civil engineer will be seen everywhere. Projects in which you will become involved must be economical, provide an adequate factor of safety for the particular use, and provide a reasonable life expectancy. To do this adequately and within a reasonable time frame, you will find that, with the exception of your engineering training, the computer is one of the most important and valuable tools you will use to produce a proper design or to complete a specific project. You may expect that your courses taken in civil engineering will require the use of computer hardware and software related to the different areas of study.

Mission Statement

The Civil Engineering Program will prepare students for professional performance in the global society and for life long development in the civil engineering profession through a comprehensive, forward-looking and broad-based curriculum in civil engineering emphasizing fundamentals and practical applications, oral and written communication skills, computer applications skills, and professional practice issues and ethics.

Civil Engineering Program Educational Objectives

Consistent with the mission of the Civil Engineering Program, graduates of the UMR Civil Engineering Program will have:

1) a strong and broad fundamental scientific and technical knowledge base which they will be able to apply to experimental design, to conducting experiments, and to the interpretation and analysis of experimental data;

2) the ability to apply engineering skills and work in multi-disciplinary teams to identify and formulate solutions for civil engineering problems and to analyze and design civil engineering projects;

3) a desire for the continuous acquisition of knowledge;

4) competence in the use of the latest tools and techniques in civil engineering practice and the ability to effectively communicate technical and professional information in written, oral, visual and graphical forms;

5) an awareness and understanding of the moral, ethical, legal and professional obligations needed to function as part of a professional enterprise and to protect human health and welfare, and the environment in a global society.

Program Outcomes - An Overview

Consistent with the program educational objectives listed above, the UMR civil engineering program graduate will have:

1. knowledge of contemporary issues, through broad education, which allows them to appreciate the impact of engineering solutions on humankind, and to be enthusiastic about and have the ability to engage in continued education throughout their lives;
2. knowledge of mathematics, science, and engineering, an ability to apply it with proficiency in at least four civil engineering areas, and an understanding of the need for up to date engineering tools acquired through life-long learning;
3. ability to design and conduct experiments in more than one CE area and communicate effectively in multi-disciplinary environments to analyze and interpret data and provide the results;
4. ability to carry out the design of an integrated system and its various components and processes for a CE project;
5. ability to provide leadership and effectively communicate among engineers and non-engineers when working in multiple disciplinary teams;
6. ability to define and state engineering problems in technical and non-technical language and to apply basic engineering principles to solve problems;
7. understanding of the responsibility of civil engineers to practice in a professional and ethical manner at all times, including procurement of work, quality based selection processes, and interaction of design professionals and construction professionals;
8. ability to communicate effectively using oral, written and graphic forms;
9. knowledge of the interactions of technology and society and their possible impacts on the practice of Civil Engineering;
10. ability to utilize their background in science, humanities and engineering, and analytical and design skills, when approaching ever changing engineering practice; and,
11. a sense of responsibility for the continued well-being of their alma mater and their profession.

Faculty

Professors:

William Andrews[1] (Emeritus), D.Sc., Washington
Abdeldjelil Belarbi, Ph.D., Houston
John Best[1] (Emeritus), Ph.D., Vanderbilt
Franklin Cheng[1] (Curators' Emeritus), Ph.D., Wisconsin
Charles Dare[1] (Emeritus), Ph.D., Iowa
Frank Gerig[1] (Emeritus), Ph.D., Texas A & M
Ju-Chang Huang[1] (Emeritus), Ph.D., Texas-Austin
Roger LaBoube[1] (Distinguished Teaching Professor), Ph.D., Missouri-Rolla
Paul Munger[1] (Emeritus), Ph.D., Arkansas
Antonio Nanni[1] (Vernon and Maralee Jones Professor), Ph.D., Miami
Thomas M. Petry[1], Ph.D., Oklahoma State
Shamsher Prakash[1] (Emeritus), Ph.D., Illinois
J. Kent Roberts[1] (Emeritus), M.S., Missouri-Rolla

Norbert Schmidt[1] (Emeritus), Ph.D., Illinois
William Schonberg[1] (Department Chair), Ph.D., Northwestern
Joseph Senne[1] (Emeritus), Ph.D., Iowa State
Richard Stephenson[1], Ph.D., Oklahoma State
Jerome Westphal[1] (Emeritus), Ph.D., Nevada
Bobby Wixson (Emeritus), Ph.D., Texas A&M
Wei-Wen Yu[1] (Curators' Emeritus), Ph.D., Cornell

Associate Professors:

Craig D. Adams[1] (John and Susan Mathes Professor), Ph.D., Kansas
Jerry Bayless[1] (Associate Dean of Engineering), M.S., Missouri-Rolla
Joel Burken, Ph.D., Iowa
Genda Chen[1], Ph.D., SUNY-Buffalo
Mark Fitch, Ph.D., Texas-Austin
Rodney Lentz[1], Ph.D., Michigan State
Ronaldo Luna[1], Ph.D., Georgia Tech.
Cesar Mendoza, Ph.D., Colorado State University
Donald Modesitt[1] (Emeritus), Ph.D., Oklahoma State
Charles Morris[1], Ph.D., Illinois
David Richardson[1], Ph.D., Missouri-Rolla
Gary Spring[1], Ph.D., Massachusetts
Purush TerKonda (Emeritus), Ph.D., Texas-Austin

Assistant Professors:

Frank Capek[1] (Emeritus), M.S., University of Missouri-Rolla
Glenn Morrison, Ph.D., California-Berkeley
John Myers[1], Ph.D., Texas-Austin
Mohammad Qureshi[1], Ph.D., Tennessee-Knoxville
William Eric Showalter[1], Ph.D., Purdue
Pedro F. Siva[1], Ph.D., California-San Diego

Lecturer:

Harold Wagner[1], M.S., University of Missouri-Rolla

[1] Registered Professional Engineer

Bachelor of Science Civil Engineering

FRESHMAN YEAR

First Semester	Credit
Bas En 10-Study & Careers in Eng[2]	1
Chem 1 & 2-Gen Chem	5
Math 14-Calc for Engineers I	4
English 20-Expos & Argumentation	3
General Ed Elective[1]	3
	16

Second Semester	
BE 20-Eng Design/Comp Appl	3
Math 15-Calc for Engineers II	4
Physics 23-Eng Physics I	4
General Ed Elective[1]	3
General Ed Elective[1]	3
	17

SOPHOMORE YEAR

First Semester	Credit
CE 1-Fund of Surveying[2]	3
CE 3-Eng Communications	2
BE 50-Eng Mech-Statics[2]	3
Math 22-Calc w/Analytic Geometry III	4
Physics 24-Eng Physics II	4
	16

Second Semester	
BE 150-Eng Mech/Dynamics	2
Stat 213-Applied Eng Statistics	3
GE 50-Geology for Engineers	3
Bas En 110-Mechanics of Materials[2]	3
Bas En 120-Materials Test Lab	1
Math 204-Differential Equations	3
	15

JUNIOR YEAR

First Semester	Credit
CE 241-Economy of Eng Design[2]	2
CE 217-Structural Analysis I[2]	3
CE 215-Elementary Soil Mech	3
CE 230-Elementary Fluid Mech[2]	3
CE 261-Fund of Environmental	3
General Ed Elective[1]	3
	17

Second Semester	
CE 216-Construction Mat	3
CE 248-Contracts & Const Eng	3
CE 211-Transportation Engineering	3
CE 234-Water Resources Eng	4
Free Elective[5]	3
	16

SENIOR YEAR

First Semester	Credit
CE 210-Senior Seminar	1
(2) CE Depth Electives[3,4]	6
CE 242-Building Systems	3
CE 221-Structural Design Metals or CE 223-Reinf Conc Des	3
General Ed Elective[1]	3
	16

Second Semester	
CE 298-Civil Eng Design Project	3
CE Tech Elective[3,6]	3
CE Depth Elective[3,4]	3
General Ed Elective[1]	3
Free Elective[5]	3
	15

1) All general education electives must be approved by the student's advisor. Students must comply with the School of Engineering general education requirements with respect to selection and depth of study. These requirements are specified in the current catalog. One general education elective must be from Engl 60, Engl 160, or SP&MS 85.
2) A grade of 'C' or better required to satisfy graduation requirements
3) A grade of 'C' or better may be required in CE technical and depth elective prerequisite courses. Refer to the UMR undergraduate catalog for this prerequisite information.
4) Choose depth electives using Guidelines for Depth and Technical Electives
5) 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.

6) Choose technical electives using Guidelines for Depth and Technical Electives

NOTE: "Note: All Civil 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 UMR 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.

Guidelines for Depth and Technical Electives

Please consult the Department's Advising Center or your academic advisor for guidelines regarding the selection of depth and technical electives.

Course Listings by Area

Construction Engineering

345 Construction Methods
346 Management of Construction Costs
349 Engineering and Construction Contract Specifications

Materials Engineering

312 Bituminous Materials
313 Composition and Properties of Concrete
317 Pavement Design

Environmental Engineering

265 Water/Wastewater
360 Environmental Law and Regulations
361 Remediation of Contaminated Groundwater and Soil
362 Public Health Engineering
363 Solid Waste Management
365 Environmental Engineering Analysis Laboratory
367 Introduction to Air Pollution
368 Air Pollution Control Methods
369 Sanitary Engineering Design

Geotechnical Engineering

229 Foundation/Pavement Engineering
314 Geosynthetics in Engineering
315 Intermediate Soil Mechanics
316 Soil Dynamics I
329 Foundation Engineering II

Water Resources Engineering

330 Hydraulic Transients
331 Hydraulics of Open Channels
335 Water Infrastructure Engineering
337 River and Harbor Engineering
338 Hydrologic Techniques

Structural Engineering

221 Structural Design Metals
223 Reinforced Concrete
318 Smart Materials and Sensors
319 Applied Mechanics in Structural Engineering
322 Analysis and Design of Wood Structures
323 Classical and Matrix Methods of Structural Analysis
326 Advanced Steel Structures Design
327 Advanced Concrete Structures Design
328 Prestressed Concrete Design
374 Infrastructure Strengthening with Composites
375 Low-Rise Building Analysis and Design

Transportation Engineering

301 Infrastructure Engineering and Management
311 Geometric Design of Highways
353 Traffic Engineering
373 Air Transportation

Civil Engineering Courses

001 Fundamentals of Surveying (Lect 2.0 and Lab 1.0) Surveying fundamentals: leveling, directions, angles, distances, errors, traverse calculations and basic adjustments. Fundamentals of horizontal curves. Lab exercises include leveling, traversing, horizontal circular curve layout and building layout. Prerequisite: Preceded or accompanied by Math 14 (or 8).

003 Engineering Communications (Lect 1.0 and Lab 1.0) Introduction to programming concepts and software tools (computer aided design drafting, computer mathematics, word processing, spreadsheets, and presentation software) with application to written and oral communication in professional civil and architectural engineering practice. Prerequisite: Sophomore standing. (Co-listed with Arch Eng 003).

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

200 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

202 Co-operative Engineering Training (Variable) 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 supervisors evaluation.

210 Senior Seminar: Engineering in a Global Society (Lect 1.0) Discussion of contemporary issues: public safety health, and welfare; the principles of sustainable development; lifelong learning; impact of engineering solutions in a global and societal and political context; relationships with owners, contractors, and the public; public service; the Code of Ethics; and the Missouri licensing Statutes and Board Rules. Prerequisite: Senior standing. (Co-listed with Arch E and Env En 210).

211 Transportation Engineering (Lect 2.0 and Lab 1.0) A study of operating characteristics of transportation modes including highways, railways, inland waterways, airways, and pipelines. Consideration of traffic control devices, safety, system capacity, design of routes, planning of urban transportation systems, and economic evaluation of transportation alternatives. Prerequisites: Cv Eng 1, Bas En 50 with a grade of "C" or better.

215 Elementary Soil Mechanics (Lect 2.0 and Lab 1.0) Analysis of soil systems including soil classification identification, index properties, permeability, compressibility and shear strength. Laboratory determination of the basic properties of soils. Prerequisite: Ge Eng 50 preceded or accompanied by Bas En 110; or Arch Eng 103.

216 Construction Materials, Properties and Testing (Lect 2.0 and Lab 1.0) A study of the origin, production, uses and general properties of construction materials accompanied by selected laboratory tests and demonstrations. Prerequisites: Bas En 120, Cv Eng 215.

217 Structural Analysis I (Lect 2.0 and Lab 1.0) Loads on Structures. Analysis of statically determinate and indeterminate beams, frames and trusses. Influence lines and moving loads. Computation of deflections. Development and use of theorems of displacement methods including slope-deflection and moment distribution to analyze statically indeterminate structures. Computer solutions. Prerequisites: Bas En 50, 110 each with a grade of "C" or better. (Co-listed with Arch Eng 217).

218 Structural Analysis (Lect 4.0 and Lab 1.0) Analysis of statically determinate and indeterminate beams, frames and trusses. Moving loads. Influence lines. Development and use of theorems of moment area, virtual work, slope deflection, moment distribution, matrix displacement. Formulation by students of several computer programs. Prerequisites: Bas En 50, 110 each with grade of "C" or better.

221 Structural Design in Metals (Lect 2.0 and Lab 1.0) The analysis and design of structural elements and connections for buildings, bridges and specialized structures utilizing structural metals. Both elastic and plastic designs are considered. Prerequisite: Cv Eng 217 with grade of "C" or better. (Co-listed with Arch Eng 221).

223 Reinforced Concrete Design (Lect 2.0 and Lab 1.0) The analysis and design of reinforced concrete beams, slabs, columns, retaining walls and footings by the elastic and ultimate strength methods, including an introduction to the design of prestressed concrete. Introduction to use of computers as a design aid tool. Prerequisite: Cv Eng 217 with grade of "C" or better. (Co-listed with Arch Eng 223).

229 Foundation and Pavement Engineering (Lect 3.0) The effect of subsoil conditions on the behavior and choice of foundations and pavement base courses. Topics include the design of foundations including the selection of foundation types, the analysis of bearing capacity and settlement of foundations and fills, soil exploration, and the behavior of base and subbases under pavements. Prerequisite: Cv Eng 215.

230 Elementary Fluid Mechanics (Lect 3.0) A study of the principles governing the behavior of fluids at rest and in motion. Emphasizes methods employed in the development of general relationships in the statics, kinematics, and kinetics of fluids. An introduction to similitude and dimensional analysis. Prerequisite: Bas En 150 or Bas En 140 with a grade of "C" or better.

233 Engineering Hydrology (Lect 2.0 and Lab 1.0) A study of hydrologic processes as they relate to design of structures for control and management of water. Emphasizes characterization of precipitation processes, development of design hydrographs, rainfall/runoff frequency analysis, ground-water and wells. Prerequisites: Cv Eng 230 with grade of "C" or better.

234 Water Resources Engineering (Lect 3.0 and Lab 1.0) An introduction to the engineering of water resources; flow in closed conduits, pumps, flow in open channels, surface water hydrology, rainfall analysis, hydrograph analysis, flow routing; and ground-water hydrology. Prerequisites: Cv Eng 230 and Stat 213 with grades of "C" or better.

235 Hydraulic Engineering (Lect 2.0 and Lab 1.0) A study of applied hydraulics to design of systems used for collection or distribution of water. Emphasis on open channel flow, hydraulic machinery, design of supply systems, drainage systems, and hydraulic transients. Prerequisites: Cv Eng 230 with grade of "C" or better.

241 Economy of Engineering Design (Lect 1.0 and Lab 1.0) Engineering decision-making procedures with emphasis on time value of money principles. Includes topics such as present, annual, and future worth analysis; rate of return and benefit/cost ratio methods; effects of taxes, depreciation, and inflation on project viability; sensitivity analysis; design component optimization; project financing costs; and applications. Prerequisite: Preceded or accompanied by Stat 213. (Co-listed with Arch E 241).

242 Introduction To Building Systems (Lect 3.0) An introduction to life support systems and technology of interest to civil and architectural engineers in the planning and operation of large buildings. Topics include building climate and human comfort; awareness of national building code requirements; fundamentals of building HVAC systems and interior air quality; the principles of plumbing and waste systems; fundamentals of electric power distribution, equipment, and wiring systems; principles of building illumination; building transportation equipment; and the fundamentals of architectural acoustics. Prerequisites: Physics 24, Math 204 and Junior standing. (Co-listed with Arch Eng 242).

247 Ethical, Legal and Professional Engineering Practice (Lect 2.0) Discussions of laws concerning contracts, torts, agencies, real property, partnerships, and corporations. The purposes and implications of the engineering registration law, the effect of legal, ethical and marketing considerations of the practice of Civil Engineering. Prerequisite: Junior standing. (Co-listed with Arch Eng 247).

248 Fundamentals of Contracts and Construction Engineering (Lect 3.0) A study of the concepts and techniques used in large construction projects for the preparation of engineer service contracts, the development of a project manual, detailed and conceptual cost estimating, and construction scheduling analysis. Prerequisite: Junior Standing. (Co-listed with Arch Eng 248).

261 Fundamentals of Environmental Engineering and Science (Lect 2.0 and Lab 1.0) Course discusses fundamental chemical, physical, and biological principles in environmental engineering and science. Topics include environmental phenomena, aquatic pollution and control, solid-waste management, air pollution and control, radiological health, and water and wastewater treatment systems.

262 Biological Fundamentals of Environmental Engineering (Lect 3.0) Introduction to the function of organisms related to environmental engineering. The course focuses on both the application of organisms to removing contaminants and the effects of contaminants on organisms. Prerequisites: Bio 211 and preceded or accompanied by Civ/Env En 261. (Co-listed with Env En 262).

263 Chemical Fundamentals of Environmental Engineering (Lect 2.0 and Lab 1.0) Introduction to the key chemical and physical concepts integral to environmental systems and processes. This course provides a fundamental background in those chemical and environmental engineering principles that are common to all environmental engineering disciplines. Prerequisites: Chem 3, Physics 23, Math 22. (Co-listed with Env En 263).

265 Water and Waste Water Engineering (Lect 3.0) A study of the engineering design principles dealing with the quantity, quality and treatment of water, and the quantity, characteristics, treatment and disposal of wastewater. Prerequisites: Cv Eng 230 with grade of "C" or better, Cv Eng 261.

298 Civil Engineering Design Project (Lect 3.0) Open-ended design projects involving one or more areas of civil engineering. Planning design projects, philosophy of design, and application of civil engineering principles to design problems. Prerequisite: To be taken in the final semester, Cv Eng 248.

299 Civil Engineering Design (Variable) Design projects, open-ended in nature, which involve one or more areas of civil engineering. Planning design projects; philosophy of design, application of the principles of civil engineering to design problems. Prerequisite: To be taken in final semester.

300 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

302 Geomatics (Lect 3.0) Horizontal and vertical geodetic datums and networks. Theory, calculations and applications of State Plane Coordinate Systems. Introduction to Geographic and Land Information Systems: hardware and software issues; data quality and accuracy; resource, environmental, cadastral and governmental applications; databases; GIS/LIS trends. Introduction to Global Positioning Systems (GPS): Project planning, data collection, data processing and network adjustment applications, Kinematic and RealTime GPS applications, hardware and software options and costs. Prerequisite: Cv Eng 1 with grade of "C" or better.

