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, structures, propulsion, and aerodynamics including cross-lineage between these areas. You will use this knowledge to design, build, and flight test an aerospace system in your senior year.

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, 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 aerospace structural test equipment, propulsion component analysis systems, and shock tubes. There is a vibration and acoustics laboratory and an automatic control systems laboratory as well as a real-time flight simulation facility.

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 (Emeritus) Ph.D., California Institute of Technology
L. R. Dharani, Ph.D., Clemson
Walter Eversman (Curators'), [1]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 (Emeritus), Ph.D., Cornell
Shen Ching Lee[1] (Emeritus), Ph.D., Washington
Terry Lehnhoff[1] (Emeritus), Ph.D., Illinois
H. Frederick Nelson, Ph.D., Purdue
Robert Oetting, (Emeritus),[1] Ph.D., Maryland
David W. Riggins, Ph.D., Virginia Polytechnic Institute and State University
Bruce Selberg (Emeritus), Aerospace Engineer, University of Michigan

[1]Registered Professional Engineer

Associate Professors:
Gearoid MacSithigh, Ph.D., Minnesota
Samit Roy, Ph.D., Virginia Polytechnic Institute and State University

Bachelor of Science Aerospace Engineering

FRESHMAN YEAR
(See Freshman Engineering Program)

SOPHOMORE YEAR

First Semester	Credit
Cmp Sc 73-Basic Scientific Programming	2
Cmp Sc 77-Computer Programming Lab	1
Bas Eng 50 or Bas Eng 51-Eng Mech-Statics	3
Math 22-Calculus/Analytic Geometry III[1]	4
Physics 24-Engineering Physics II	4
Ae Eng 161-Aerospace Vehicle Performance	3
	17

Second Semester	
Ae Eng 180-Intro to Aerospace Design	2
EMech 160-Engineering Mechanics-Dynamics[2]	3
Math 204-Elementary Differential Equations	3
Mc Eng 219-Thermodynamics[1,2]	3
Elective/Literature	3
Bas Eng 110-Mechanics of Materials	3
	17

JUNIOR YEAR

First Semester	Credit
Ae Eng 213-Aerospace Mechanics I[1]	3
Ae Eng 231-Aerodynamics I[1,2]	3
Ae Eng 377-Principles of Engineering Materials	3
Electives-Advanced Math/Cmp Sc[3]	3
El Eng 281-Electrical Circuits	3
	15

Second Semester	
Ae Eng 251-Aerospace Structures I[1]	3
Ae Eng 261-Flight Dynamics and Control	3
Ae Eng 271-Aerodynamics II	3
Ae Eng 282-Experimental Methods in Ae Eng I	2
Elective/Technical[5]	3
Elective/Communications[4]	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-Aerospace Systems Design I	2
Ae Eng 283-Experimental Methods in Ae Eng II	2
Electives-Technical[5]	3
Electives/Hum/Soc Sci[6]	3
	17

Second Semester	
Ae Eng 233-Intro to Aerothermochemistry	3
Ae Eng 281-Aerospace Systems Design II	3
Electives-Technical[5]	3
Electives-Hum/Soc Sci[6]	3
Electives Technical[5]	3
Electives-Hum/Soc Sci[6]	3
	18

Note: All electives must be chosen in conference with the student's advisor. 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 133 hours.

1 A grade of "C" or better in Math 8, 21, 22, and Physics 23 is required both for enrollment in Mc Eng 219, Ae Eng 213, Ae Eng 231 or Ae Eng 251 and for graduation.
2 A grade of "C" or better in EMech 160 and Mc Eng 219 are required both for enrollment in any

courses which require either EMech 160 or Mc Eng 219 as prerequisites and for graduation.

3 This course must be selected from the following: Cmp Sc 228, Math 203, Math 208, or any 300 level math or computer science course approved by the student's advisor.

4 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, & 108 or Aerospace Studies 350, 351, 380, and 381.)

5 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. Three hours of technical elective must be in the manufacturing area. Mc Eng 253, Mc Eng 353, or Mc Eng 355. Honors students have special requirements for technical electives.

6 All electives must be approved by the student's advisor. Students must comply with the School of Engineering social science and humanities requirements with respect to selection and depth of study. These requirements are specified in the current catalog.