304 Legal Aspects of Boundary Surveying (Lect 3.0) The U.S. Public Land Survey System (USPLSS): original GLO survey instructions and procedures. Resurveys on the USPLSS law, standards, procedures with emphasis on Missouri. Rights in real property; statute, case and administrative law applied to boundaries. Simultaneous and sequence conveyances. Unwritten rights in real property. Riparian boundaries. Writing and interpreting boundary descriptions. Land surveyor duties and responsibilities. Prerequisite: Cv Eng 1 with grade of "C" or better.

306 Surveying Systems (Lect 3.0) Celestial observations for azimuths. Introduction to State Plane Coordinate systems. Theory and calculations. Route surveying and geometrics, horizontal, spiral and vertical curves. Surveying aspects of residential and commercial subdivision design: lot layout, rights of way, easements, setbacks, platting, planning and zoning constraints, application of surveying software. Instrumentation: total stations, electronic levels, instrument calibrations. Prerequisite: Cv Eng 1 with grade of "C" or better.

310 Seminar (Lect 1.0) Discussion of current topics. Prerequisite: Senior standing.

311 Geometric Design of Highways (Lect 2.0 and Lab 1.0) Development and applications of concepts of geometric design for rural and urban highways. Design controls and criteria; elements of design, including sight distance, horizontal and vertical alignment; cross-section elements; highway types; intersection design elements; types of interchanges and interchange design elements; grade separations and clearance; development of visual elements. Prerequisites: Cv Eng 211 with grade of "C" or better.

312 Bituminous Materials (Lect 2.0 and Lab 1.0) Properties, types, and grades of bituminous materials are presented. Emphasis is placed on usage, distress, surface treatment design, and as-

phalt concrete mix properties, behavior, design manufacture, and construction. Prerequisite: Preceded or accompanied by Cv Eng 216.

313 Composition and Properties of Concrete (Lect 3.0) Properties of plastic and hardened concrete and the influence of cements, aggregates, water and admixtures upon these properties. The microstructure of cement gel and other factors are related to the behavior of hardened concrete under various types of loading and environments, drying shrinkage, creep and relaxation, fatigue, fracture, and durability. Introduction to statistical quality control of concrete production. Prerequisite: Preceded or accompanied by Cv Eng 216.

314 Geosynthetics in Engineering (Lect 3.0) Geotechnical principles are applied to design of geosynthetic systems for foundation support, earth retention, drainage, and disposal of hazardous conventional wastes. Geosynthetic testing and identification. Emphasis is on design of geosynthetic earth reinforcement, roadway stabilization, filters, and waste containment systems. Prerequisites: Cv Eng 215 with grade of "C" or better.

315 Intermediate Soil Mechanics (Lect 3.0) General principles of soil mechanics and their applications, including mineralogy, soil structure, flow through porous media, shear strength, slope stability and consolidation. Prerequisites: Cv Eng 215 with grade of "C" or better.

316 Geotechnical Earthquake Engineering (Lect 3.0) Geotechnical earthquake hazards and mitigations, damage to structures, plate tectonics, seismicity, wave propagation, characterization of ground motions, theory of vibrations (1-DOF), effect of local soil conditions on ground response, development of design ground motions, liquefaction, dynamic lateral earth pressures and slope stability/deformation. Prerequisites: Cv Eng 215 with a grade of "C" or better.

317 Pavement Design (Lect 3.0) Structural design of rigid and flexible pavements including loading characteristics, properties of pavement components, stress distribution and the effects of climatic variables on design criteria. Prerequisites: Preceded or accompanied by Cv Eng 216 and Cv Eng 229.

318 Smart Materials and Sensors (Lect 2.0 and Lab 1.0) Smart structures with fiber reinforced polymer (FRP) composites and advanced sensors. Multidisciplinary topics include characterization, performance, and fabrication of composite structures; fiber optic, resistance, and piezoelectric systems for strain sensing; and applications of smart composite structures. Laboratory and team activities involve manufacturing, measurement systems, instrumented structures, and performance tests on a large-scale smart composite bridge. Prerequisites: Senior Standing and Math 204. (Co-listed with Ae Eng, E Mech, Mc Eng and El Eng 329).

319 Applied Mechanics in Structural Engineering (Lect 3.0) A study of the basic relationships involved in the mechanics of structures. Topics include basic elasticity, failure criteria, fundamental theories of bending and buckling of plates and cylindrical shells for practical application in analysis and design of bridge, building floors, and shell roofs. Prerequisite: Cv Eng 217 with grade of "C" or better. (Co-listed with Arch Eng 319).

322 Analysis and Design of Wood Structures (Lect 3.0) A critical review of theory and practice in design of modern wood structures. Effect of plant origin and physical structure of wood on its mechanical strength; fasteners and their significance in design; development of design criteria and their application to plane and three dimensional structures. Prerequisite: Cv Eng 217 with grade of "C" or better. (Co-listed with Arch Eng 322).

323 Classical and Matrix Methods of Structural Analysis (Lect 3.0) Classical displacement and force methods applied to structures of advanced design. Displacement matrix methods and computer techniques applied to continuous beams, frames and trusses, plane grid and three-dimensional frames. Prerequisite: Cv Eng 217 with grade of "C" or better. (Co-listed with Arch Eng 323).

324 Numerical Methods of Structural Analysis (Lect 3.0) The application of numerical integration techniques for determining shears, moments, slopes and deflections of beams and frames. Numerical techniques for structural element stability. Application of finite difference methods on one and two dimensional structural systems. Prerequisite: Cv Eng 217 with grade of "C" or better.

326 Advanced Steel Structures Design (Lect 3.0) The design of structural steel systems into a final integrated structure. Plate girders, composite systems, stability, connections, rigid frames, single and multistory buildings, and similar type problems of interest to the student. Use of the computer as a tool to aid in the design will be emphasized. Prerequisites: Cv Eng 221 with a grade of "C" or better. (Co-listed with Arch Eng 326).

327 Advanced Concrete Structures Design (Lect 3.0) The design of structural concrete systems into a final integrated structure. Two-way slabs, long columns, connections, and discontinuity regions, deflections and cracking of beams and slabs, ACI design criteria, and similar type problems of interest to the student. Use of the computer as a tool to aid in the design will be emphasized. Prerequisite: Cv Eng 223 with a grade of "C" or better. (Co-listed with Arch Eng 327).

328 Prestressed Concrete Design (Lect 3.0) Behavior of steel and concrete under sustained load. Analysis and design of pre-tensioned and post-tensioned reinforced concrete members and the combining of such members into an integral structure. Prerequisite: Cv Eng 223 with a grade of "C" or better. (Co-listed with Arch Eng 328).

329 Foundation Engineering II (Lect 3.0) Classical earth pressure theories. Analysis of shallow and deep foundations to include bearing capacity and settlement of footings, rafts, piles, and drilled piers. Analysis of stability and design of retaining walls and anchored bulkheads. Prerequisites: Cv Eng 229 with a grade of "C" or better. (Co-listed with Arch Eng 329).

330 Unsteady Flow Hydraulics (Lect 3.0) The study of unsteady flow and its effect on closed water systems and in open channels. Prerequisites: Cv Eng 230 with a grade of " C" or better.

331 Hydraulics of Open Channels (Lect 3.0) The phenomena accompanying the flow of water in open channels, such as uniform and varied flow, critical conditions, backwater curves, hydraulic jump, hydraulic drop and applications are studied in detail. Prerequisites: Cv Eng 230 with a grade of "C" or better.

333 Intermediate Hydraulic Engineering (Lect 3.0) Application of fluid mechanics principles to the design. Kinematics of fluid motion, conservation of mass, linear and angular momentum, and energy. Requirements for similarity of fluid flow. Introduction to dynamics of fluid flows and viscous incompressible flows. Prerequisites: Cv Eng 230 with a grade of "C" or better.

335 Water Infrastructure Engineering (Lect 2.0 and Lab 1.0) Fundamental principles underlying comprehensive water infrastructure development; sanitary sewers, sanitary treatment facilities, stormwater sewers, stormwater detention, water power development, and hydraulic structures. The student is responsible for the planning and design of a water infrastructure development project. Prerequisite: Cv Eng 230 with a grade of "C" or better.

337 River Mechanics and Sediment Transport (Lect 3.0) Formation of rivers and the laws governing river regulation and improvements, including navigation and flood protection. Principles governing sediment transport. Prerequisites: Cv Eng 230 with a grade of "C" or better.

338 Hydrologic Engineering (Lect 3.0) A study of current up-to-date hydrologic techniques involving design of hydrologic input for bridges, culverts, reservoirs. Techniques involve extreme value statistics, model hydrographs, routing, etc. Prerequisites: Cv Eng 234 with a grade of "C" or better.

341 Professional Aspects of Engineering Practice (Lect 3.0) A study of engineering registration laws, regulations, rules of professional responsibility and standards of practice. Review of causative factors of selected failures and their relationship to professional responsibility. Prerequisite: Senior standing.

345 Construction Methods (Lect 3.0) Introduction to construction planning, selection of equipment and familiarization with standard methods for horizontal and vertical construction. Application of network analysis and schedules to project control. Prerequisite: Cv Eng 248 with a grade of "C" or better. (Co-listed with Arch Eng 345).

346 Management of Construction Costs (Lect 3.0) Management of construction projects from inception to completion: estimates, role of network preplanning, project monitoring and control. Prerequisites: Cv Eng 248 with a grade of "C" or better. (Co-listed with Arch Eng 346).

349 Engineering and Construction Contract Specifications (Lect 3.0) Legal and business aspects of contracts and contracting procedure in the construction industry to include contracts for engineering services and for construction. Analysis, study of precedents, and application of the more important provisions, including changes, differing site conditions, liability, arbitration, termination, disputes, appeal procedure, payments, insurance, inspection, liquidated damages, and technical provisions. Prerequisite: Preceded or accompanied by Cv Eng 248. (Co-listed with Arch Eng 349).

353 Traffic Engineering (Lect 3.0) Driver, vehicle, and roadway characteristics; traffic control devices; traffic studies; intersection capacity, intersection design, traffic safety, and evaluation of traffic improvements. Traffic laws and ordinances, traffic engineering, traffic circulation, parking design, and forecasting traffic impacts. Prerequisites: Cv Eng 211 with a grade of "C" or better.

360 Environmental Law and Regulations (Lect 3.0) This course provides comprehensive coverage of environmental laws and regulations dealing with air, water, wastewater, and other media. The primary focus is permitting, reporting, and compliance protocols. The course topics include U.S. and international legal systems and judicial processes, liability, enforcement, Clean Air Act, Clean Water Act (NPDES) permitting), Safe Drinking Water Act, OSGA, TSCA, RCRA, AND CERCLA. Case studies will be emphasized. (Co-listed with Env En 360).

361 Remediation of Contaminated Groundwater and Soil (Lect 2.0 and Lab 1.0) Course covers current in-situ and ex-situ remediation technologies. Current literature and case studies are utilized to provide the focus for class discussions and projects. Prerequisites: Cv Eng 265, Ge Eng 337 or Graduate Standing. (Co-listed with Env En 361).

362 Public Health Engineering (Lect 3.0) A comprehensive course dealing with the environmental aspects of public health. Prerequisites: Cv Eng 261 with a grade of "C" or better. (Co-listed with Env En 362).

363 Solid Waste Management (Lect 3.0) A systematic study of the sources, amounts and characteristics of solid wastes and methods used for their collection, reclamation, and ultimate disposal. Prerequisites: Cv Eng 261 with grade of "C" or better; or graduate standing. (Co-listed with Env En 363).

364 Environmental Systems Modeling (Lect 3.0) Introductory course in modeling environmental systems. Course will focus on contaminant fate and transport in the environment. Models will be developed that will include physical, chemical and biological reactions and processes that impact this fate. Prerequisites: Env En/Cv Eng 261, Env En/Cv Eng 262 and Env En/ Cv Eng 263; or Graduate standing. (Co-listed with Env En 364).

367 Introduction to Air Pollution (Lect 3.0) Introduction to the field of air pollution dealing with sources, effects, federal legislation, transport and dispersion and principles of engineering control. Prerequisite: Cv Eng 230; or graduate standing. (Co-listed with Env En 367).

368 Air Pollution Control Methods (Lect 3.0) Study of the design principles and application of the state-ofthe-art control techniques to gaseous and particulate emissions from fossil fuel combustion, industrial and transportation sources. Prerequisite: Cv Eng 230; or graduate standing. (Co-listed with Env En 368).

369 Sanitary Engineering Design (Lect 2.0 and Lab 1.0) Functional design of water and waste water treatment facilities. Prerequisites: Cv Eng 265 with a grade of "C" or better. (Co-listed with Env En 369).

373 Air Transportation (Lect 2.0 and Lab 1.0) Runway configuration, airfield capacity, geometrics and terminal layout and design. Aircraft perfomance; navigation and air traffic control; airport planning and design; airline operations; aviation systems planning. Prerequisite: Cv Eng 211 with a grade of "C" or better.

374 Infrastructure Strengthening with Composites (Lect 2.0 and Lab 1.0) The course presents composite materials and includes principles of reinforcing and strengthening for flexure, shear, and ductility enhancement. It covers the design of new concrete members reinforced with composites as well as existing members strengthened with externally bonded laminates or near surface mounted composite. Case studies are discussed and substantial laboratory exposure is provided. Prerequisites: Cv Eng 217 and Cv Eng 223. (Co-listed with Arch Eng 374).

375 Low-Rise Building Analysis and Design (Lect 3.0) Fundamentals of structural dynamics including the concept of natural frequency, mode shape, and damping. Responses of single-story buildings under blast, earthquake, and wind loading. Response spectrum analysis of low-rise buildings under earthquake loads. Review of various design loads specified in IBC2000. Design of columns, walls, joints, and frames. Prerequisite: Preceded or accompanied by Cv Eng 221 or Cv Eng 223.

380 Water Resources and Wastewater Engineering 380 Water Resources and Wastewater Engineering (Lect 3.0) Application of engineering principles to the planning and design of multipurpose projects involving water resources development and wastewater collection/treatment/disposal/systems. Latest concepts in engineering analysis are applied to evaluation of alternative solutions. Prerequisites: Cv Eng 233, 235, 265. (Co-listed with Env En 380).

382 Teaching Engineering (Lect 3.0) Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Eng Mg 370, Env En 382, Cp Eng 382, El Eng 382).

390 Undergraduate Research (Variable) 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.

Environmental Engineering

Bachelor of Science
Master of Science

Emphasis areas at all levels in Water and Wastewater Resources Engineering; Geo-Environmental Engineering; Air Pollution and Control; Environmental Chemistry and Processes, Environmental Microbiology and Processes

Environmental engineers uphold the dual goals of minimizing our impact on the local, regional, and global environment and concurrently improving our standard of living. In this role of preserving environmental and public well being, environmental engineers face unique issues and must have a strong background in the fundamental earth sciences in order to understand complex environmental problems and then pose and design appropriate engineering solutions. As problem solvers for something as diverse as "the environment," environmental engineers also need to understand the most current technologies used in practice and have a desire to maintain a high level of learning in this rapidly evolving and developing field.

The work place you will enter as an environmental engineer is diverse. Consulting firms represent a large portion of the work force and many specialize in areas of water and wastewater treatment. Drinking water and wastewater treatment are cornerstones of the environmental engineering field, and your education in this area will be thorough. Turning river, lake, or even sea water into drinking water is a unique expertise and takes great understanding as each water source offers distinctive challenges. Air pollution has become a great concern on scales ranging from the global atmosphere to the indoor environment. From a fundamental understanding of the chemistry and dynamics of air pollution,

you will learn how human activities degrade air quality and also be able to evaluate and design control technology to reduce emissions from industry and other sources. The geology of a location greatly impacts its water resources, and your understanding hydrogeology is important as an environmental engineer. The amount and quality of water a geologic formation can produce can determine the development in an area, and your understanding the subsurface hydrology will be required in order to remediate a contaminated groundwater site. You will also be ready to enter a number of government agencies which are active in environmental issues. The U.S. Environmental Protection Agency, state departments of natural resources, departments of health, and the US Departments of Energy and Defense all have positions that require a wide array of skills and expertise. These skills and expertise can include all those mentioned above and specific chemical and biological processes used to mitigate unique contamination problems, as well as public health, regulation enforcement, or project management. The courses and skills learned as an undergraduate student will also prepare you for entering graduate studies and furthering your expertise and preparing you for a leadership role in the field. There are numerous specialized positions that will require a graduate education.

Within the UMR Environmental Engineering Program you can focus your education in any of the emphasis areas: Water and Wastewater Resources Engineering, Geo-Environmental Engineering, Air Pollution and Control, Environmental Chemistry and Processes, Environmental Microbiology and Processes. While you can focus your education to meet specific emphasis of your choice, some courses are required in each of these areas. The breadth of the programs offered in environmental engineering at UMR allows graduates to interact with many different aspects of the field and communicate with the wide range of professionals that are encountered in this particularly interdisciplinary field. Project teams may include health care professionals, city planners, developers, and all types of engineers. Additionally, the ever-developing field of environmental engineering is saturated with legal issues, many of which are yet to have precedents or legal statutes established.

You will have courses in all the areas mentioned, and many will include laboratory courses and experience in the newly built John and Susan Mathes Environmental Engineering Laboratories in the Civil Engineering Building. In addition to new teaching laboratories, the laboratory facilities include a pilot-scale unit-operations laboratory, temperature control facilities, a roof-top greenhouse, and state of the art analytical facilities. Undergraduate-level research is encouraged and allows you to participate in environmental research carried out it the Environmental Research Center and across the UMR campus. In summary, the diverse curricula, interdisciplinary faculty, and superb facilities afford you an excellent opportunity for an unparalleled education and prepare you for a bright future of solving tomorrow's problems in environmental engineering.

Mission Statement

The Environmental Engineering Program will prepare students for a career in the global, interdisciplinary field of environmental engineering and for life-long development in the profession. The program's fundamental base in biological and earth sciences and development of specific engineering application skills prepares graduates to approach unique, atypical problems with a true problem-solving approach, develop solutions to benefit society and the environment, and promote these solutions.

Environmental Engineering Program Educational Objectives

Consistent with the mission of the Environmental Engineering Program, graduates of the UMR Environmental Engineering Program will have:

1) a strong and broad fundamental scientific and technical knowledge base which they will be able to apply to experimental design, to conducting experiments, and to the interpretation and analysis of experimental data;
2) the ability to apply engineering skills and work in multi-disciplinary teams to identify and formulate solutions for environmental engineering problems and to analyze and design environmental engineering projects;
3) an appreciation for the continuous acquisition of knowledge;
4) competence in the use of the latest tools and techniques in environmental engineering practice and the ability to effectively communicate technical and professional information in written, oral, and graphical forms;
5) an awareness and understanding of the moral, ethical, legal, and professional obligations needed to function as part of a professional enterprise and to protect human health and welfare, and the environment in a global society.

Program Outcomes - An Overview

Consistent with the program educational objectives listed above, the UMR environmental engineering program graduate will have:

1. knowledge of contemporary issues, through broad education, which allows them to appreciate the impact of engineering solutions on humankind, and to be eager about and have the ability to engage in continued education throughout their lives;
2. knowledge of mathematics, science, and engineering, an ability to apply it with proficiency in at least four environmental engineering areas, and an understanding of the need for up to date engineering tools acquired through life-long learning;
3. ability to outline and conduct experiments in more than one environmental engineering area and communicate effectively in multi-disciplinary environments to analyze and interpret data and provide the results;

4. ability to carry out the design of an integrated system and its various components and processes for an environmental engineering project;
5. ability to provide leadership and effectively communicate among engineers and non-engineers when working in multi-disciplinary teams;
6. ability to define and state engineering and science problems in technical and non-technical language and to apply engineering principles to solve problems;
7. understanding of the responsibility of environmental engineers to practice in a professional and ethical manner at all times, including procurement of work, quality based selection processes, and interaction of design professionals and construction professionals;
8. ability to communicate effectively using oral, written, and graphic forms;
9. knowledge of the interactions of technology and society and their possible impacts on the practice of environmental engineering;
10. ability to utilize their background in science, humanities and engineering, and analytical and design skills when approaching ever changing engineering practice; and,
11. a sense of responsibility for the continued well-being of their alma mater and their profession.

Faculty

Professors:
Jeffrey Cawlfield[1], Ph.D., California-Berkeley
Douglas Ludlow, Ph.D., Arizona State University
Associate Professors:
Craig D. Adams[1] (John and Susan Mathes Professor), Ph.D., Kansas
Joel Burken (Undergraduate Program Coordinator), Ph.D., Iowa
Mark Fitch, Ph.D., Texas-Austin
Ronaldo Luna[1], Ph.D., Georgia Tech.
Cesar Mendoza, Ph.D., Colorado State University
David Wronkiewicz, Ph.D., New Mexico Institute of Mining and Technology
Assistant Professors:
Melanie Mormile, PhD. Oklahoma
Glenn Morrison, Ph.D., California-Berkeley
[1] Registered Professional Engineer

Environmental Engineering Technical Areas And Course Listings

AREA I, WATER AND WASTEWATER RESOURCES ENGINEERING

Cv Eng 331 Hydraulics of Open Channels
Cv Eng 335 Water Infrastructure Engineering
Cv Eng 346 Management of Construction Costs
Cv Eng 380 Water Resources and Wastewater Engineering
Cv Eng 337 River and Harbor Engineering
Cv Eng 338 Hydrologic Engineering

AREA II, GEO-ENVIRONMENTAL ENGINEERING

Cv Eng 314 Geosynthetics in Engineering
Ch Eng 351 Principles in Environmental Monitoring (Pre-req Chem, 221, 223)
Ge Eng 248 Fundamentals of GIS
Ge Eng 275 Geomorphology and Terrain Analysis
Ge Eng 333 Risk Assessment in Environmental Studies
Ge Eng 335 Environmental Geological Engineering
Ge Eng 339 Groundwater Remediation
Ge Eng 376 Mined Land Reclamation
Pet Eng 131 Drilling Practices
Geo 275 Introduction to Geochemistry
Geo 376 Aqueous Geochemistry
Geo 382 Environmental and Engineering Geophysics

AREA III, AIR POLLUTION AND CONTROL

Cv/Env Eng 368 Air Pollution Control Methods
Cv/Env Eng 390 Undergraduate Research
Chem 241 Physical Chemistry I (prereq for Chem 243)
Chem 373 Atmospheric Chemistry
Physics 337 Atmospheric Science

AREA IV, ENVIRONMENTAL CHEMISTRY AND PROCESSES

Ch Eng 245 Chemical Engineering Thermodynamics II
Ch Eng 231 Chemical Engineering Fluid Flow
Ch Eng 233 Chemical Engineering Heat Transfer
Ch Eng 251 Chemical Engineering Process Dynamics and Control
Chem 014 Elementary Analytical Chemistry
Chem 051 Elementary Quantitative Chemical Analysis
Chem 221 Organic Chemistry I
Chem 241 Physical Chemistry
Geo 275 Introduction to Geochemistry
Geo 376 Aqueous Geochemistry

AREA V, ENVIRONMENTAL MICROBIOLOGY AND PROCESSES

Bio Sc 231 General Genetics
Bio Sc 251 Ecology
Bio Sc 321 Pathogenic Microbiology
Bio Sc 322 Pathogenic Microbiology Laboratory
Bio Sc 325 Microbiology in Bioengineering
Bio Sc 331 Molecular Genetics (prereq = Bio 231)
Bio Sc 332 Molecular Genetics Laboratory (accomp. Bio 331)
Bio Sc 370 Toxicology

Environmental Engineering Bachelor of Science

FRESHMAN YEAR

First Semester	Credit
BE 10-Study & Careers in Eng[2]	1
Chem 1,2-Gen Chem	5
Math 14-Calculus for Engineers I	4
English 20-Expos & Argumentation	3
General Education Elective[1]	3
	16
Second Semester	
BE 20-Eng Design w/Cmp Apps	1
Math 15-Calculus for Engineers II	4

Phy 23-Engineering Physics I 4
Chem 3-General Chemistry 3
General Education Elective[1] 3
17

SOPHMORE YEAR

First Semester Credit
BE 140-Statics & Dynamics 3
Math 22-Calculus w/Analytic Geo III 4
Physics 24-Eng Physics II 4
Bio Sc 211-Cellular Biology 4
15

Second Semester Credit
ChE 120-Chem Eng Mat Bal 3
EnvE 262-Env Eng Bio Fund 3
CE 230-Elem Fluid Mech[2] 3
EnvE 261-Intro to Env Eng & Sci 3
General Education Elective[1] 3
Math 204-Elem Diff Equations 3
18

JUNIOR YEAR

First Semester Credit
EnvE 265-Water & Wastewater Eng 3
EnvE 263-Env Eng Chem Fund 3
Stat 213-Applied Eng Stat 3
GE 50-Geology for Engineers 3
Communications Elective[7] 3
15

Second Semester Credit
EnvE Depth Elective[3,4] 3
EnvE Depth Elective[3,4] 3
CE 234-Hydraulic Eng 4
ChE 141 or ME 227-Thermal Analysis 3
General Education Elective[1] 3
16

SENIOR YEAR

First Semester Credit
CE 248-Contracts & Construc Eng 3
EnvE 210-Senior Seminar 1
EnvE Depth Elective[3,4] 3
EnvE Technical Elective[3,6] 3
Hist 270-History of Technology 3
Free Elective[5] 3
16

Second Semester Credit
EnvE 298-CE Design Project 3
EnvE Depth Elective[3,4] 3
EnvE Depth Elective[3,4] 3
EnvE Technical Elective[3,6] 3
Free Elective[5] 3
15

[1] All general education electives must be approved by the student's advisor. Students must comply with the School of Engineering general education requirements with respect to selection and depth of study. These requirements are specified in the current catalog.

[2] A grade of 'C' or better required to satisfy graduation requirements

[3] A grade of 'C' or better may be required in CE technical and depth elective prerequisite courses. Refer to the UMR undergraduate catalog for this prerequisite information.

[4] Choose 5 of the following: CE 360, 361, 362, 363, 364, 367, 368, 369 or GE331

[5] 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.

[6] Select technical electives from approved list.

[7] Choose 1 of the following: Engl 60, Engl 160, or SP&MS 85

Note: All Environmental 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 UMR 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.

Environmental Engineering Courses

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

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

210 Senior Seminar: Engineering in a Global Society (Lect 1.0) Discussion of contemporary issues: public safety, health, and welfare; the principles of sustainable development; lifelong learning; impact of engineering solutions in a global and societal and political context; relationships with owners, contractors, and the public; public service; the Code of Ethics; and the Missouri licensing Statutes and Board Rules. Prerequisite: Senior standing. (Co-listed with Cv Eng and ArchE 210).

262 Biological Fundamentals of Environmental Engineering (Lect 3.0) Introduction to the function of organisms related to environmental engineering. The course focuses on both the application of organisms to removing contaminants and the effects of contaminants on organisms. Prerequisites: Bio 211 and preceded or accompanied by Civ/Env En 261. (Co-listed with Cv Eng 262).

263 Chemical Fundamentals of Environmental Engineering (Lect 2.0 and Lab 1.0) Introduction to the key chemical and physical concepts integral to environmental systems and processes. This course provides a fundamental background in those chemical and environmental engineering principles that are common to all environmental

engineering disciplines. Prerequisites: Chem 3, Physics 23, Math 22. (Co-listed with Cv Eng 263).

300 Special Problems (Variable) Problems or readings on specific subjects or projects in the department.

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

360 Environmental Law and Regulations (Lect 3.0) This course provides comprehensive coverage of environmental laws and regulations dealing with air, water, wastewater, and other media. The primary focus is permitting, reporting, and compliance protocols. The course topics include U.S. and international legal systems and judicial processes, liability, enforcement, Clean Air Act, Clean Water Act (NPDES) permitting), Safe Drinking Water Act, OSGA, TSCA, RCRA, and CERCLA. Case studies will be emphasized. (Co-listed with Cv Eng 360).

361 Remediation of Contaminated Groundwater and Soil (Lect 2.0 and Lab 1.0) Course covers current in-situ and ex-situ remediation technologies. Current literature and case studies are utilized to provide the focus for class discussions and projects. Prerequisites: Cv Eng 265, Ge Eng 337 or Graduate Standing. (Co-listed with Cv Eng 361).

362 Public Health Engineering (Lect 3.0) A comprehensive course dealing with the environmental aspects of public health. Prerequisites: Cv Eng 261 with grade of "C" or better. (Co-listed with Cv Eng 362).

363 Solid Waste Management (Lect 3.0) A systematic study of the sources, amounts and characteristics of solid wastes and methods used for their collection, reclamation, and ultimate disposal. Prerequisites: Cv Eng 261 with grade of "C" or better; or graduate standing. (Co-listed with Cv Eng 363).

364 Environmental Systems Modeling (Lect 3.0) Introductory course in modeling environmental systems. Course will focus on contaminant fate and transport in the environment. Models will be developed that will include physical, chemical and biological reactions and processes that impact this fate. Prerequisites: Env En/Cv Eng 261, Env En/Cv Eng 262 and Env En/ Cv Eng 263; or Graduate standing. (Co-listed with Cv Eng 364).

367 Introduction to Air Pollution (Lect 3.0) Introduction to the field of air pollution dealing with sources, effects, federal legislation, transport and dispersion and principles of engineering control. Prerequisite: Cv Eng 230 or equivalent; or graduate standing. (Co-listed with Cv Eng 367).

368 Air Pollution Control Methods (Lect 3.0) Study of the design principles and application of the state-ofthe-art control techniques to gaseous and particulate emissions from fossil fuel combustion, industrial and transportation sources. Prerequisite: Cv Eng 230 or equivalent; or graduate standing. (Co-listed with Cv Eng 368).

369 Sanitary Engineering Design (Lect 2.0 and Lab 1.0) Functional design of water and waste water treatment facilities. Prerequisites: Cv Eng 265 with grade of "C" or better. Co-listed with: Cv Eng 369

380 Water Resources and Wastewater Engineering (Lect 3.0) Application of engineering principles to the planning and design of multipurpose projects involving water resources development and wastewater collection/treatment/disposal systems. Latest concepts in engineering analysis are applied to evaluation of alternative solutions. Prerequisites: Cv Eng 233, 235, 265. (Co-listed with Cv Eng 380).

382 Teaching Engineering (Lect 3.0) Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Eng Mg 370, Cp Eng 382, El Eng 382, Cv Eng 382).

Computer Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy

The Computer Engineering Program is designed to prepare an engineer to work in both the abstract software world, where high level languages and more complexity will often provide a solution to a problem, and in the physical world where designs are often compromises between many opposing factors. The program further prepares engineers to compete in today's rapidly changing marketplace by providing the fundamental concepts and attributes that will enable them to recognize and understand future developments.

The distinction between a computer engineer and the more traditional computer science major or digital design electrical engineer may be in his/her desire to understand and participate in the entire process of using abstract algorithms and data structures to control changes in real physical devices.

There are many aspects to Computer Engineering. A Computer Engineer might be working on the design of a new automobile brake system where a knowledge of the electronic sensors and the dynamic nature of the brakes might be as important as the programming of the I/O handler interrupt subroutine in high level C or assembly language. Another project such as the design of a distributed control system for a factory floor might require the engineer to have an extensive background

in computer networks and programming as well as an understanding of the manufacturing process.

The major objective of the Bachelor of Science in Computer Engineering degree curriculum is to provide an in-depth education in both the hardware and software aspects of modern computer systems. At the same time it provides options that allow students to select courses in other science and engineering areas that will provide additional background for future positions where knowledge about a system may be as important for a particular task as computer skills.

The Bachelor of Science in Computer Engineering Degree Program is designed to meet ABET accreditation requirements. It provides training in technical skills in both lecture and laboratory courses. It develops communication techniques in courses such as technical writing and speech. It provides humanities and social science electives that help develop the perspective necessary to understand the social impact of engineering solutions. A two-semester senior project allows students to hone technical and communication skills while working as a team on a challenging venture.

The Computer Engineering Program follows the Electrical Engineering Program into the sophomore year and then branches into Computer Science courses in data structures, discrete mathematics, operating systems, and computer networks as well as continuing with core courses in electrical engineering. It includes computer design courses and hardware laboratories. Students will first complete the Freshman Engineering program thus obtaining basic science skills along with orientation about the various degree programs at UMR. This allows students time to consider different career options before they have to commit to a given degree program.

Students should work closely with their advisor to carefully plan each semester's class schedule in order to have the correct prerequisites for courses in the following semesters. They should also select electives in the program to provide the background in areas they wish to emphasize for a different career path.

Students in other disciplines working with their advisor should be able to plan a program that would allow them to graduate with a degree in the original discipline and a Computer Engineering degree by sharing some electives and taking additional course work. Students with a qualifying GPA should consider the alternative of working towards a MS degree in graduate school instead of a second B.S. degree.

The following are examples of four different areas or career paths. They are by no means exhaustive and it is not necessary to select any one of them. You are encouraged to select your own grouping of electives to suit your unique needs and interests. Digital Systems Design topics include computer architecture, digital circuits, high performance systems, parallel processor, testing, and VLSI design. Electrical Engineering can be a career path in Computer Engineering or a separate degree. See the section on Electrical Engineering for emphasis areas in electrical engineering. Embedded Computer Systems topics include hardware/software co-design, microprocessor systems, real-time systems, and smart sensors. Systems, Intelligence, and Software Engineering topics include computational intelligence, computer networks, dependability, fault tolerance, image processing, neural networks, and system security/survivability.

Mission Statement

The mission of the Computer Engineering Program, consistent with the School of Engineering and the UMR campus mission statements, is the education of students to fully prepare them to provide leadership in the recognition and solution of society's problems in the area of Computer Engineering. Fundamental to the mission of the Department of Electrical and Computer Engineering is the operation of the B.S., M.S., and Ph.D., degree programs in Computer Engineering. The educational objectives for the undergraduate program are: First, you will obtain a broad education that crosses departmental boundaries while still attaining technical depth in areas impacted by computer engineering. Your skills will allow individual or team solutions to difficult, novel, multidisciplinary problems; effective balancing of multiple design issues; and lifelong adaptation to new technological developments. Secondly, you will obtain a solid understanding of professional and ethical responsibility and a recognition of the need for, and ability to engage in, a program of lifelong learning. Finally, you will experience an academic environment in which small classes are taught by full-time faculty and which fosters lifelong learning, leadership, scholarship, and an appreciation of the value of diversity.

Computer Engineering Faculty

Professors:

Darrow F. Dawson[1] (Emeritus), Ph.D., University of Arizona
Ann Miller (The Cynthia Tang Distinguished Professor of Computer Engineering), Ph.D., St. Louis University
Paul D. Stigall[1] (Emeritus), Ph.D., University of Wyoming
Donald C. Wunsch II[1], (The Mary K. Finley Missouri Distinguished Professor of Computer Engineering), Ph.D., University of Washington

Associate Professor:

Hardy J. Pottinger (Emeritus), Ph.D., University of Missouri-Rolla

Assistant Professors:

Daryl Beetner[1], D.Sc., Washington University
Minsu Choi, Ph.D., Oklahoma State University
Scott C. Smith, Ph.D., University of Central Florida
Ronald Joe Stanley, Ph.D., University of Missouri-Columbia
Ganesh Kumar Venayagamoorthy, Ph.D., University of Natal, South Africa

Electrical Engineering Faculty

Professors:

David R. Cunningham[1] (Emeritus), Ph.D., Oklahoma State University
James Drewniak, Ph.D., University of Illinois at Urbana-Champaign
Kelvin T. Erickson1[1] Ph.D., Iowa State University
O. Robert Mitchell[1], Ph.D., Massachusetts Institute of Technology
Randy H. Moss[1], Ph.D., University of Illinois

S. Vittal Rao (Director of Intelligent Systems Center and William A. Rutledge Emerson Electric Co.) (Distinguished Professor) Ph.D., I.I.T., New Delhi
Cheng-Hsiao Wu, Ph.D., University Rochester

Associate Professors:
Levent Acar, Ph.D., Ohio State University
Norman R. Cox[1], Ph.D., University of Texas-Arlington
Kurt L. Kosbar, Ph.D., University of Southern California
Steve Watkins, Ph.D., University of Texas at Austin

[1] Registered Professional Engineer

Bachelor of Science Computer Engineering

FRESHMAN YEAR

First Semester	Credit
BE 10-Study & Careers in Eng	1
Chem 1-General Chemistry	4
Chem 2-General Chemistry Laboratory	1
Math 14-Calculus I for Engineers[3]	4
Hist 112, 175, 176, or Pol Sc 90	3
English 20-Exposition & Argumentation	3
	16

Second Semester	Credit
Bas Eng 20 - Eng. Design with Comp. App	3
Math 15-Calculus II for Engineers[3]	4
Physics 23-Engineering Physics I[3,5]	4
Econ 121 or 122	3
	14

SOPHOMORE YEAR

First Semester	Credit
El Eng 151-Circuits I[3,4]	3
El Eng 152-Circuit Analysis Lab[4]	1
Math 22-Calculus w/Analytic Geometry III[3]	4
Cmp Sc 53-Intro to Programming[3]	3
Cmp Sc 54-Intro to Programming Lab[3]	1
Physics 24-Engineering Physics II[3,5]	4
	16

Second Semester	
Cp Eng 111-Intro to Computer Engineering [4]	3
Cp Eng 112-Computer Engineering Lab I [4]	1
El Eng 153-Circuits II [3, 4, 7]	3
El Eng 154-Circuit Analysis Lab II [4,7]	1
Math 204-Elementary Differential Equations [3]	3
Cmp Sc 153-Data Structures I	3
Cmp Sc 158-Discrete Mathematics	3
	17

JUNIOR YEAR

First Semester	Credits
Elective -Mathematics [10]	3
SP&M S 85 or SP&M S 283	3
Cp Eng 213-Digital Systems Design[4]	3
Cp Eng 214-Computer Engineering Lab II [4]	1
Cp Eng Science Elective I [11]	3
Elective-Hum or Soc Sci[6]	3
	16

Second Semester	Credits
English 160-Technical Writing [12]	3
Statistics 217-Intro. To Probability & Statistics [13]	3
Cmp Sc 284-Intro. to Operating Systems [17]	3
Cp-Eng Science Elective II [11]	3
Cp Eng Computer Organization Elective [14]	3
Free Elective [20]	3
	18

SENIOR YEAR

First Semester	Credit
Elective-Hum or Soc Sc (upper level) [6]	3
El Eng-Cp Eng 391-Senior Project I	1
Cmp Sc 285-Computer Network Concepts & Tech [19]	3
Cp Eng Senior Elective A [15]	3
Cp Eng Senior Elective B [16]	3
Free Elective [20]	3
	16

Second Semester	Credit
Elective-Hum or Soc Sci (upper level) [6]	3
El Eng-Cp Eng 392-Senior Project II	3
Cp Eng-Senior Elective C [16]	3
Cp Eng-Senior Elective D [16]	3
Cp Eng-Senior Elective E [8, 9]	3
	15

NOTES: Student must satisfy the common engineering freshman year requirements and be admitted into the department.