7 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 this 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] This course is designed to give the department an opportunity to test a new course. Variable title.

161 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 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] 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] 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 8, 21, 22, and Physics 23.

231 Aerodynamics I [Lect 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 8, 21, 22, Physics 23, and Mc Eng 219.

233 Introduction to Aerothermochemistry [Lect 3.0] Principles of thermochemistry in reacting

flow including an introduction to fundamentals of quantum mechanics, statistical mechanics and statistical thermodynamics. Applications in flow through nozzles and shock waves, combustion, aerodynamic heating, ablation and propulsion. Prerequisites: Ae Eng 231, Ae Eng 271.

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 8, 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 distributions in data analysis and interpretation. Prerequisites: Ae Eng 231 and El Eng 281.

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

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 Theory of Combustion [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 Theory of Stability I [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. (Co-listed with Mc Eng 350 and Eng Mg 350)

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 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 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 Flow [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 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 Ch Eng 377, Physics 377, Mt Eng 377, Cr Eng 377)

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)

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 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 studio 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, port facilities, 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 very rigorous degree program. Entering students should be prepared to have their studies consume almost all their time and energy. However, you will have a rewarding career after you graduation. Each student is encouraged to become a registered Professional Engineer.

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 also may find that you will be working with engineers in the other disciplines such as mechanical, electrical, or geological engineering 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. 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 programming ability and usage of computer hardware and software related to the different areas 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:

Roger LaBoube[1] (Distinguished Teaching Professor), Ph.D., University of Missouri-Rolla
Harry Eisenman, Ph.D., Case Western Reserve
Walter Eversman[1] (Curators'), Ph.D., Stanford
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., University of Missouri-Rolla
Abdeldjelil Belarbi, Ph.D., Houston
Rodney Lentz[1], Ph.D., Michigan State
Ronaldo Luna[1], Ph.D., Georgia Tech.
David Richardson[1], Ph.D., University of Missouri-Rolla

Assistant Professors:

Genda Chen[1], Ph.D., Suny-Buffalo
John Myers[1], Ph.D., Texas
William Eric Showalter, Ph.D., Purdue University, W. Lafayette, IN
Pedro F. Siva[1], Ph.D., University of California, San Diego

Bachelor of Science Architectural Engineering

FRESHMAN YEAR

(See Freshman Engineering Program)

SOPHOMORE YEAR

First Semester	Credit
Cv Eng/ArchE 001-Fund Survey[3]	4
Bas En 50-Eng Mc/Statics	3
Math 22-Calc/Analytic Geom III	4
Physics 24-Eng Physics II	4
Cv Eng/ArchE 003-Cv Eng Communication[3]	3
	18

Second Semester	
Cv Eng 230-Elem Fluid Mech	3
Cv Eng/ArchE 241-Econ of Eng Design[3]	3
Bas En 110-Mech of Materials	3
Bas En 120-Materials Testing Lab	1
ArchE 1xx-Mat & Meth of Const[8]	2
ArchE 2xx-Intro to Arch Design I[4,8]	3
Math 204-Diff Equations	3
	18

JUNIOR YEAR

First Semester	Credit
Cv Eng/ArchE 217-Structural Analysis[3]	3
Bas En 150-Eng Mech/Dynamics	2
ArchE 2xx-Intro to Arch Design II[4,8]	3
El Eng 281-Elec Circuits	3
Mc Eng 227-Thermal Analysis	3
History 270-History of Technology	3
	17

Second Semester	
Cv Eng 215-Elem Soil Mech[5]	3
Cv Eng/ArchE 223-Reinf Concrete Design[3]	3
Cv Eng/ArchE 247-Ethical, Legal & Prof Eng Pract[3]	2
Stat 213-Prob & Stat	3
Mc Eng 371-Environment Controls	3
Hum/Soc Sc-Elective[1]	3
	17

SENIOR YEAR

First Semester	Credit
Cv Eng/ArchE 210-Seminar[3,7]	0
Cv Eng 216-Construction Mat	3
Cv Eng/ArchE 221-Struct Design Metals[3]	3
Cv Eng/ArchE 248-Intro to Cont & Const Eng[3]	3
ArchE 2xx-Illumination of Bldgs.[8]	3
History 2xx-Arch History:19th & 20th Century[8]	3
Technical Elective 300 level[9]	3
	18

Second Semester	Credit
Cv Eng/ArchE 298-Senior Design[3]	3
Technical Elective 300 level[9]	3
Technical Elective 300 level[9]	3
Technical Elective 300 level[9]	3
Elective Communications[6]	3
Cv Eng 229-Foundation/Pavement Eng	3
	18

NOTE: Students must satisfy the common engineering freshman year requirements in addition to the sophomore, junior and senior year requirements listed above with a minimum of 138 credit hours.

1 Select from School of Engineering approved list
2 Select from History 112, 175, 176, or Pol Sc 90
3 Existing Cv Eng course that is cross-listed as ArchE; ArchE course pending approval FS2001
4 To be developed as Hum/Soc Sc course to meet ABET requirements
5 Prerequisite to be reevaluated by the Cv Eng faculty and Cv Eng Curriculum Committee
6 Select from English 60, 160, or SP&MS 85
7 S/U grading only
8 New courses
9 Technical elective course selected from approved list depending on emphasis area selected

Emphasis Areas for Architectural Engineering Students

Area I, Structural Engineering

Cv Eng 301	Applied Mechanics in Structural Engineering
Cv Eng 301	Design of Low Rise Buildings under Wind and Earthquake Loads
Cv Eng 320	Indeterminate Structural Analysis
Cv Eng 322	Analysis and Design of Wood Structures
Cv Eng 323	Classical and Matrix Methods of Structural Analysis
Cv Eng 326	Advanced Steel Structures Design
Cv Eng 327	Advanced Concrete Structures Design
Cv Eng 328	Prestressed Concrete Design
Cv Eng 329	Foundation Engineering II
Arch Eng 3XX	Masonry Engineering

Area II, Construction Engineering and Project Management

Cv Eng 345	Construction Methods
Cv Eng 346	Management of Construction Costs
Cv Eng 349	Engineering and Construction Contract Specifications
Cv Eng 3XX	Project Delivery System
Cv Eng 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	Mechanical Systems for Environmental 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	Introduction to Computer Eng

Area IV, Construction Materials

Cv Eng 301	Applied Mechanics in Structural Engineering
Cv Eng 312	Bituminous Materials
Cv Eng 313	Composition & Properties of Concrete
Cv Eng 317	Pavement Design
Arch Eng 3XX	Special Concretes
Ch Eng 381	Corrosion and Its Prevention

Architectural Engineering Courses (to be developed in AY2001/2002)

ArchE 1xx	Materials and Methods of Construction
ArchE 2xx	Intro to Architectural Design I
ArchE 2xx	Intro to Architectural Design II
ArchE 2xx	Illumination of Buildings

ArchE 3xx	Masonry Engineering
ArchE 3xx	Special Concretes

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

ArchE 001	Fundamentals of Surveying
ArchE 101	Special Topics
ArchE 200	Special Problems
ArchE 201	Special Topics
ArchE 202	Co–operative Engineering Training
ArchE 210	Seminar
ArchE 217	Structural Analysis I
ArchE 221	Structural Design in Metals
ArchE 223	Reinforced Concrete Design
ArchE 241	Economy of Engineering Design
ArchE 247	Ethical, Legal, and Professional Engineering Practice
ArchE 248	Introduction to Contracts and Construction Engineering
ArchE 298	Senior Design
ArchE 300	Special Problems
ArchE 301	Special Topics
ArchE 310	Seminar
ArchE 320	Intermediate Structural Analysis
ArchE 322	Analysis and Design of Wood Structures
ArchE 323	Classical and Matrix Methods of Structural Analysis
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 390	Undergraduate Research

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

Cv Eng 215	Elementary Soil Mechanics
Cv Eng 216	Construction Materials, Properties, and Testing
Cv Eng 229	Foundation/Pavement Engineering
Cv Eng 230	Elementary Fluid Mechanics
Cv Eng 312	Bituminous Materials
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 Engineering Practice
Cv Eng 345	Construction Methods
Cv Eng 346	Management of Construction Costs
Cv Eng 349	Engineering and Construction Contract Specifications