1) The minimum number of hours required for a degree in Computer Engineering is 128.
2) Students that transfer to UMR after their freshman year are not required to enroll in Freshman Engineering Seminars.
3) A minimum grade of "C" must be attained in Math 14, 15, 22 and 204, Physics 23 and 24 (or their equivalents), El Eng 151, 153, Cmp Sc 53 and Cmp Sc 54.
4) Students who drop a lecture prior to the last week to drop a class must also drop the corequisite lab.
5) Students may take Physics 21 & 22 or 21 & 27 in place of Physics 23. Students may take Physics 25 & 26 or 25 & 28 in place of Physics 24.
6) All electives must be approved by the student's advisor. Students must comply with the School of Engineering general education requirements with respect to selection and depth of study. These requirements are specified in the current catalog. The selection of one or more courses that relate to other cultures is encouraged.
7) Students must earn a passing grade on the El Eng Advancement Exam I before they enroll in El Eng 153 and 154.
8) Cp Eng Senior Elective E to be selected from El Eng 265 and 266, El Eng 253 and 255, El Eng 271 and 272, or Power Elective to be selected from El Eng 205 and 208, or El Eng 207 and 209.
9) Students must earn a passing grade on the El Eng Advancement Exam II before they enroll in El Eng 205 and 208, 207 and 209, 253 and 255, 265 and 266, 271 and 272.

[10] All Computer Engineering students must complete at least one of the following courses: Math 203, 208, 305, 307, 309, 315, 322, 325, 330, 351, 383 or Computer Science 228.

[11] The six hours of Science Electives to be selected from an approved list which include Bas En 140, Mc Eng 227, Mc Eng 219, Physics 107, Chem 221, Bio Sc 110, 112, 211, 231, 235, 242, 361.

[12] English 60 Writing and Research may be taken in place of English 160 Technical Writing.

[13] Stat 215 Engineering Statistics or Stat 343 Probability and Statistics may be taken in place of Stat 217 Introduction to Probability and Statistics.

[14] Cp Eng Computer Organization Elective to be selected from an approved list which includes Cp Eng 311, Cp Eng 312, Cp Eng 313 and Cp Eng 315.

[15] Senior Elective A to be selected from Cp Eng 3xx, El Eng 3xx, or Cmp Sc 3xx courses.

[16] Senior Electives B, C, and D are to be selected from an approved list. This list contains most 200 and 300 level science, mathematics and engineering courses.

[17] Cp Eng 111 and Cp Eng 213 can be used in place of Cmp Sc 234 as the requirement for Cmp Sc 284.

[18] All Computer 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 UMR assessment process as described in Assessment Requirements found elsewhere in this undergraduate catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

[19] Students may take Cp Eng 319 or Cmp Sc 385 in place of Cp Sc 285.

[20] 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.

Computer Engineering Courses

101 Special Topics (Variable) This course is designed to give the department an opportunity to test a new course. Variable title. Co-listed with: El Eng 101

111 Introduction to Computer Engineering (Lect 3.0) Binary arithmetic, Boolean algebra, logic and memory elements, Computer Aided Design (CAD) techniques, computer organization. Prerequisites: Cmp Sc 53, 73, or 74. Students should enroll in Cp Eng 111 and Cp Eng 112 simultaneously.

112 Computer Engineering Laboratory (Lab 1.0) Introduction to digital design techniques, logic gates, Medium Scale Integration (MSI) parts and flipflops, Timing analysis, Programming and use of Programmable Logic Devices (PLD). Prerequisite: Preceded or accompanied by Cp Eng 111.

200 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

202 Cooperative Engineering Training (Variable) 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 supervisors evaluations.

210 Senior Seminar (Lect 0.5) Discussion of current topics. Prerequisite: Next to last semester.

213 Digital Systems Design (Lect 3.0) Microcontroller-based digital systems design methodology and techniques. Basic machine organization. Interface design. C and assembly language programming for real-time embedded systems. Prerequisites: Cp Eng 111 and Cmp Sc 53, or Cmp Sc 74, or equivalent.

214 Digital Engineering Lab II (Lab 1.0) Advanced digital design techniques, Microcontroller based design, hardware and software codesign. Prerequisites: Cp Eng 111 and 112. Simultaneous enrollment in Cp Eng 213.

300 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

311 Introduction to VLSI Design (Lect 2.0 and Lab 1.0) An introduction to the design and implementation of very large scale integrated systems. Procedures for designing and implementing digital integrated systems, structured design methodology, stick diagrams, scalable design rules, and use of computer aided design tools. Prerequisite: Cp Eng 213.

312 Digital Systems Design Laboratory (Lect 2.0 and Lab 1.0) Experimental studies of problems with high speed digital signals in circuits. Student designs, wires, tests, and programs a microprocessor based single board computer project. A FPGA design is programmed and tested. Prerequisite: Cp Eng 213 or 313.

313 Microprocessor Systems Design (Lect 3.0) The design of digital systems based around microcomputers, microcomputer architecture, logic replacement, hardware vs. software tradeoffs, memory design, timing considerations, input/output design, and total systems design. Prerequisites: Cp Eng 213 and Cp Eng 214.

315 Digital Computer Design (Lect 3.0) Organization of modern digital computers; design of processors, memory systems and I/O units, hardware-software tradeoffs in different levels of com-

puter system design. Prerequisites: Cp Eng 213 and Cp Eng 214.

316 Advanced Microcomputer System Design (Lect 3.0) The design of digital systems based on advanced microprocessors. Introduction to microcomputer logic development systems. I/0 interfaces. Assembly and high level language tradeoffs. Hardware and software laboratory projects required. Prerequisite: Cp Eng 313.

317 Fault-Tolerant Digital Systems (Lect 3.0) Design and analysis of fault-tolerant digital systems. Fault models, hardware redundancy, information redundancy, evaluation techniques, system design procedures. Prerequisites: Cp Eng 111 and Cp Eng 112.

318 Digital System Modeling (Lect 3.0) Digital system modeling for simulation, synthesis, and rapid system prototyping Structural and behavioral models, concurrent and sequential language elements, resolved signals, generics, configuration, test benches, processes and case studies. Prerequisites: Cp Eng 111 and Cp Eng 112; or Cmp Sc 234.

319 Digital Network Design (Lect 3.0) Simulation-based design of digital networks including local, metropolitan, and wide-area networks. Network standards, performance, trade-off, and simulation tools. Prerequisite: Cp Eng 213 or computer hardware competency.

331 Real-Time Systems (Lect 3.0) Introduction to real-time (R-T) systems and R-T kernels, also known as R-T operating systems, with an emphasis on scheduling algorithms. The course also includes specification, analysis, design and validation techniques for R-T systems. Course includes a team project to design an appropriate R-T operating system. Prerequisite: Cp Eng 213 or Cmp Sc 284.

342 Real-Time Digital Signal Processing (Lect 3.0) Introduction to the use of programmable DSP chips to implement DSP algorithms in real-time. Includes real-time data acquisition, interrupt-driven programs, deterministic and random signal generation, quantization effects, division of labor between numerical analysis, high-level language and assembly level routines. Prerequisites: Cp Eng 213 and El Eng 267.

345 Digital Image Processing (Lect 3.0) Fundamentals of human perception, sampling and quantization, image transforms, enhancement, restoration, channel and source coding. Prerequisite: El Eng 267 (Co-listed with El Eng 345).

349 Trustworthy, Survivable Computer Networks (Lect 3.0) This course examines basic issues in network management, testing, and security; it also discusses key encryption, key management, authentication, intrusion detection, malicious attack, and insider threats. Security of electronic mail and electronic commerce systems is also presented. Prerequisite: Cp Eng 319 or Cmp Sc 285.

382 Teaching Engineering (Lect 3.0) Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Eng Mg 370, Env En 382, El Eng 382, Cv Eng 382).

390 Undergraduate Research (Variable) 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.

391 Computer Engineering Senior Project I (Lect 0.5 and Lab 0.5) A complete design cycle. Working in small teams, students will design, document, analyze, implement, and test a product. Topics include: Iteraton in design, prototyping, group dynamics, design reviews, making effective presentations, concurrent design, designing for test, ethics and standards, testing and evaluation. Prerequisites: Stat 217, Cp Eng 111, Econom 121 or 122, Sp&M S 85, English 160, Cp Eng 213, 214, and a computer organization elective.

392 Computer Engineering Senior Project II (Lab 3.0) A continuation of Cp Eng 391. Prerequisite: Cp Eng 391.

Electrical Engineering

Bachelor of Science
Master of Science
Doctor of Philosophy
Doctor of Engineering

Emphasis areas at all levels in circuits, communications-signal processing, computer engineering, control, electromagnetics, electronics, and power.

Electrical engineers are involved in channeling natural resources into uses for man such as heating, lighting, home appliances, transportation, and communications. They are primarily concerned with the processes of generation, transmission, transformation, control, and utilization of energy or information.

In electrical engineering education at UMR, you can choose to emphasize an area which especially interests you or you can study a broader spectrum of course work.

In circuits, you will study the application of basic electrical elements - energy sources, resistors, inductors, capacitors, diodes, and transistors - as they are found interconnected in operational electrical networks.

The communications-signal processing area includes such studies as the makeup of information-bearing signals, modulation systems, and detection techniques.

If you want to stress computer engineering, you will study the design and/or applications of microprocessor systems, digital logic, digital-logic devices, digital design

and automation, large computer systems, robot vision systems, artificial intelligence, and distributed processing.

The control emphasis area provides course work in the design and application of circuits and systems used to automatically monitor and regulate devices, machines, and systems for optimal performance in a variety of operations including flexible manufacturing.

In electromagnetics, you will study high-frequency waves, antennas, and microwave systems of various types for propagation and transmission of electrical signals through space or conductors.

Physical electronics focuses on the operation of transistors, solid state devices, and integrated circuits as used in linear, digital, and wave-shaping circuits.

In power, you will deal with the design and application of motors, generators, transformers, distribution systems, high-voltage design methods, and the economic transmission of energy.

No matter which emphasis area you choose, your first two years of study will be devoted to courses in the fundamentals of engineering, basic sciences, mathematics, and humanities and social sciences. Electrical engineering courses become concentrated during the last two years. Required electrical engineering courses in the junior and senior years cover all the specialty topics of electrical engineering.

Elective courses provide for study in greater depth of areas of particular interest to individual students.

Your classrooms and laboratories will be in the Emerson Electric Co. Hall. Additional electrical and electronics research activities are being conducted in the various research centers and in the Engineering Research Laboratory.

Mission Statement

The mission of the Electrical Engineering Program, consistent with the School of Engineering and the UMR Campus mission statements, is the education of students to fully prepare them to provide leadership in the recognition and solution of society's problems in the area of Electrical Engineering. Fundamental to the mission of the Department of Electrical and Computer Engineering is the operation of the B.S., M.S., and Ph.D degree programs in electrical engineering. The educational objectives for the undergraduate program are: First, you will obtain a broad education that crosses departmental boundaries while still attaining technical depth in areas impacted by electrical engineering. Your skills will allow individual or team solutions to difficult, novel, multidisciplinary problems; effective balancing of multiple design issues; and lifelong adaptation to new technological developments. Secondly, you will obtain a solid understanding of professional and ethical responsibility and a recognition of the need for, and ability to engage in, a program of life long learning. Finally, you will experience an academic environment in which small classes are taught by full-time faculty and which fosters lifelong learning, leadership, scholarship, and an appreciation of the value of diversity.

Faculty

Professors:

Max Anderson[1] (Emeritus), Ph.D., Arizona State University
Jack Boone (Emeritus), Ph.D., University of Denver
Jack Bourquin (Emeritus), Ph.D., University of Illinois
Gordon Carlson[1], (Emeritus), Ph.D., University of Illinois
Ralph Carson (Emeritus), Ph.D., University of Illinois
Badrul Chowdhury, Ph.D., Virginia Tech
Mariesa Crow[1], (Associate Dean), Ph.D., University of Illinois at Urbana-Champaign
David Cunningham[1], (Emeritus), Ph.D., Oklahoma State University
Darrow Dawson[1], (Emeritus), Ph.D., University of Arizona
James Drewniak, Ph.D., University of Illinois at Urbana-Champaign
Richard E. DuBroff[1] (Interim Chair), University of Illinois
Kelvin T. Erickson[1], Ph.D., Iowa State University
David Ronald Fannin (Director, Freshman Engineering Program), Ph.D., Texas Tech
Walter J. Gajda, Jr. ,Ph.D.,Massachusetts Institute of Technology
Burns Hegler[1], (Emeritus), Ph.D., Kansas State University
Todd Hubing, Ph.D., North Carolina State University
Frank Kern[1] (Emeritus), Ph.D., University of Oklahoma
George McPherson (Emeritus), M.S., Ohio State University
Ann K. Miller (Cynthia Tang Missouri Distinguished Professor), Ph.D., St. Louis University
Robert Mitchell[1] (Dean of Engineering), Ph.D., Massachusetts Institute of Technology
Randy Moss[1], Ph.D., University of Illinois
S. Vittal Rao (Director of the Intelligent Systems Center and William A. Rutledge Emerson Electric Co.) (Distinguished Professor) Ph.D., I.I.T., New Delhi
Earl Richards[1] (Emeritus), Ph.D., UMR
Gabriel Skitek (Emeritus), M.S., UMR
E. Keith Stanek[1] , (Fred Finley Distinguished Professor), Ph.D., Illinois Institute of Technology
Paul Stigall[1] (Emeritus), Ph.D., University of Wyoming
John Alan Stuller (Emeritus), Ph.D., University of Connecticut
William Tranter (Emeritus), Ph.D., University of Alabama
Thomas Van Doren[1] (Emeritus), Ph.D., UMR
Cheng-Hsiao Wu, Ph.D., University of Rochester
Donald C. Wunsch II[1] (Mary K. Finley Missouri Distinguished Professor), Ph.D., University of Washington
Reza Zoughi (Schlumberger Distinguished Professor), Ph.D., University of Kansas

Associate Professors:

Levant Acar, Ph.D., Ohio State University
Norman Cox[1], Ph.D., University of Texas at Arlington
James H. Hahn[1] (Emeritus), Ph.D., UMR
Thomas Herrick (Emeritus), M.S., UMR
Kurt Kosbar, Ph.D., University of Southern California
Jack Morris (Emeritus), M.S., UMR
Steven D. Pekarek, Ph.D., Purdue University
David Pommerenke, Dr.-Ing, Technical University of Berlin
Hardy J. Pottinger (Emeritus), Ph.D., UMR
Jagannathan Sarangapani, Ph.D., University of Texas-Arlington
Steve Watkins, Ph.D., University of Texas at Austin

Assistant Professors:
Daryl Beetner, D.Sc., Washington University
Minsu Choi, Ph.D., Oklahoma State University
Babak Fahimi, Ph.D., Texas A&M
Chang - Soo Kim, Ph.D., Kyungpook National University
Scott Smith, Ph.D. University of Central Florida
Ronald Joe Stanley, Ph.D., University of Missouri-Columbia
Ganesh Kumar Venayagamoorthy, Ph.D., University of Natal
William Weeks IV, Ph.D., University of Illinois at Urbana-Champaign

[1] Registered Professional Engineer

Bachelor of Science Electrical Engineering

FRESHMAN YEAR

First Semester	Credit
BE 10-Study & Careers in Eng	1
Chem 1-General Chemistry	4
Chem 2-General Chemistry Lab	1
Math 14-Calculus I for Engineers [3]	4
Hist 112, 175, 176, or Pol Sc 90	3
English 20-Exposition & Argumentation	3
	16

Second Semester	Credit
BE 20 - Eng. Design with Comp. Appl.	3
Math 15-Calculus II for Engineers [3]	4
Physics 23-Engineering Physics I [3, 6]	4
Econ 121 or 122	3
Elective-Hum or Soc Sci [7]	3
	17

SOPHOMORE YEAR

First Semester	Credit
El Eng 151-Circuits I [3, 4]	3
El Eng 152-Circuit Analysis Lab I [4]	1
Math 22-Calculus w/Analytic Geometry III [3]	4
Cmp Sc 74-Intro to Programming Methodology [5]	2
Cmp Sc 78-Programming Methodology Lab [5]	1
Physics 24-Engineering Physics II [3, 6]	4
	15

Second Semester	Credit
Cp Eng 111-Introduction to Computer Engineering [4]	3
Cp Eng 112-Computer Engineering Lab [4]	1
El Eng 153-Circuits II [3, 4, 8]	3
El Eng 154-Circuit Analysis Lab II [4]	1
Math 204-Elementary Differential Equations [3]	3
Engineering Science Elective [9, 16]	3
Sp&M 85-Principles of Speech	3
	17

JUNIOR YEAR

First Semester	Credit
El Eng 253-Electronics I [4, 10]	3
El Eng 255-Electronics I Lab [4]	1
El Eng 265-Linear Systems I [4, 10]	3
El Eng 266-Linear Systems I Lab [4]	1
El Eng 271-Electromagnetics [4, 10]	3
El Eng 272-Electromagnetics Lab [4]	1
Math 208-Linear Algebra	3
	15

Second Semester	Credit
El Eng 267-Linear Systems II [4]	3
El Eng 268-Linear Systems II Lab [4]	1
El Eng Power Elective [4, 10, 11]	3
El Eng-Power Elective Lab [4, 11]	1
Stat 217-Prob & Stat for Eng and Scientists [12]	3
English 160-Technical Writing [13]	3
El Eng 225	3
	17

SENIOR YEAR

First Semester	Credit
El Eng Elective A [14]	3
El Eng Elective B [14]	3
El Eng Elective C [14]	3
El Eng 391-El Eng Senior Project I	1
Free Elective [19]	3
Elective-Hum or Soc Sci (upper level) [7]	3
	16

Second Semester	Credit
El Eng Elective D [17]	3
El Eng Elective E [18]	3
El Eng 392-El Eng Senior Project II	3
Elective-Hum or Soc Sci (upper level) [7]	3
Free Elective [19]	3
	15

NOTE: Student must satisfy the common engineering freshman year requirements and be admitted into the department.

1) The minimum number of hours required for a degree in Electrical Engineering is 128.
2) Students that transfer after their freshman year are not required to enroll in Freshman Engineering Seminars.
3) A minimum grade of "C" must be attained in Math 14, 15, 22 and 204, Physics 23, and 24 (or their equivalents) and El Eng 151 and 153.
4) Students who drop a lecture prior to the last week to drop a class must also drop the corequisite lab.
5) Students may take Cmp Sc 53 (C++ for Cmp Sc majors) or Cmp Sc 73 and 77 (Fortran) in place of Cmp Sc 74 and 78 (C++ for Eng majors.)
6) Students may take Physics 21 & 22 or 21 & 27 in place of Physics 23. Students may take Physics 25 & 26 or 25 & 28 in place of Physics 24.
7) All electives must be approved by the student's advisor. Students must comply with the School of Engineering general education requirements with respect to selection and depth of study. These requirements are specified in the current catalog. The selection of one or more courses that relate to other cultures is encouraged.
8) Students must earn a passing grade on the El Eng Advancement Exam I before they enroll in El Eng 153 and 154.
9) The pair of courses Bas Eng 50 & Bas En 150 or the pair Bas Eng 50 & EMech 160 may be taken in place

of Bas En 140. Students pursuing a physics minor may replace Bas En 140 with Physics 208.

[10] Students must earn a passing grade on the El Eng Advancement Exam II before they enroll in El Eng 205, 207, 253, 265 or 271.

[11] The El Eng Power Elective may be satisfied with El Eng 205 and El Eng 208 or El Eng 207 and El Eng 209.

[12] Stat 217 may be replaced by Stat 215 or Stat 343.

[13] English 160 may be replaced by English 60.

[14] El Eng Electives A, B and C must be chosen from El Eng 205 and 208, 207 and 209, 231 or 235, 243, 254, or Cp Eng 213.

[15] All Electrical Engineering students must take the Fundamentals of Engineering Exam 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 UMR assessment process as described in Assessment Requirements found elsewhere in this undergraduate catalog. Students must sign a release form giving the University access to their Fundamentals of Engineering Examination score.

[16] Bas Eng 140, Mc Eng 219, or Mc Eng 227.

[17] El Eng Elective D must be a 300 level El Eng or Cp Eng course with at least a 3 hour lecture component. This normally includes all El Eng and Cp Eng 3xx courses except El Eng and Cp Eng 300, 390, 391, and 392.

[18] El Eng Elective E may be any 200 or 300 level El Eng or Cp Eng course except El Eng 281, 282, 283, and El Eng and Cp Eng 391, and 392.

[19] 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.

Emphasis Areas for Electrical Engineering

Note: The following emphasis areas identify courses from which a student may opt to develop an emphasis area. It is not required that students obtain an emphasis specialty within electrical engineering.

Circuits

- **Highly Recommended**
  - El Eng 225-Electronic & Photonic Devices
  - El Eng 254-Electronics II
  - El Eng 256-Electronics Laboratory II
  - El Eng 351-Advanced Electronic Circuits
  - El Eng 363-Introduction to Circuit Synthesis

Suggested

- El Eng 353-Power Electronics
- El Eng 355-High Frequency Amplifiers
- El Eng 361-Computer Aided Network Design
- El Eng 371-Grounding & Shielding

Communications-Signal Processing

Highly Recommended

- Math 208-Linear Algebra I
- El Eng 243-Communication Systems
- El Eng 341-Digital Signal Processing
- El Eng 343-Communications Systems II

Suggested

- Cp Eng 213-Digital Systems Design
- El Eng 231-Control Systems
- El Eng 331-Digital Control
- El Eng 345-Digital Image Processing
- El Eng 347-Machine Vision

Computer Engineering

Highly Recommended

- Cp Eng 213-Digital Systems Design
- Cp Eng 311-Introduction to VLSI Design
- Cp Eng 312-Digital Systems Design Laboratory
- Cp Eng 313-Microprocessor Systems Design

Suggested

- El Eng 235-Controllers for Factory Automation
- El Eng 254-Electronics II
- El Eng 256-Electronics Laboratory II
- Cp Eng 315-Digital Computer Design
- Cp Eng 316-Advanced Microcomputer System Design
- Cp Eng 317-Fault-Tolerant Digital Systems
- El Eng 331-Digital Control
- El Eng 341-Digital Signal Processing
- El Eng 345-Digital Image Processing
- El Eng 371-Grounding and Shielding

Controls

Highly Recommended

- Math 208-Linera Algebra I
- El Eng 231-Control Systems
- El Eng 235-Controllers for Factory Automation
- El Eng 331-Digital Control

Suggested

- Cp Eng 213-Digital Systems Design
- El Eng 332-Plantwide Process Control
- El Eng 333-System Simulation & Identification
- El Eng 335-Advanced PLC
- El Eng 337-Neural Networks for Control

Electromagnetics

Highly Recommended

- Physics 107-Introduction to Modern Physics
- El Eng 225-Electronic & Photonic Devices
- El Eng 371-Grounding & Shielding

Suggested

- El Eng 373-Antennas & Propagation
- El Eng 379-Microwave Principles for Mixed-Signal Design
- El Eng/Physics 324-Fourier Optics
- Math 208-Linear Algebra I
- Math 325-Partial Differential Equations

Electronics

Highly Recommended

- Math 208-Linear Algebra I
- Physics 107-Introduction to Modern Physics

- El Eng 225-Electronic & Photonic Devices

Suggested

- El Eng/Physics 323-Classical Optics
- El Eng/Physics 324-Fourier Optics
- El Eng 325-Optical Computing
- El Eng/Physics 326-Fiber & Integrated Optics
- Physics 371-Quantum Electronics

Power

Highly Recommended

- El Eng 205-Electromechanics
- El Eng 208-Electromechanics Lab
- El Eng 207-Power System Analysis & Design
- El Eng 209-Power System Analysis & Design Lab

Suggested

- El Eng 303-Elec Dist System Design & Protection
- El Eng 304-Electric Drive Systems
- El Eng 306-Adv Power System Analysis & Design
- El Eng 331-Digital Control
- El Eng 353-Power Electronics
- Math 208-Linear Algebra I
- Cmp Sc 228-Intro to Numerical Methods
- Eng Mg 208-Engineering Economy
- Nu Eng 205-Principles of Nuclear Engineering

Electrical Engineering Courses

101 Special Topics (Variable) This course is designed to give the department an opportunity to test a new course. Variable title. Co-listed with: Cp Eng 101

110 Transfer Student Seminar (Lect 0.5) Discussion of current topics. Prerequisite: First semester transfer student.

151 Circuits I (Lect 3.0) Circuit elements, signals, Kirchhoff's laws, network theorems, mesh and nodal analysis, transient and complete response of RL, RC, and RLC circuits. Prerequisites: Math 15 (or 21) with a grade of "C" or better. Students should enroll in El Eng 151 and El Eng 152 simultaneously.

152 Circuit Analysis Laboratory I (Lab 1.0) Safety, basic measurements and meters, oscilloscopes, resistor networks, measurement of capacitors and inductors, RLC circuit response. Prerequisite: Preceded or accompanied by El Eng 151. A student who drops El Eng 151 must also drop El Eng 152.

153 Circuits II (Lect 3.0) Analysis of steady state AC circuits, phasor notation, polyphase circuits, complex frequency and frequency response, magnetically coupled circuits. Prerequisites: Both Math 22 and El Eng 151 with a grade of "C" or better. Passing grade on EE Advancement Exam I. Students should enroll in El Eng 153 and 154 simultaneously.

154 Circuit Analysis Laboratory II (Lab 1.0) Continuation of EL Eng 152. Advanced oscilloscope measurement techniques, direct current power supply circuits, resonance. Prerequisites: Preceded or accompanied by El Eng 153, passing grade on EE Advancement Exam I. A student who drops El Eng 153 must also drop El Eng 154.

155 Circuit Analysis Laboratory I and II (Lab 2.0) A combination of El Eng 152 and 154. Prerequisites: Preceded or accompanied by El Eng 153, passing grade on EE Advancement Exam I. A student who drops El Eng 153 must also drop El Eng 155.

200 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

202 Cooperative Engineering Training (Variable) 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 supervisors evaluation.

205 Electromechanics (Lect 3.0) Magnetics and magnetically coupled circuits, electromechanical energy conversion, rotating magnetic fields, stepper motors, DC machines, induction machines, synchronous machines, and brushless DC machines. Prerequisites: El Eng 153 with a grade of "C" or better, passing grade on the El Eng Advancement Exam II. El Eng 208 is a corequisite.

207 Power System Design and Analysis (Lect 3.0) Power system components and transmission lines, three phase balanced power system theory, analysis and design including economic and reliability considerations, and fault analysis. A power system design project using a graphical power flow program is included. Prerequisites: El Eng 153 with a grade of "C" or better and passing grade on the El Eng Advancement Exam II. Co-req El Eng 209.

208 Electromechanics Laboratory (Lab 1.0) Experiments with power measurement, transformers, magnetically coupled circuits, rotating magnetic fields, stepper motors, DC machines, induction machines, synchronous machines, and brushless DC machines. Prerequisites: El Eng 153 with a grade of "C" or better, passing grade on the El Eng Advancement Exam II. El Eng 205 is a corequisite.

209 Power System Design and Analysis Laboratory (Lab 1.0) Computer-aided analysis of voltage regulation, power flow, compensation, and economic analysis. Individual projects are required. Prerequisites: El Eng 153 with a grade of "C" or better, passing grade on the El Eng Advancement Exam II. El Eng 207 is a corequisite.

210 Senior Seminar (Lect 0.5) Discussion of current topics. Prerequisite: Next to last semester senior.

225 Electronic and Photonic Devices (Lect 3.0) Application of semiconductor materials for electronic and photonic applications. Topics include crystal physics, electron and photon behavoir, pn junctions, heterojunctions, junction diodes, optoelectronic devices, and ohmic and rectifying contacts. Prerequisites: Physics 24, Math 22, and preceded or accompanied by El Eng 271.

231 Control Systems (Lect 3.0) Formulation of the control problem, system equations and models, frequency, time, and state space analysis and design of linear control systems. Prerequisite: El Eng 267.

235 Controllers for Factory Automation (Lect 2.0 and Lab 1.0) Introduction to programmable automation, programmable logic controller (PLC) hardware, programming languages and techniques, closed-loop strategies using PLC's, sensors, transducers. Case studies. Laboratory experiments. Prerequisites: Cp Eng 111, El Eng 153.

243 Communication Systems (Lect 3.0) Signals and their spectra; signal filtering; amplitude, angle and pulse modulation; multiplexing; noise in communications systems. Prerequisite: El Eng 265.

253 Electronics I (Lect 3.0) Diode and transistor circuits, small signal analysis, amplifier design, differential and operational amplifiers, flipflop circuits and waveshaping. Prerequisites: El Eng 153 with a grade of "C" or better and Cp Eng 112. Passing grade on the El Eng Advancement Exam II. El Eng 255 is a corequisite.

254 Electronics II (Lect 3.0) Diode and transistor circuits, small signal analysis, amplifier design, differential and operational amplifiers, logic families, flipflop circuits and waveshaping. Prerequisites: El Eng 253 and El Eng 255. Co-req El Eng 256.

255 Electronics I Laboratory (Lab 1.0) Experiments in design with diodes, transistors, differential and operational amplifiers, and logic components. Prerequisites: El Eng 153 with a grade of "C" or better and Cp Eng 112. Passing grade on the El Eng Advancement Exam II. El Eng 253 is a corequisite.

256 Electronics II Laboratory (Lab 1.0) Experiments in design with diodes, power transistors, integrated circuits, advanced bipolar and FET logic gates, flipflops and registers. Prerequisites: Preceded by El Eng 253 and El Eng 255. El Eng 254 is a corequisite.

265 Linear Systems I (Lect 3.0) Analysis methods for continuous-time systems in the time frequency domains including signal models. Fourier transforms, and Laplace transforms. Examples of control and communication systems are included. Prerequisites: El Eng 153 and Math 204 with a grade of "C" or better, El Eng 154; passing grade on the El Eng Advancement Exam II. El Eng 266 is a corequisite.

266 Linear Systems I Laboratory (Lab 1.0) This laboratory explores the use of software tools for signal and system representation and analysis. Prerequisites: El Eng 153 and Math 204 with a grade of "C" or better, El Eng 154, a passing grade on El Eng Advancement Exam II. El Eng 265 is a corequisite.

267 Linear Systems II (Lect 3.0) Design and analysis methods for continuous and discrete-time systems including analog filter design, analog to digital conversion, z-transforms, and Discrete Fourier Transforms. Prerequisites: El Eng 265 and El Eng 266. El Eng 268 is a corequisite.

268 Linear Systems II Laboratory (Lab 1.0) This laboratory introduces the spectrum analyzer and other tools for that analysis of specific systems. Prerequisites: El Eng 265 and El Eng 266. El Eng 267 is a corequisite.

271 Electromagnetics (Lect 3.0) Static electric and magnetic fields using vector analysis and time-varying electromagnetic fields using Maxwell's equations. Topics include Coulomb's law, Gauss's law, Ampere's law, dielectric and magnetic materials, plane waves, and transmission lines. Prerequisites: El Eng 153, Physics 24, and Math 204 with a grade of "C" or better, El Eng 154, and a passing grade on the El Eng Advancement Exam II. El Eng 272 is a corequisite.

272 Electromagnetics Laboratory (Lab 1.0) Safety using electrical and high-frequency devices, measurement of circuit parameters, and application of Maxwell's equations. Topics include electromagnetic coupling, circuit models, transmission lines, and laser propagation. Prerequisites: El Eng 153, Physics 24, and Math 204 with a grade of "C" or better, El Eng 154, and a passing grade on the El Eng Advancement Exam II. El Eng 271 is a corequisite.

281 Electrical Circuits (Lect 3.0) Alternating and direct current circuits taught primarily as an a-c course with d-c as special case. Current, voltage and power relations; complex algebra, network theorums; voltage and power relations in polyphase circuits. Not for electrical majors. Prerequisites: Math 204 or 229; Physics 24.

282 Electronic Circuits & Machines (Lect 3.0) Direct and alternating current circuit theory. Network theorems, complex algebra, power in single phase and polyphase circuits. Introduction to electronic circuits. DC and AC generation and machines. Machine types and characteristics, protection and control devices. Electric power systems. Electrical safety. (Not for Electrical Engineering majors.) Prerequisites: Physics 24, Math 204 or 229.

283 Electronics for Instrumentation (Lect 3.0) Electronic device characteristics; electronic circuits for signal processing including amplifying and filtering; wave-shaping, modulating, analog computing and digital circuits; instruments; electronic power conversion and control. Not for electrical majors. Prerequisite: El Eng 281.

300 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

303 Electrical Distribution System Design and Protection (Lect 3.0) Analysis of unbalanced faults in distribution systems. Computer methods are used for modeling and calculations, protection devices and their applications, new technologies

such as load management and distribution automation are developed and demonstrated. Prerequisite: El Eng 207.

304 Electric Power Quality (Lect 3.0) Definitions and standards of power quality, kinds of power quality problems; sources of sags and transient overvoltages; distribution principles of controlling harmonics, devices for filtering harmonics, time and frequency domain methods of analysis; power quality monitoring; power quality improvement methods. Prerequisite: El Eng 153 - Circuits II.

305 Electric Drive Systems (Lect 3.0) Course content is roughly 1/3 power electronics, 1/3 applied control and 1/3 electric machinery and focuses on analysis, simulation, and control design of electric drive based speed, torque, and position control systems. Prerequisites: El Eng 205 and El Eng 231.

307 Power Systems Engineering (Lect 3.0) Network analysis applied to power systems; the load flow concept; economic operation of power systems; synchronous machine reactances and transient stability; symmetrical components and asymmetrical faults; protective relaying. Prerequisite: El Eng 207.

323 Classical Optics (Lect 3.0) Physical optics and advanced topics in geometrical optics. Topics include ray propagation, electromagnetic propagation, mirrors, lenses, interference, diffraction, polarization, imaging systems, and guided waves. Prerequisites: Math 22 and Physics 24 or 25. (Co-listed with Physics 323).

324 Fourier Optics (Lect 3.0) Applications of Fourier analysis and linear systems theory to optics. Topics include scalar diffraction theory, Fourier transforming properties of lenses, optical information processing, and imaging systems. Prerequisites: El Eng 265 & 271 or Physics 208 & 321. (Co-listed with Physics 324).

325 Optical Computing (Lect 0.3) Introduction to the principles, subsystems, and architectures of optical computing. Topics include characteristics of optical devices; optical implementations of memory, logic elements, and processors; and computational structures. Prerequisites: Cp Eng 111 & El Eng 271 or equivalent.

326 Fiber and Integrated Optics (Lect 3.0) Introduction to optical waveguides and their applications to communication and sensing. Topics include dielectric waveguide theory, optical fiber characteristics, integrated optic circuits, coupled-mode theory, optical communication systems, and photonic sensors. Prerequisite: El Eng 271 or Physics 321. Co-listed with: Physcs 326

329 Smart Materials and Sensors (Lect 2.0 and Lab 1.0) Smart structures with fiber reinforced polymer (FRP) composites and advanced sensors. Multidisciplinary topics include characterization, performance, and fabrication of composite structures; fiber optic, resistance, and piezoelectric systems for strain sensing; and applications of smart composite structures. Laboratory and team activities involve manufacturing, measurement systems, instrumented structures, and performance tests on a large-scale smart composite bridge. Prerequisites: Senior standing and Math 204. Co-listed with: Ae Eng 329, Cv Eng 318, E Mech 329, Mc Eng 329

331 Digital Control (Lect 3.0) Analysis and design of digital control systems. Review of ztransforms; root locus and frequency response methods; state space analysis and design techniques; controllability, observability and estimation. Examination of digital control algorithms. Prerequisites: El Eng 231, 267.

332 Plantwide Process Control (Lect 3.0) Synthesis of control schemes for continuous and batch chemical plants from concept to implementation. Mulitloop control, RGA, SVD, constraint control, multivariable model predictive control, control sequence descriptions. Design project involving a moderately complicated multivariable control problem. Prerequisite: Ch Eng 251 or graduate standing. (Co-listed with Ch Eng 359).

333 System Simulation and Identification (Lect 3.0) Computationally efficient methods of digital simulation of linear systems. Non-parametric identification. Parametric identification with least squares and recursive least squares algorithms. Algorithms programmed using MATLAB. Prerequisites: El Eng 231, 267.

335 Advanced PLC (Lect 2.0 and Lab 1.0) Advanced programmable logic controller (PLC) programming, function block, structured text, function chart, sequencer. Factory communications, system simulation, human-machine interface (HMI) programming. Advanced PID control. Network security and reliability. Class-wide project. Prerequisite: El Eng 235.

337 Neural Networks for Control (Lect 3.0) Introduction to artificial neural networks and various supervised and unsupervised learning techniques. Detailed analysis of some of the neural networks that are used in control and identification of dynamical systems. Applications of neural networks in the area of Control. Case studies and a term project. Prerequisite: El Eng 231.

338 Fuzzy Logic Control (Lect 3.0) A mathematical introduction to the analysis, synthesis, and design of control systems using fuzzy sets and fuzzy logic. A study of the fundamentals of fuzzy sets, operations on these sets, and their geometrical interpretations. Methodologies to design fuzzy models and feedback controllers for dynamical systems. Various applications and case studies. Prerequisite: El Eng 231.

341 Digital Signal Processing (Lect 3.0) Spectral representations, sampling, quantization, z-transforms, digital filters and discrete transforms including the Fast Fourier transform. Prerequisite: El Eng 267.

343 Communications Systems II (Lect 3.0) Random signals and their characterization; noise performance of amplitude, angle and pulse modula-

tion systems; digital data transmission; use of coding for error control. Prerequisite: El Eng 243.

344 Stochastic Signal Analysis I (Lect 3.0) Introduction to the application of probabilistic models to typical electrical engineering problems. Topics include: methods for describing random voltages, random digital signals, correlation, linear mean-square estimation, linear transformation of random digital signals, and bit-error rate calculation for communication systems. Prerequisites: Math 204 and El Eng 153.

345 Digital Image Processing (Lect 3.0) Fundamentals of human perception, sampling and quantization, image transforms, enhancement, restoration, channel and source coding. Prerequisite: El Eng 267. (Co-listed with Cp Eng 345).