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

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:
Archie W. Culp, Jr. (Emeritus), Ph.D., University of Missouri-Columbia
Robert L. Davis[1], 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, D.Sc., University of Virginia

Associate Professors:
Douglas R. Carroll[1], Ph.D., UMR
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
Rodney A. Schaefer (Emeritus), M.S., UMR
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
Robert B. Stone, Ph.D., University of Texas-Austin

Lecturers:
Thomas E. Bryson, M.S., UMR
Edward M. Raney[1], Ph.D., UMR
Jeffery S. Thomas, 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; preceded or accompanied 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

ENGINEERING GRAPHICS COURSES

121 Engineering Graphics I [Lect 1.0 and Lab 1.0] A study of graphical calculations in the engineering field, including charts, graphs and diagrams, graphical solutions, functional scale relationships and nomographs. Prerequisite: Math 6.

Chemical Engineering

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

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 analyses, 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
James Johnson[1], (Emeritus), Ph.D., University of Missouri-Columbia
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
Gary Patterson[1], (Emeritus), Ph.D., University of Missouri-Rolla
X B Reed, Jr., Ph.D., Minnesota
Stephen L. Rosen[1], 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
Partho Neogi, Ph.D., Carnegie-Mellon
Oliver Sitton, Ph.D., University of Missouri-Rolla

Assistant Professors:
Dionyssios D. Sourlas, Ph.D., University of California Los Angeles
Jee-Ching Wang, Ph.D., Pennsylvania State University

Lecturer:
Robert Ybarra, Ph.D., Purdue

[1]Registered Professional Engineer

Bachelor of Science Chemical Engineering

FRESHMAN YEAR
(See Freshman Engineering Program)

SOPHOMORE YEAR

First Semester	Credit
Ch Eng 27-Chemical Engineering Calculations[3]	3
Physics 24-Engineering Physics II	4
Chem 221-Organic Chemistry I	3
Math 22-Calculus w/Analytic Geometry III	4
Cmp Sc 73-Basic Scientific Prog or Cmp Sc 74-Intro to Prog Meth	2
Cmp Sc 77-Computer Prog Lab or Cmp Sc 78-Prog Meth Lab	1
	17

Second Semester	
Chem 51-Elem Quan Chem Analysis	2
Chem 52-Elem Quan Chem Analysis Lab	2
Ch Eng 141-Chemical Eng Thermodynamics I[3]	3
Chem 223-Organic Chemistry II	3
Chem 224-Organic Chemistry Lab	1
Math 229-Elem Diff Equations or Math 204	3
Elective-Hum/Soc[1]	3
	17

JUNIOR YEAR

First Semester	Credit
Ch Eng 143-Chem Eng Thermo II[3]	3
Ch Eng 231-Prin of Chem Eng I	3
Ch Eng 233-Prin of Chem Eng II	2
Chem 241-Physical Chemistry I	3
Chem 242-Physical Chemistry I Lab	1
Elective-Hum/Soc Sci (UL)[1]	3
	15

Second Semester	
Ch Eng 234-Chem Eng Lab I[5]	3
Ch Eng 235-Prin of Chem Eng III	3
Ch Eng 237-Prin of Chem Eng IV	3
Bas Eng 50 or Bas Eng 51-Statics or El Eng 281-Electrical Circuits	3
Chem 243-Physical Chemistry II	3
Electives-Hum/Soc Sci (UL)[1]	3
	18

SENIOR YEAR

First Semester	Credit
Ch Eng 111-Professional Guidance[4]	1
Ch Eng 236-Chem Eng Lab II[5]	3
Ch Eng 243-Chem Eng Reactor Design	3
Ch Eng 253-Chem Eng Economics[5]	3
Ch Eng 261-Industrial Instrumentation	3
Ch Eng 262-Industrial Instrumentation Lab	1
Electives-Technical (Ch Eng)[2]	3
	17

Second Semester	
Ch Eng 255-Chem Eng Design[5]	3
Ch Eng 258-Chem Process Safety[5]	3
Electives-Technical (Ch Eng)[2]	3
Electives-Technical (Ch Eng)[2]	3
Electives-Hum/Soc Sci (UL)[1]	3
	15

Note: Students who take Chemistry 5 must elect an additional 3 hour chemistry course (200 level or above). All electives must be chosen in conference with the student's advisor.