347 Machine Vision (Lect 3.0) Image formation, image filtering, template matching, histogram transformations, edge detection, boundary detection, region growing and pattern recognition. Complementary laboratory exercises are required. Prerequisites: Cp Eng 111 and preceded or accompanied by El Eng 267.

351 Advanced Electronic Circuits (Lect 3.0) Linear and nonlinear integrated circuits, feedback amplifiers, oscillators, power amplifiers, power supplies. Prerequisite: El Eng 254.

353 Power Electronics (Lect 3.0) Power semiconductor devices in switching mode converter and control circuits, phase-controlled rectifiers, synchronous inverters, AC regulators, cyclo-convertors; self commutated inverters; and frequency changers; thermal analysis and protection. Applications to industry and HVDC. Prerequisite: El Eng 253.

355 High-Frequency Amplifiers (Lect 3.0) Analysis and design of high frequency amplifiers. Topics include parameter conversions, activity and passivity, stability criteria, device operating conditions, Smith chart usage, matching networks, microstrip, scattering parameters, and practical applications. Prerequisites: El Eng 254, 271.

357 Communication Circuits (Lect 3.0) Analysis and design of circuits used in communication systems. Topics include RF semiconductor devices, low-noise amplifiers, mixers, modulators, crystal oscillators, AGC circuits, highpower RF amplifiers, phase-locked loops, impedence matching, and frequency-selective networks and transformers. Prerequisites: El Eng 254, preceded or accompanied by El Eng 243.

361 Computer-Aided Network Design (Lect 3.0) Analysis and design of active and passive electric networks. Theory and computer application, including methods for automatic formulation of network state equations, network tolerance, network optimization, and device modeling. Prerequisites: El Eng 253, 267.

363 Introduction to Circuit Synthesis (Lect 3.0) Fundamentals of linear circuit theory. Matrix formulation, and topological methods as applied to circuit analysis. Properties of network functions and introductory network synthesis. Prerequisite: El Eng 267.

368 Introduction to Neural Networks & Applications (Lect 3.0) Introduction to artificial neural network architectures, adaline, madaline, back propagation, BAM, and Hopfield memory, counterpropagation networks, self organizing maps, adaptive resonance theory, are the topics covered. Students experiment with the use of artificial neural networks in engineering through semester projects. Prerequisite: Math 229 or Math 204 or equivalent. (Co-listed with Eng Mg 378, Cmp Sc 378).

371 Grounding and Shielding (Lect 3.0) Fundamental principles involved in typical grounding and shielding problems, objectives and techniques for grounding and shielding to reduce misconceptions and a more systematic approach to replace “trial and error” methods, interference mechanisms and shielding techniques. Prerequisites: El Eng 265 and 271.

373 Antennas and Propagation (Lect 3.0) Propagated fields of elemental dipole, directivity and gain, radiation resistance, the half-wave dipole, wire antennas, arrays, broadband antennas, aperture antennas, horn antennas, and antenna temperature. Prerequisite: El Eng 271.

377 Microwave and Millimeter Wave Engineering and Design (Lect 3.0) Introduce senior and graduate students to the concept of microwave an millimeter wave engineering and component design such as waveguide, couplers, detectors, mixers, etc., including network theory and scattering matrix. Finally, their application in various microwave circuits will be discussed. Prerequisites: El Eng 253, 271.

379 Microwave Principles for Mixed-Signal Design (Lect 3.0) Transmission lines; coupled transmission lines; microwave network analysis; impedance matching and tuning; design of microwave amplifiers and oscillators. Prerequisite: El Eng 271.

382 Teaching Engineering (Lect 3.0) Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Eng Mg 370, Env En 382, Cp Eng 382, Cv Eng 382).

390 Undergraduate Research (Variable) 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.

391 Electrical Engineering Senior Project I (Lect 0.5 and Lab 0.5) A complete design cycle. Working in small teams, students will design, document, analyze, implement and test a product.

Topics include: Iteration in design, prototyping, group dynamics, design reviews, making effective presentations, concurrent design, designing for test, ethics and standards, testing and evaluation. Prerequisites: Stat 217, Cp Eng 111, Econom 121 or 122, Sp&M 85, English 160, at least 3 of the following: El Eng 205, El Eng 207, El Eng 265, El Eng 267, El Eng 271, El Eng 254.

392 Electrical Engineering Senior Project II (Lab 3.0) A continuation of El Eng 391. Prerequisite: El Eng 391.

Engineering Management

Bachelor of Science
Master of Science
Doctor of Philosophy

The Engineering Management Department prepares students for leadership roles in today's complex environment as engineers, managers and educators. Graduates are capable of designing, implementing, operating and optimizing sophisticated high technology enterprises in manufacturing, government or service sectors of our global economy.

In today's economy there is a need to see the business unit as a complete, technology driven enterprise and to integrate system components thus ensuring that the company thrives in global competition. In such an environment engineers need both excellent technical and managerial skills to cope effectively with the continuous change that will take place during their careers.

The Engineering Management discipline prepares individuals to successfully integrate engineering and management knowledge while optimizing the use of people, equipment, money and information. The discipline also seeks to develop students into individuals with leadership potential who achieve results in an ethical manner and with respect for the environment.

UM-Rolla's Engineering Management program has served the needs of students at the B.S., M.S., and Ph.D. level, enabling graduates to pursue career opportunities in the private sector, government, and academia. Furthermore, many alumni now occupy top executive positions in a variety of enterprises. A recent survey indicates that approximately one-third of department alumni have achieved to top level executive positions.

Mission and Educational Objectives

Mission

The Engineering Management Department equips individuals with engineering and management expertise to prepare them to be leaders in the identification and solution of technical and organizational problems that are complex and evolving.

Engineering Management Educational Objectives:

A) Develop in students the capabilities to successfully apply engineering expertise to the problems of the 21st century in manufacturing and service enterprises.

B) Develop in students the knowledge and skills that are the foundation for successful management of people, systems, and projects.

C) Develop in students the ability and desire to grow intellectually and personally in light of an increasingly global and multicultural work environment.

D) Provide students with the knowledge of a specific engineering management emphasis area.

E) The Engineering Management Department at the University of Missouri-Rolla will provide an educational environment to support and encourage students to succeed.

Bachelor's Degree Components

The bachelor's program includes the basic chemistry, physics, mathematics and engineering science courses required by all engineering disciplines at UM-Rolla. These courses are followed by required core Engineering Management courses and students then specialize in focused emphasis areas with 24 hours of course work.

Engineering Management Core

- Managing Engineering & Technology
- Management Accounting Systems
- Marketing Management
- Financial Management
- Engineering Management Practices
- Operations and Production Management
- General Management Design & Integration

As a senior you will take Engneering Management 260, the senior design course that integrates both the technical and managerial skills that you have previously acquired. Students complete their Bachelor of Science degree requirements by taking the Fundamentals of Engineering Examination and a Department Assessment exam prior to graduation.

Emphasis Areas in Engineering Management

Manufacturing Engineering focuses on the design and improvement of manufacturing and packaging systems, including flexible manufacturing systems, computer integrated manufacturing systems, sustainable product design and process development, and packaging engineering systems.

Industrial Engineering focuses on productivity analysis and system optimization for manufacturing and service organizations. Industrial engineering includes a variety of quantitative and qualitative techniques to identify potential improvements in productivity, quality, safety, and other areas.

Quality Engineering addresses the continous improvement needs of diverse industrial organizations including piece part manufacturing, health care, and gov-

ernment. This emphasis area includes courses in total quality management, statistical process control, engineering design optimization, reliability, experimentation and quality engineering.

Management of Technology focuses on the management aspects of scheduling, budgeting, information system design and development, legal aspects of technology management, managing people, and decision making for positions in project engineering/scheduling, operations management, cost control/estimating, technical marketing/procurement, sales engineering, engineering administration, information systems, and finance economic analysis.

Specialized Emphasis Areas allow students to customize their degree program and create a unique emphasis area, with the approval of their advisor that focuses on a traditional engineering field or even a unique combination of engineering courses.

The Engineering Management idea of bridging the gap between the traditional curricula of engineering and management has proved to be extremely successfully and durable with many graduates now in top executive positions.

Faculty

Professors:

Cihan Dagli, (Interim Chair), Ph.D., University of Birmingham, England
Donald Myers[1], J.D., Saint Louis University
Kenneth Ragsdell[1], Ph.D., University of Texas
Henry Wiebe Ph.D.,(Vice-Provost for UMR Global) University of Arkansas - Fayetteville

Associate Professors:

Venkat Allada, Ph.D, Cincinnati University
Susan L. Murray[1], Ph.D., Texas A & M University
Halvard E. Nystrom, Ph.D., Arizona State University
Stephen Raper, Ph.D., University of Missouri-Rolla

Assistant Professors:

David Enke, Ph.D., University of Missouri-Rolla
Scott E. Grasman, Ph.D., University of Michigan
Ray Luechtefeld, Ph.D., Boston College
Sreeram Ramakrishnan, Ph.D., Penn State University
Timothy S. Meinert, Ph.D., University of Arkansas-Fayetteville
Can Saygin, Ph.D., The Middle East Technical University
Peter Schmidt, Ph.D., University of Missouri-Rolla
David Spurlock, Ph.D., University of Illinois at Urbana-Champaign

Lecturers:

Donald Higginbotham, B.S., Washington University
Robert Laney, M.B.A., University of Missouri-Columbia

Emeritus:

John Amos Professor, Ph.D., Ohio State University
Daniel Babcock[1] Professor, Ph.D., University of California-Los Angeles
Madison Daily Professor, Ph.D., University of Missouri-Rolla
Yildirim Omurtag[1] Professor, Ph.D., Iowa State University
Henry Sineath[1] Professor, Ph.D., Georgia Institute of Technology
Henry Metzner, Associate Professor, Ph.D., Utah University
David Shaller, Assistant Professor, J.D., Cleveland State University

[1] Registered Professional Engineer

Bachelor of Science Engineering Management

FRESHMAN YEAR

First Semester	Credit
BE 10 Study and Careers in Engineering	1
Chem 1 General Chemistry	4
Chem 2 General Chemistry Lab	1
Chem 4 Intro to Lab Safety	1
Math 14 Calc I for Eng[1]	4
English 20 Expo & Argument	3
Hist 112, 175, 176, or Pol Sc 90	3
	17

Second Semester	Credit
BE 20 Eng Design w/Comp Appl	3
Math 15 Calc II for Eng[1]	4
Phys 23 Eng Physics I[1]	4
Econ 121 or122-Princ of Micro or Macro	3
Humanities Elective[2]	3
	17

SOPHOMORE YEAR

First Semester	Credit
Math 22-Calc w/Analytic Geometry III[1]	4
Physics 24-Eng Physics II[1]	4
BE 50 or Bas Eng 51-Eng of Mech-Statics[1]	3
Cmp Sc 74-Intro to Prog Meth[1]	2
Cmp Sc 78-Prog Meth Lab	1
Eng Mg 265 - Eng Mgt Practices[1]	2
	16

Second Semester	Credit
Math 229-Diff Equat & Matrix Algebra[1]	3
Stat 211-Stat Tools For Decision Making or Stat 213-Stat Meth in Eng or Stat 215-Eng Stat[1]	3
BE 110-Mechanics of Materials	3
BE 120-Materials Testing	1
Eng Mg 211-Mgt Eng & Tech[1]	3
Psych 50-Gen Psych	3
	16

JUNIOR YEAR

First Semester	Credit
Eng Mg 230-Mgt Accounting Sys[1]	3
Eng Mg 251-Marketing Mg[1]	3
BE 150-Eng Mech-Dyn	2
Mc Eng 227-Thermal Analysis	3
Hum/Soc Science Upper Level Elective	3
Sp&MS 85 or 181	3
	17

Second Semester	Credit
Eng Mg 252-Financial Mgt[1]	3
Eng Mg 282-Operations & Prod Mgt [1]	3
El Eng 281-Electrical Circuits	3

English 160-Technical Writing 3
Free Elective[3] 3
15

SENIOR YEAR

First Semester — Credit
Technical Electives[4] 12
Free Elective[3] 3
15

Second Semester — Credit
Eng Mg 260-Gen Mgt Design & Integ[1] 3
Technical Electives[4] 12
15

Example Emphasis Area Programs for Engineering Management Students

One unique aspect of the Engineering Management degree is the student's ability to select an established emphasis area or create a specialize emphasis. Three examples of established emphasis areas are shown below.

Industrial Engineering

(6) Required Courses:

Credit
Eng Mg 257-Mat. Hand & Plant Layout 3
Eng Mg 311-Human Factors 3
Eng Mg 372-Prod Plan & Schd 3
Eng Mg 380-Work Design 3
Eng Mg 382-Methods of Ind Eng 3
Eng Mg 385-Stat Process Control 3

(2) Elective Courses . . . . . .6 hours
(In consultation with your advisor, from approved elective clusters)

Management of Technology

Choose 6 of 7 courses

Credit
Eng Mg 208-Engineering Economy 3
Eng Mg 313-Managerial Decision Making 3
Eng Mg 320-Tech Entrepreneurship 3
Eng Mg 327-Legal Environment 3
Eng Mg 333-Mgt Info Systems 3
Eng Mg 361-Project Management 3
Eng mg 366-Bus Logistics Systems Analysis 3

(2) Elective Courses.....6 hours
(In consultation with your advisor, from approved elective clusters)

Manufacturing Engineering

(6) Required Courses

Credit
Eng Mg 334-Cmp Integrated Mfg Sys 3
Eng Mg 344-Interdisp Prob in Mfg Auto 3
Eng Mg 354-Integ Prod and Process Design 3
Eng Mg 364-Value Analysis 3
Eng Mg 372-Prod Planning & Schd 3
Eng Mg 383-Packaging Mgt 3

(2) Elective Courses . . . . . .6 hours
(In consultation with your advisor, from approved elective clusters)

Quality Engineering

Choose 6 of 7 Courses

Credit
Eng Mg 361-Project Mgt 3
Eng Mg 374-Eng Design Opt 3
Eng Mg 375-Total Quality Mgt 3
Eng Mg 376-Intro to Quality Engineering 3
Eng Mg 381-Mgt & Methods in Reliability 3
Eng Mg 385-Stat Process Control 3
Eng Mgt 387-Exp In Eng Mgt (or equivalent) 3

(2) Elective Courses.....6 hours
(In consultation with your advisor, from approved elective clusters)

Specialized Emphasis Areas:
Students must choose courses in consultation with the Engineering Management General Emphasis Area advisor. A minimum of 24 hours must be specified. The courses specified must contribute to meeting Department outcomes and objectives and also must contain appropriate design content.

NOTE: All electives must be chosen in conference with the student's advisor. Students must satisfy the common engineering freshman year course requirements in addition to the sophomore, junior, and senior year requirements listed above with a minimum of 128 hours.

1) Must have a grade of "C" or better in these courses for graduation. Math 8 and 21 may be substituted for Math 14 and 15, respectively.
2) Humanities and Social Science electives must be approved by the student's advisor. Students must comply with the School of Engineering general education requirements with respect to selection and depth of study.These requirements are specified in the current catalogue.
3) 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.
4) Students are required to select an emphasis area and maintain a minimum 2.0 GPA for these courses.
5) All Engineering Management 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 UMR 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.

Engineering Management Courses

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

104 Personal Finance I (Lect 1.0) Covers the entire realm of personal finance ranging from daily expenditures to estate building techniques.

105 Personal Finance II (Lect 1.0) Covers personal investments stressing simulation of stockmarket strategies including short selling.

130 Accounting I (Lect 3.0) Accounting principles in relation to business papers, journals, ledgers, balance sheets, income statements, trial balances, and work sheets using the problem approach.

131 Accounting II (Lect 3.0) Accounting for the partnership and the corporation, consideration of cost and departmental accounting. Prerequisite: Eng Mg 130.

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

202 Cooperative Engineering Training (Variable) 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 supervisors evaluation.

208 Engineering Economy (Lect 3.0) Techniques for capital investment decision making; time-value of money and the concept of equivalence, multiple alternatives, replacement criteria, and cost of capital depreciation.

209 Engineering Economy and Management (Lect 3.0) Engineering economy topics include equivalence; present worth, annual and rate of return analysis; depreciation and taxes. Engineering management topics include planning, organizing, motivation, controlling and their applications in design and manufacturing.

211 Managing Engineering and Technology (Lect 3.0) Introduces the management functions of planning, organizing, motivating, and controlling. Analyzes the application of these functions in research, design, production, technical marketing, and project management. Studies evolution of the engineering career and the transition to engineering management. A grade of "C" or better is required in this course to meet Engineering Management degree requirements.

230 Management Accounting Systems (Lect 3.0) The course is designed to introduce the theory and practice of accounting, and to study the flows of accounting information through the business firm. Topics are the fundamentals of accounting, technology of accounting information systems, and accounting system applications. A grade of "C" or better is required in this course to meet Engineering Management degree requirements.

251 Marketing Management (Lect 3.0) Study of basic functions of marketing in the technological enterprise, including product selection and development, market research, market development, selection of distribution channels and advertising, marketing strategy. Prerequisite: Eng Mg 211. A grade of "C" or better is required in this course to meet Engineering Management degree requirements.

252 Financial Management (Lect 3.0) Organization of financial function in the technically based enterprise; analysis and projection of financial statements, cost elements in pricing, cost control and design of accounting systems. Prerequisites: Eng Mg 211 and 230. A grade of "C" or better is required in this course to meet Engineering Management degree requirements.

256 Personnel Management (Lect 3.0) Selection, placement, training, motivation, and adjustment of the worker in an industrial organization. Forms and methods in practical use.

257 Materials Handling and Plant Layout (Lect 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. Prerequisite: Eng Mg 282 or Mc Eng 153. (Co-listed with Mc Eng 256).

260 General Management-Design and Integration (Lect 3.0) Integrating and executing marketing, production, finance, and engineering policies and strategies for the benefit of an enterprise. Analysis, forcasting, and design methods using case studies and management simulation. Prerequisites: Eng Mg 251, 252, and 282; senior standing. A grade of "C" or better is required in this course to meet Engineering Management degree requirements.

265 Engineering Management Practices (Lect 2.0) This course will specifically address issues that are relevant to successful engineering management education and engineering management practice. Topics will include but are not limited to fundamentals of project management, fundamentals of teamwork, working in groups, and basic communication methods. Additional content will address ethics, global and societal issues, and life long learning. A grade of "C" or better is required in this course to meet Engineering Management degree requirements.

282 Operations and Production Management (Lect 3.0) Concepts of operations and production management are presented at an introductory level. Qualitative and quantitative tools and techniques used for the optimization of the operations component of the total enterprise are explored in the context of improved productivity and strategic competitiveness. Prerequisites: Eng Mg 211 and Stat 213 or 215. A grade of "C" or better is required in this course to meet degree requirements.

300 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

308 Economic Decision Analysis (Lect 3.0) Comprehensive treatment of engineering economy including effects of taxation and inflation; sensitivity analysis; decisions with risk and uncertainty; decision trees and expected value, normally includes solutions on personal computer and student problem report. Prerequisite: Graduate students without previous course in engineering economy because of partial overlap.

311 Human Factors (Lect 3.0) An examination of human-machine systems and the characteristics of people that affect system performance. Topics include applied research methods, systems analysis, and the perceptual, cognitive, physical and social strengths and limitations of human beings. The focus is on user-centered design technology, particularly in manufacturing environments. Prerequisite: Psych 50. (Co-listed with Psych 311).

313 Managerial Decision Making (Lect 3.0) Individual and group decision making processes and principles for engineers and technical managers with emphasis on the limitations of human rationality and the roles of social influence and organizational contexts; principles and skills of negotiation. Prerequisite: Senior or graduate standing.

314 Management for Engineers (Lect 3.0) The transition of the engineer to manager; planning and organizing technical activities; selecting and managing projects; team building and motivation; techniques of control and communication; time management. Prerequisite: Senior or graduate standing; students who have taken Eng Mg 211 cannot enroll in this course.

320 Technical Entrepreneurship (Lect 3.0) Student teams develop a complete business plan for a company to develop, manufacture and distribute real technical/product service. Lectures & business fundamentals, patents, market/ technical forecasting, legal and tax aspects, venture capital, etc., by instructor and successful technical entrepreneurs. Prerequisite: Senior or graduate standing.

324 Fundamentals of Manufacturing (Lect 2.0 and Lab 1.0) This course provides a comprehensive treatment of topics of concern to the Manufacturing Engineer. The effect of manufacturing processes on product design and cost is discussed, and an introduction to inspection and quality control is presented. Prerequisite: Eng Mg 282.

327 Legal Environment (Lect 3.0) Study of the effect of the legal environment on the decisions which the engineering manager must make. The course investigates the social forces that produced this environment and the responsibilities incumbent upon the engineer.

332 Engineering Cost Accounting (Lect 3.0) Analysis and design of job, process and standard cost accounting methods in manufacturing environment, interrelationship of cost accounting methods, and justification of automation in a technological setting. Prerequisite: Senior or graduate standing.

333 Management Information Systems (Lect 3.0) Study of the operational and managerial information needs of an organization. Emphasis is on the information needed throughout an organization and on information systems to meet those needs. Prerequisite: Senior or graduate standing.

334 Computer Integrated Manufacturing Systems (Lect 2.0 and Lab 1.0) Study of the design and use of computer-based integrated manufacturing management systems in the allocation and control of plant, equipment, manpower, and materials. Prerequisite: Eng Mg 282.

344 Interdisciplinary Problems in Manufacturing Automation (Lect 1.0 and Lab 2.0) Introduction to basic techniques and skills for concurrent engineering, manufacturing strategies, product design, process planning, manufacturing data management and communication are the topics covered. Students experiment the design process through team projects and structured manufacturing laboratory work. Prerequisite: Eng Mg 334. (Co-listed with Mc Eng 344, Ch Eng 384).

351 Industrial Marketing Systems Analysis (Lect 3.0) An analysis of the factors of engineered products, customers, communication, promotion, personal selling, persuasion and management within a dynamic industrial sales environment.

352 Activity Based Accounting and Financial Decision Making (Lect 3.0) This course reviews the fundamentals of activity based accounting and financial decision making.

354 Integrated Product and Process Design (Lect 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-ofproduct life options. Prerequisite: Eng Mg 282 or Mc Eng 253. (Co-listed with Mc Eng 357).

356 Industrial System Simulation (Lect 3.0) Simulation modeling of manufacturing and service operations through the use of computer software for operational analysis and decision making. Prerequisite: Stat 213 or 215.

357 Advanced Facilities Planning & Design (Lect 1.0 and Lab 2.0) Development of an integrated approach to the planning and design of facilities; examination of advanced techniques and tools for facility location, space allocation, facility layout materials handling system design, work place design; e.g. mathematical programming, simulation

modeling, CAD systems, ergonomics. Prerequisite: Eng Mg 257 or instructor's permission.

358 Integrated Product Development (Lect 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 Mg 354 or Mc Eng 357. (Co-listed with Mc Eng 358).

361 Project Management (Lect 3.0) Organization structure and staffing; motivation, authority and influence; conflict management; project planning; network systems; pricing, estimating, and cost control; proposal preparation; project information systems; international project management. Prerequisite: Eng Mg 211.

364 Value Analysis (Lect 3.0) An organized effort at analyzing the function of goods or services for the purpose of achieving the basic functions at the lowest overall cost, consistent with achieving the essential characteristics. Covers the basic philosophy, function analysis, FAST diagramming, creativity techniques, evaluation of alternatives, criteria analysis, and value stream mapping. Prerequisite: Senior or graduate standing.

366 Business Logistics Systems Analysis (Lect 3.0) An analysis of logistics function as a total system including inventory, transportation, order processing, warehousing, material handling, location of facilities, customer service, and packaging with trade-off and interaction. Prerequisite: Stat 213 or 215.

368 System Engineering and Analysis I (Lect 3.0) The concepts of Systems Engineering are covered. The objective is to provide the basic knowledge and tools of transforming an operational need into a defined system configuration through the iterative process of analysis, system integration, synthesis, optimization and design. Prerequisite: Graduate or senior standing.

370 Teaching Engineering (Lect 3.0) Introduction to teaching objectives and techniques. Topics include: using course objectives to design a course; communication using traditional and cutting-edge media; textbook selection; assessment of student learning; grading; student learning styles; cooperative/active learning; and student discipline. Prerequisite: Graduate standing. (Co-listed with Env En 382, Cp Eng 382, El Eng 382, Cv Eng 382).

372 Production Planning and Scheduling (Lect 3.0) Introduction to basic techniques of scheduling, manufacturing planning and control, just-in-time systems, capacity management, master production scheduling, single machine processing, constructive Algorithms for flow-shops, scheduling heuristics, intelligent scheduling systems are the topics covered. Prerequisite: Eng Mg 282.

374 Engineering Design Optimization (Lect 3.0) This course is an introduction to the theory and practice of optimal design as an element of the engineering design process. The use of optimization as a tool in the various stages of product realization and management of engineering and manufacturing activities is stressed. The course stresses the application of nonlinear programming methods. Prerequisite: Math 204 or 229.

375 Total Quality Management (Lect 3.0) Examination of various quality assurance concepts and their integration into a comprehensive quality management system: statistical techniques, FMEA's, design reviews, reliability, vendor qualification, quality audits, customer relations, information systems, organizational relationships, motivation. Prerequisite: Senior or graduate standing.

376 Introduction to Quality Engineering (Lect 3.0) This course is an introduction to the theory and practice of quality engineering with particular emphasis on the work of Genichi Taguchi. The application of the quality loss function, signal to noise ratio and orthogonal arrays is considered in-depth for generic technology development; system, product and tolerance design; and manufacturing process design. The emphasis of the course is off-line quality control. Other contributions in the field are also considered. Prerequisite: Eng Mg 375.

377 Introduction to Intelligent Systems (Lect 3.0) Introduction to the design of intelligent systems. Topics include: definitions of intelligence, rule-based expert systems, uncertainty management, fuzzy logic, fuzzy expert systems, artificial neural networks, genetic algorithms and evolutionary computation, hybrid systems, and data mining. Prerequisite: Graduate or senior standing.

378 Introduction to Neural Networks & Applications (Lect 3.0) Introduction to artificial neural network architectures, adaline, madaline, back propagation, BAM, and Hopfield memory, counterpropagation networks, self organizing maps, adaptive resonance theory, are the topics covered. Students experiment with the use of artificial neural networks in engineering through semester projects. Prerequisite: Math 204 or 229. (Co-listed with Cmp Sc 378, El Eng 368).

379 Packaging Machinery (Lect 3.0) Examination and evaluation of packaging machinery as a subset of the packaging system and its relation to the total production and marketing system. Determination of criteria for selection, design and implementation of packaging machinery and systems into the production facility. Prerequisite: Sr standing in engineering.

380 Work Design (Lect 3.0) Addresses the design of workstations and tasks. Topics include micromotion, operational analysis, manual material handling, workstations organization, macroergonomics, anthropometrics, biomechanics, cumulative trauma disorders, handtool design, controls/displays design, work sampling, stopwatch time studies, predetermined time standard systems,

and time allowances. Prerequisite: Senior or graduate standing.

381 Management and Methods in Reliability (Lect 3.0) Study of basic concepts in reliability as they apply to the efficient operation of industrial systems. Prerequisite: Stat 213 or 215 or 343.

382 Methods of Industrial Engineering (Lect 2.0 and Lab 1.0) Topics to be covered will include the types of problems frequently encountered by industrial engineers, their impact on the management of an industrial concern, and an exposure to the industrial engineering techniques available to solve problems. Prerequisite: Stat 213 or 215.

383 Packaging Management (Lect 3.0) Provides a comprehensive background in the field of packaging and its place in productive systems. Emphasizes the design or economics of the system. Analyzes the management of the packaging function and interrelationship with other functions of an enterprise.

385 Statistical Process Control (Lect 3.0) The theoretical basis of statistical process control procedures is studied. Quantitative aspects of SPC implementation are introduced in context along with a review of Deming's principles of quality improvement and a brief introduction to sampling inspection Prerequisite: Stat 213 or 215.

386 Safety Engineering Management (Lect 3.0) This course is an introduction to the principles of safety engineering applied to industrial situations. Job safety analysis, reduction of accident rates, protective equipment, safety rules and regulations, environmental hazards, health hazards, and ergonomic hazards are covered. Prerequisite: Senior or graduate standing.

387 Experimentation in Engineering Management (Lect 3.0) The techniques for planning and analyzing industrial experiments are introduced with emphasis on their application to the design, development, and production of quality goods and services. Prerequisite: Stat 213 or Stat 215.

390 Undergraduate Research (Variable) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor. Consent of instructor required.

Engineering Mechanics

Master of Science
Doctor of Philosophy

The Engineering Mechanics program exists within the Department of Mechanical and Aerospace Engineering and Engineering Mechanics and offers degrees only at the graduate level. However, there are courses at the 300 level that are available to undergraduate students who wish to learn more about stress analysis, dynamics, vibrations, finite element analysis, composite materials, fracture mechanics, fatigue analysis, continuum mechanics, and/or applied mathematics.

Faculty

Professors:
Xavier Avula (Emeritus), Ph.D., Iowa State
Charles Benjamin Basye[1] (Emeritus), Ph.D., Iowa State
Victor Birman, Ph.D., Technion, (Israel)
K. Chandrashekhara, Ph.D., Virginia Polytechnic Institute and State University
L. R. Dharani, Ph.D., Clemson

Associate Professors:
Gearoid MacSithigh, Ph.D., Minnesota
Daniel S. Stutts, Ph.D., Purdue

[1] Registered Professional Engineer

Engineering Mechanics Courses

160 Engineering Mechanics-Dynamics (Lect 3.0) Designed for those students who desire a broader coverage, with a more general development, of the topics covered in E Mech 150; more emphasis is given to three-dimensional kinematics and kinetics. Prerequisites: Bas En 50 with grade of "C" or better and Math 22.

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

202 Cooperative Engineering Training (Variable) 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 supervisors evaluation.

211 Engineering Materials: Properties and Selection (Lect 3.0) A study treating the properties and uses of engineering materials. Treatment includes strengths, creep, fatigue, thermal and electrical characteristics, formability, and heat treating. Studies of joining processes, corrosion and dynamic loading are included. Practical applications requiring selection and justification of materials for specific applications are used. Prerequisites: E Mech 110, Mt Eng 121.

300 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

303 Industrial Applications of Composite Materials Technology (Lect 1.0) 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: Bas En 110. (Co-listed with Mc Eng 383).

305 Applications of Numerical Methods to Mechanics Problems (Lect 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: Bas En 110, Bas En 150 or E Mech 160. (Co-listed with Mc Eng 314).

307 Finite Element Approximation I - An Introduction (Lect 3.0) Variational statement of a problem, Galerkin approximation, finite element basis functions and calculations, element assemble, solution of equations, boundary conditions, interpretation of the approximate solution, development of a finite element program, two-dimensional problems. Prerequisite: Math 204. (Co-listed with Mc Eng 312, Ae Eng 352).

310 Seminar (Variable) Discussion of current topics. Prerequisite: Senior standing.

311 Introduction to Continuum Mechanics (Lect 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: Bas En 110, Math 204. (Co-listed with Mc Eng 311).

321 Intermediate Mechanics of Materials (Lect 3.0) Continuation of first course in mechanics of materials. Topics to include: theories of failure, torsion of noncircular sections, shear flow, shear center, unsymmetrical bending, bending of curved members and pressurization of thick walled cylinders. Prerequisites: Bas En 110, Math 204.

322 Introduction to Solid Mechanics (Lect 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, Mc Eng 322).

324 Engineering Plasticity I (Lect 3.0) The stress-strain relations of materials loaded beyond the elastic range. Yield criteria. Applications to tension, bending, and torsion and their interaction, and to problems with spherical or cylindrical symmetry. Prerequisite: Bas En 110.

329 Smart Materials and Sensors (Lect 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 Mc Eng, Ae Eng, El Eng 329 and Cv Eng 318).

334 Stability of Engineering Structures (Lect 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: Bas En 110, 150, or E Mech 160, Math 204. (Co-listed with Ae Eng 334 and Mc Eng 334).

336 Fracture Mechanics (Lect 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: Bas En 110. (Co-listed with Ae Eng 336, Mc Eng 336).

337 Fatigue Analysis (Lect 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: Bas En 110. (Co-listed with Mc Eng 338, Ae Eng 344).

341 Experimental Stress Analysis I (Lect 2.0 and Lab 1.0) Acquaints the student with some techniques of experimental stress analysis. Principal stresses, strain to stress conversion, mechanical and optical strain gages, electrical resistance strain gages, transducers, and brittle coatings. Prerequisite: Bas En 110. (Co-listed with Mc Eng 341, Ae Eng 341).

342 Experimental Stress Analysis II (Lect 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 photo-elastic methods, Moire fringe methods and analogies. Prerequisites: Bas En 110 and E Mech 321. (Co-listed with Mc Eng 342, Ae Eng 342).

354 Variational Formulations of Mechanics Problems (Lect 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: Bas En 110, 150 or E Mech 160, Math 204. (Co-listed with Mc Eng 354).

361 Vibrations I (Lect 3.0) Equations of motion, free and forced vibration or single degree of freedom systems and multidegree of freedom systems. Natural frequencies, resonance, modes of vibration and energy dissipation are studies. The vibration of continuous systems is introduced. Prerequisites: Mc Eng 211 and Mc Eng 213, or Ae Eng

213 and Math 204. (Co-listed with Mc Eng 307, Ae Eng 307).

362 Experimental Vibration Analysis (Lect 2.0 and Lab 1.0) Methods for measuring and analyzing motion and strain response of dynamically excited structures. Includes frequency-response testing of elementary beam, torsion bar, plate and shell structures. Experiments on the effectiveness of isolators and dynamic absorbers. Prerequisite: E Mech 361 or Ae Eng 307 or Mc Eng 307. (Co-listed with Mc Eng 362, Ae Eng 362).

373 Advanced Dynamics (Lect 3.0) Review of kinematics of particles and rigid bodies. Development of equations of motion using energy principles and Euler's equations. Stability of motions. Special topics. Prerequisites: Bas En 150 or E Mech 160, Math 204.

375 Structural Modal Analysis: Theory and Application (Lect 2.0 and Lab 1.0) A modeling technique for the dynamic behavior of structures. Topics include structural dynamics theory, digital signal processing and instrumentation, modal parameter extraction, vibration simulation and design modification. Hands-on experience with an integrated analysis of the experimental modal testing and the analytical finite element method. Prerequisite: Bas En 110 and 150 or E Mech 160, Math 203 and 204.

381 Introduction to Composite Materials & Structures (Lect 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: Bas En 110. (Co-listed with Mc Eng 382 and Ae Eng 311).

390 Undergraduate Research (Variable) Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six (6) credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor. Consent of instructor required.

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 career.

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

Faculty

Professors:

Christopher W. Ramsay (Associate Director of Freshman Engineering Program), Ph.D., Colorado School of Mines

D. Ronald Fannin[1] (Director of Freshman Engineering Program), Ph.D., Texas Tech University

[1] Registered Professional Engineer

Other Faculty

Departments from the Schools of Engineering and Mines and Metallurgy, as well as the Department of Basic Engineering, contribute to providing a centralized and coordinated advising effort.

Common Engineering Freshman Year

The following courses are common to all the engineering programs offered at UMR and are normally taken while the student is in the Freshman Engineering Program. Courses required in the remainder of each program are listed under that program's description in this catalog.

- Mathematics 14 and 15
- Freshman Chemistry Requirement[1]
- English 20
- Humanities/Social Sciences courses[2]
- Basic Engineering 10
- Basic Engineering 20
- Physics 23

[1)] Chemistry 1,2, and Chemistry 4, or an equivalent training program approved by UMR. Students planning to major in ceramic engineering, chemical engineering, environmental engineering, or metallurgical engineering will require additional chemistry and should either plan to also take Chemistry 3 during their freshman year or to take Chemistry 5 in lieu of Chemistry 1, 2 and 3 if they are qualified to do so. Students planning to major in Petroleum or Geological Engineering should take a three hour elective in chemistry, geochemistry, or biology in the freshman year, in addition to Chem 1, 2, and 4.

[2)] Students, at some point in their course of studies, must take a course that fulfills the Williams law requirement. (History 112,175,176 or Political Science 90).

Students may transfer from the Freshman Engineering Program to their major departments after having satisfied all of the above requirements except two courses, provided the departments will accept them.

Students are advised to check special program requirements as listed with the program curricula in this catalog.

Students who will be in the Freshman Engineering Program more than two semesters may request a Freshman Engineering advisor from their major departments for the third semester.

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 and Engineering Mechanics.

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 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 and Engineering Mechanics 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. (See Aerospace Engineering)

Mission Statement

To build and enhance the excellent public program that the Department of Mechanical and Aerospace Engineering and Engineering Mechanics 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 following Education Objectives represent the broad objectives of this department as they relate to the students.

1) To provide students with a solid foundation in the fundamental principles of science and engineering.
2) To examine current and relevant technical problems in engineering as examples of the applications of such principles.
3) To provide comprehensive course work in both the thermal and mechanical systems areas, including cross-linkage between the two areas.
4) To provide students with meaningful design experiences.
5) To provide students with opportunities to develop teamwork, communication, and computer skills.

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.
D) An ability to function on multi-disciplinary 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 solution in a global 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) A knowledge of chemistry and calculus-based physics, with depth in at least one.
M) An ability to apply advanced mathematics through multivariate calculus and differential equations.
N) Familiarity with statistics and linear algebra.

O) An ability to work professionally in both thermal and mechanical systems areas including the design and realization of such systems.

Faculty

Professors:
Darryl Alofs, Ph.D., Michigan
Bassem Armaly (Curators'), Ph.D., California-Berkeley
Alfred Crosbie (Curators'), Ph.D., Purdue
James Drallmeier, Ph.D., Illinois
Walter Eversman[1] (Curators'), Ph.D., Stanford
Virgil Flanigan[1], Ph.D., UMR
K. Krishnamurthy (Assoc. Chair, Graduate), 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.
Harry Sauer[1], Ph.D., Kansas State
John Sheffield, Ph.D., North Carolina State
Hai-Lung Tsai, Ph.D., California-Berkeley

Associate Professors:
Umit Koylu, Ph.D., University of Michigan
J. Keith Nisbett (Associate Chair), Ph.D.,Texas-Arlington
Daniel Stutts, Ph.D., Purdue

Assistant Professors:
Joohyun Choi, Ph.D., Illinois
Xiaoping Du, Ph.D., Illinois
Kelly Homan, Ph.D., University of Illinois at Urbana-Champaign
Robert Landers, Ph.D., University of Michigan
Daniel McAdams, Ph.D., Texas
Brad Miller, Ph.D., Georgia Institute of Technology
Kai-Tak Wan, Ph.D., Maryland

Emeritus Professors:
Clark Barker (Emeritus), Ph.D., Illinois
Ta-Shen Chen (Curators'), (Emeritus), Ph.D., Minnesota
Donald Cronin (Emeritus), Ph.D., California Institute of Technology
Charles Edwards[1] (Emeritus), Ph.D., Arkansas
Ronald Howell[1] (Emeritus), Ph.D., Illinois
Leslie Koval[1] (Emeritus), Ph.D., Cornell
Shen Ching Lee[1] (Emeritus), Ph.D., Washington
Terry Lehnhoff[1] (Emeritus), Ph.D., Illinois
Dwight Look (Emeritus), Ph.D., Oklahoma
Robert Medrow (Emeritus), Ph.D., Illinois
Robert Oetting[1] (Emeritus), Ph.D., Maryland
Josef Podzimek (Emeritus), Ph.D., Charles University, Prague
Charles Remington[1] (Emeritus), M.S., UMR

[1] Registered Professional Engineer

Bachelor of Science Mechanical Engineering

FRESHMAN YEAR

First Semester	Credit
BE 10 Study and Careers in Engineering	1
Chem 1 General Chemistry	4
Chem 2 General Chemistry Lab	1
Math 14 Calculus I for Engineers[a]	4
Engl 20 Exposition and Argumentation	3
Hist 112, 175, 176, or Pol Sc 90	3
	16

Second Semester	
BE 20 Eng Design with Computer Appl	3
Math 15 Calculus II for Engineers[a]	4
Phys 23 Engineering Physics I[a]	4
Econ 121 or 122	3
Elective-Hum or Soc Sci[f]	3
	17

SOPHOMORE YEAR

First Semester	Credit
Cmp Sc 73 Basic Scientific Programming or Cmp Sc 74-Intro to Programming Methodology	2
Cmp Sc 77 Cmp Prog Lab or Cmp Sc 78-Programming Methodology Lab	1
BE 50 -Eng Mech-Statics	3
Math 22-Calculus w/Analytic Geometry III[a]	4
Physics 24-Eng Physics II	4
Mc Eng 153-Intro to Manufacturing Processes	3
	17

Second Semester	
Mc Eng 161-Intro to Design	3
Mc Eng 219-Thermodynamicsa[a,b]	3
EMech 160-Eng Mech-Dynamics[b]	3
Math 204-Elementary Differential Equations	3
Mt Eng 121-Metallurgy for Engineers	3
	15

JUNIOR YEAR

First Semester	Credit
Mc Eng 213-Machine Dynamics[a]	3
Mc Eng 221-Applied Thermodynamics	3
El Eng 281-Electrical Circuits	3
Bas Eng 110-Mechanics of Materials [c]	3
Bas Eng 120-Material Lab	1
Elective-Math/Stat or Cmp Sc[e]	3
	16

Second Semester	
Mc Eng 211-Linear Systems in Mc Eng[a,b]	3
Mc Eng 208-Machine Design I[c]	3
Mc Eng 225-Heat Transfer	3
Mc Eng 231-Thermofluid Mechanics I	3
Mc Eng 240-Mechanical Instrumentation	2
Elective-Communications[d]	3
	17

SENIOR YEAR

First Semester	Credit
Mc Eng 242-Mech Engineering Systems	2
Mc Eng 279-Automatic Control of Mech Systems	3
Mc Eng technical elective[g]	3
Elective[i]	3
Literature elective[f]	3
Elective-Advanced Hum or Soc Sci[f]	3
	17

Second Semester	
Eng Mg 209-Eng Economy & Management	3
Mc Eng 261-Analysis & Synthesis in Eng Design	3
Mc Eng 280-Control Systems Lab	1

Mc Eng 3xx technical elective[g] 3
Elective[i] 3
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 in Math 14, 15, 22 and Physics 23 is required both for enrollment in Mc Eng 211, Mc Eng 213 and Mc Eng 219 and for graduation. Math 8 and 21 may be substituted for Math 14 and 15, respectively.

b) A grade of "C" or better in EMech 160, Mc Eng 211 and Mc Eng 219 is required both for enrollment in any courses which require either EMech 160 or Mc Eng 211 or 219 as prerequisites, and for graduation.

c) A grade of "C" or better in Bas En 110 is required both for enrollment in Mc Eng 208 and for graduation.

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 Arosp 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 School of Engineering 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 and Engineering Mechanics. 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 UMR 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.

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. Mc Eng 357 and 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[a]	3
El Eng 281-Electrical Circuits	3
Mc Eng 221-Applied Thermodynamics	3
Bas En 110-Mechanics of Materials[c]	3
Bas En 120-Materials Lab	1
Stat 213-Stat Meth in Eng or Stat 215-Eng Stat	3
	16

Second Semester	
Mc Eng 211-Linear Systems in Mc Eng[a,b]	3
Mc Eng 231-Thermofluid Mechanics	3
Mc Eng 225-Heat Transfer	3
Mc Eng 240-Mechanical Instrumentation	2
Mc Eng 253-Manufacturing[c]	3
Elective-Communications[d]	3
	17

SENIOR YEAR

First Semester	Credit
Mc Eng 242-Mech Eng Systems	2
Mc Eng 279-Auto Control of Mech Systems	3
Mc Eng 208-Machine Design I[c]	3
Mc Eng 357-Integrated Prod & Proc Design	3
Mc Eng Technical Elective[f]	3
Elective Literature[e]	3
	17

Second Semester	
Eng Mg 209-Eng Economy & Mgt	3
Mc Eng 358-Integrated Product Dev	3
Mc Eng 280-Control System Lab	1
Mc Eng Technical Elective[f]	3
Electives-Hum or Soc Sci[e]	3
	13

NOTES:

[a] A grade of "C" or better in Math 14, 15, 22, and Physics 23 is required both for enrollment in Mc Eng 211, Mc Eng 213 and Mc Eng 219 and for graduation. Math 8 and 21 may be substituted for Math 14 and 15, respectively.

[b] A grade of "C" or better in EMech 160, Mc Eng 211 and Mc Eng 219 is required both for enrollment in any courses which require either EMech 160 or Mc Eng 211 or Mc Eng 219 as prerequisites, and for graduation.

[c] A grade of "C" or better in Bas En 110 is required both for enrollment in Mc Eng 208 and Mc Eng 253, and for graduation.

[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 Arosp 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 School of Engineering 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 UMR 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 Engineering Courses

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

153 Introduction to Manufacturing Processes (Lect 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: Bas En 20.

161 Introduction to Design (Lect 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: Bas En 20, Math 14 (or 8), Physics 23, Mc Eng 153; preceded or accompanied by Bas En 50.

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

202 Cooperative Engineering Training (Variable) 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 (Lect 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: Mc Eng 153, Mt Eng 121 & accompanied or preceded by Mc Eng 161 and a grade of "C" or better in Bas En 110.

209 Machine Design II (Lect 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 (Lect 1.0) Discussion of current topics.

211 Linear Systems in Mechanical Engineering (Lect 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: Math 204, E Mech 160 and a course grade of "C" or better in Math 14 (or 8), 15 (or 21), 22, and Physics 23.

212 Introductory Finite Element Analysis (Lect 3.0) Introduction to finite element analysis concepts with examples from solid mechanics, heat transfer, and fluid mechanics. A brief consideration of preprocessing, analysis and post processing using PC-based software is included. Prerequisite: Mc Eng 208.

213 Machine Dynamics (Lect 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 E Mech 160, Math 14 (or 8), 15 (or 21), 22, and Physics 23.

219 Thermodynamics (Lect 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: Cmp Sc 53 or 73 or 74; and a grade of "C" or better in each of Math 14 (or 8), 15 (or 21), 22, and Physics 23.

221 Applied Thermodynamics (Lect 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: Mc Eng 219.

225 Heat Transfer (Lect 3.0) Fundamental principles of heat transmission by radiation, conduction and convection; application of these principles to the solution of engineering problems. Prerequisites: Math 204, Mc Eng 219; and Cmp Sc 53 or 73 or 74.

227 Thermal Analysis (Lect 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.

229 Energy Conversion (Lect 3.0) The study of the principles of energy release transfers and conversion into useful work. Specific applications to vapor power cycles, internal combustion engines, propulsion, and direct conversion devices are considered. Prerequisite: Mc Eng 221.

231 Thermofluid Mechanics I (Lect 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 (Lect 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.

237 Applications of Heat and Mass Transfer (Lect 3.0) Introduction to various applications using heat and mass transfer principles. Subjects to be discussed will include diffusion, biomedical, cryogenic, heat exchangers, boiling and other thermal processes. Prerequisite: Mc Eng 225.

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: Math 204, Mc Eng 219.

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: Mc Eng 240, 221, 231, 225.

253 Manufacturing (Lect 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: Mc Eng 153, and a grade of "C" or better in Bas En 110.

255 Manufacturing Planning (Lect 3.0) A study of the methods used in planning for manufacture such as selection of machines, location of machines relative to assembly point, estimating time and cost of manufacture and manufacturing design. Prerequisite: Mc Eng 153.

256 Materials Handling and Plant Layout (Lect 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 recieving 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. Prerequisite: Eng Mg 282 or Mc Eng 153 (Co-listed with Eng Mg 257).

257 Tool and Die Design (Lect 2.0 and Lab 1.0) Lectures on the construction and design of dies, tools and jigs as prepared for industry. Emphasis on fabrication and metal; some consideration is given to plastics. Laboratory work is drafting room design. Prerequisite: Mc Eng 208.

259 Production Processes (Lect 3.0) An advanced study in manufacturing including high energy rate forming, numerical control electro-machining, plasma welding, electron beam welding and related current developments. Prerequisite: Mc Eng 153.

261 Analysis and Synthesis in Engineering Design (Lect 1.0 and Lab 2.0) The philosophy of design is discussed using specific illustrations in the lecture. Individual and group design projects are carried out in the laboratory. These projects illustrate the application of engineering principles to the design and analysis of mechanical systems. Should be taken in final semester. Prerequisites: Mc Eng 208, 225, 231, El Eng 283.

279 Automatic Control of Mechanical Systems (Lect 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: Mc Eng 211, 219.

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: Mc Eng 279, 242.

300 Special Problems (Variable) Problems or readings on specific subjects or projects in the department. Consent of instructor required.

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

302 Synthesis of Mechanisms (Lect 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 (Lect 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: Mc Eng 213, Bas En 110.

305 Lubrication (Lect 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 (Lect 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 (Lect 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 studies. The vibration of continuous systems is introduced. Prerequisites: Mc Eng 211 and 213, or Ae Eng 213 and Math 204. (Co-listed with E Mech 361, Ae Eng 307).

308 Rapid Product Design and Optimization (Lect 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 (Lect 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 (Lect 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: Bas En 110, Math 204. (Co-listed with E Mech 311).

312 Finite Element Approximation I—An Introduction (Lect 3.0) Variational statement of a problem. Galerkin Approximation, finite element basis functions and calculations, element assembly, solution of equations, boundary conditions, interpretation of the approximation solution, development of a finite element program, two-dimensional problems. Prerequisite: Math 204. (Co-listed with E Mech 307, Ae Eng 352).

313 Intermediate Dynamics of Mechanical and Aerospace Systems (Lect 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 (Lect 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: Bas En 110 and either Bas En 150 or E Mech 160. (Co-listed with E Mech 305).

315 Concurrent Engineering I (Lect 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: Mc Eng 213 or Ae Eng 231, and Bas En 110. (Co-listed with Ae 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 (Lect 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: Mc Eng 221. (Co-listed with Ae Eng 319)

322 Introduction to Solid Mechanics (Lect 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, E Mech 322).

323 Transport Phenomena in Manufacturing Processes (Lect 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.

309 Engineering Acoustics I (Lect 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 (Lect 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: Bas En 110, Math 204. (Co-listed with E Mech 311).

312 Finite Element Approximation I—An Introduction (Lect 3.0) Variational statement of a problem. Galerkin Approximation, finite element basis functions and calculations, element assembly, solution of equations, boundary conditions, interpretation of the approximation solution, development of a finite element program, two-dimensional problems. Prerequisite: Math 204. (Co-listed with E Mech 307, Ae Eng 352).

313 Intermediate Dynamics of Mechanical and Aerospace Systems (Lect 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 (Lect 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: Bas En 110 and either Bas En 150 or E Mech 160. (Co-listed with E Mech 305).

315 Concurrent Engineering I (Lect 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: Mc Eng 213 or Ae Eng 231, and Bas En 110. (Co-listed with Ae 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 (Lect 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: Mc Eng 221. (Co-listed with Ae Eng 319)

322 Introduction to Solid Mechanics (Lect 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, E Mech 322).

323 Transport Phenomena in Manufacturing Processes (Lect 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 (Lect 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 (Lect 3.0) Application of chemical, thermodynamic, and gas dynamic prin-

ciples 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 (Lect 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 Ae Eng, E Mech, El Eng 329 and Cv Eng 318).

331 Thermofluid Mechanics II (Lect 3.0) Derivation of Navier-Stokes equations, exact solutions of some simple flows. Superposition methods for inviscid flows. Intermediate treatment of boundary layer theory, and gas dynamics. Introduction to turbulence and kinetic theory. Prerequisite: Mc Eng 231 or Ae Eng 231. (Co-listed with Ae Eng 331)

333 Internal Combustion Engines (Lect 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 (Lect 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: Bas En 110, 150, or E Mech 160, Math 204. (Co-listed with E Mech 334 and Ae Eng 334).

336 Fracture Mechanics (Lect 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: Bas En 110. (Co-listed with E Mech 336, Ae Eng 336).

337 Atmospheric Science (Lect 3.0) An introductory survey designed to acquaint engineering and science students with the fundamentals of Atmospheric Science. Topics include atmospheric thermodynamics, synoptic scale disturbances, atmospheric aerosols (including cloud and precipitation physics), atmospheric electricity, and radiative transfer. Prerequisites: Mc Eng 221 or 227, or Ch Eng 141, or Chem 241, or Physics 311. (Co-listed with Physics 337).

338 Fatigue Analysis (Lect 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: Bas En 110. (Co-listed with E Mech 337, Ae Eng 344).

339 Computational Fluid Mechanics (Lect 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: Cmp Sc 73, one course in fluid mechanics. (Co-listed with Ae Eng 339).

341 Experimental Stress Analysis I (Lect 2.0 and Lab 1.0) Acquaints the student with some techniques of experimental stress analysis. Principal stresses, strain to stress conversion, mechanical and optical strain gages, electrical resistance strain gages, transducers, and brittle coatings. Prerequisite: Bas En 110. (Co-listed with E Mech 341, Ae Eng 341).

342 Experimental Stress Analysis II (Lect 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: Bas En 110, E Mech 321. (Co-listed with E Mech 342, Ae Eng 342).

343 Photographic Systems for Engineering Applications (Lect 2.0 and Lab 1.0) Study of photographic techniques applied to engineering uses including observations of events, recording and storage of data, and communication and dissemination of information. Both conventional and special photo-optical systems are covered. Prerequisite: Senior standing. (Co-listed with Ae Eng 343)

344 Interdisciplinary Problems in Manufacturing Automation (Lect 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. Prerequisite: Mc Eng 253 or approved courses in Ch Eng or Eng Mg. (Co-listed with Ch Eng 384, Eng Mg 344).

345 Non-Intrusive Measurement Methods (Lect 2.0 and Lab 1.0) Introduction to measurement methods useful to a mechanical engineer. Emphasis is placed on radiation measurement methods, including the effects of various sources and detectors. Prerequisite: Senior standing.

349 Robotic Manipulators and Mechanisms (Lect 2.0 and Lab 1.0) Overview of industrial applications, manipulator systems and geometry. Manip-

ulator 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).

351 Intermediate Aerospace Structures (Lect 3.0) Discussion of the finite element method for static and dynamic analysis of complex aerospace structures. Solution of basic problems using established finite element computer programs. Prerequisite: Ae Eng 253 or Mc Eng 212. (Co-listed with Ae Eng 351).

353 Computer Numerical Control of Manufacturing Processes (Lect 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 (Lect 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: Bas En 110 and Math 204; either Bas En 150 or E Mech 160. (Co-listed with E Mech 354).

355 Automation in Manufacturing (Lect 3.0) Manufacturing automation at the workstation level. Topics include kinematic and geometric error modeling of manufacturing workstations, control system hardware, servomechanism modeling and control, CNC programming, dynamic simulation, PLCs and PCs, industrial robotics modeling and control, and manufacturing systems analysis. Prerequisites: Mc Eng 253 and Mc Eng 279.

356 Design for Manufacture (Lect 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 (Lect 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 Mg 282 or Mc Eng 253. (Co-listed with Eng Mg 354).

358 Integrated Product Development (Lect 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 Mg 354 or Mc Eng 357. (Co-listed with Eng Mg 358).

362 Experimental Vibration Analysis (Lect 2.0 and Lab 1.0) Methods for measuring and analyzing motion and strain response of dynamically excited structures. Includes frequency-response testing of elementary beam, torsion bar, plate and shell structures. Experiments on the effectiveness of isolators and dynamic absorbers. Prerequisites: E Mech 361 or Mc Eng 307 or Ae Eng 307. (Co-listed with Ae Eng 362, E Mech 362).

363 Principles and Practice of Computer Aided Design (Lect 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.

365 Solar Heating and Cooling (Lect 3.0) A review of heat transfer and the nature of solar radiation. Methods of collecting and storing solar energy. Analysis and design of systems for heating and cooling by solar energy. Prerequisite: Mc Eng 225.

367 Heat Pump and Refrigeration Systems (Lect 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 Control (Lect 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: Mc Eng 221 and accompanied or preceded by Mc Eng 225.

373 Thermal System Analysis (Lect 3.0) The usage of simulation, optimization, and computer-aided design in thermal systems. Power generation, heating and refrigeration, and other complete thermal process systems are analyzed considering all factors which affect the design optimization of the system. Prerequisites: Mc Eng 221, 225.

375 Mechanical Systems for Environmental Control (Lect 3.0) Analysis of refrigeration, heating, and air-distribution systems. Synthesis of environmental control systems. Prerequisites: Mc Eng 221, 225.

377 Environmental Quality Analysis and Control (Lect 3.0) Study of the thermal and particulate effluents of engineering systems, such as engines,

fossil-fuel fired, and nuclear power plants. Investigation of the techniques for measurement and control of combustible and particulate discharges. Development of stochastic models and other comprehensive techniques for prediction of particulate and energy transport and distribution phenomena.

379 Fluid Systems and Controls (Lect 3.0) Analysis and design of pneumatic, fluidic, and hydraulic power and control systems, particular emphasis on the basic mechanics of pneumatic and fluidic components and systems. Prerequisites: Mc Eng 231, 279.

381 Mechanical and Aerospace Control Systems (Lect 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 (Lect 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: Bas En 110. (Co-listed with E Mech 381 and Ae Eng 311).

383 Industrial Applications of Composite Materials Technology (Lect 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: Bas En 110. (Co-listed with E Mech 303).

390 Undergraduate Research (Variable) 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.