Basic ROTC may be elected in the freshman and sophomore year, but it not counted toward degree requirements.

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 134 hours.

1. The humanities/social science electives must satisfy the School of Engineering humanities/social science requirements.
2. Six semester hours of technical electives must be from Ch Eng 301 to Ch Eng 389 courses. The additional 3 hours can come from Ch Eng 300 to Ch Eng 390 courses or a variety of out of department courses. Check with your advisor for a list of approved substitutions. Honor students may apply 6 hours of 390H towards the technical elective requirement and hence would only need to take one course from Ch Eng 301 to Ch Eng 389 to fulfill their technical elective requirement.
3. A grade of "C" or better is required in Ch Eng 27 and in Ch Eng 141 to enroll in Ch Eng 143.
4. All Chemical 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.
5. All UMR students must take two communication intensive or four communication emphasized courses. This course has been designated as a communication emphasized course.

Chemical Engineering
Biochemical Engineering Emphasis

FRESHMAN YEAR
(See Freshman Engineering Program)

SOPHOMORE YEAR

First Semester	Credit
Ch Eng 27-Chemical Engineering Calculations[2]	3
Cmp Sc 73-Basic Scientific Prog or Cmp Sc 74-Intro to Prog Meth	2
Cmp Sc 77-Computer Prog Lab or Cmp Sc 78-Prog Meth Lab	1
Chem 221-Organic Chemistry I	3
Math 22-Calculus w/Analytic Geometry III	4
Bio 211-Cellular Biology	4
	17

Second Semester	Credit
Ch Eng 141-Chemical Eng Thermodynamics[2]	3
Chem 51-Elementary Quan Chem Analysis	2
Chem 52-Elementary Quan Chem Analysis Lab	2
Chem 223-Organic Chemistry II	3
Chem 224-Organic Chemistry Lab	1
Math 229-Elem Diff Equations or Math 204	3
Physics 24-Engineering Physics II	4
	18

JUNIOR YEAR

First Semester	Credit
Ch Eng 143-Chem Eng Thermodynamics II[2]	3
Ch Eng 231-Principles of Chem Eng I	3
Ch Eng 233-Principles of Chem Eng II	2
Chem 241-Physical Chemistry I	3
Chem 242-Physical Chemistry I Lab	1
Econ 121-Prin of Microecon or Econ 122-Prin of Macroecon	3
	15

Second Semester	
Bio 221-Microbiology	5
Ch Eng 235-Prin Ch Eng III	3
Ch Eng 238-Fund of Mass Transfer & Sep for Biopro	3
Chem 243-Physical Chemistry II	3
Elective-Hum/Soc Sc[1]	3
	17

SENIOR YEAR

First Semester	Credit
Ch Eng 111-Professional Guidance	1
Ch Eng 240-Biochemical Engineering Lab I[4]	2
Ch Eng 243-Chem Eng Reactor Design	3
Ch Eng 253-Chem Eng Economics[4]	3
Ch Eng 261-Industrial instrumentation	3
Ch Eng 262-Industrial Instrumentation lab	1
Bio 331-Molecular Genetics	3
Bio 332-Molecular Genetics Lab	2
	18

Second Semester	
Ch Eng 241-Biochem Eng Lab II[4]	3
Ch Eng 255-Chem Eng Design[4]	3
Ch Eng 345-Chem Eng in Biochem Tech	3
El Eng 281-Electrical Circuits	3
Electives-Hum/Soc Sci[1] (UL)	6
	18

NOTE: Students who take Chemistry 5 must elect an additional 3 hour chemistry course (200 level or above). All electives must be chosen in conference with the student's advisor.

Basic ROTC may be elected in the freshman and sophomore years, but is not counted toward degree requirements.

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 138 hours.

1 The humanities/social science electives must satisfy the School of Engineering humanities/social science requirements listed in this catalog.
2 A grade of "C" or better is required in Ch Eng 27 and in Ch Eng 141 to enroll in Ch Eng 143.
3 All Chemical 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.

4. All UMR students must take two communication intensive or four communication emphasized courses. This course has been designated as a communication emphasized course.

Chemical Engineering Courses

027 Chemical Engineering Calculations [Lect 2.0 and Lab 1.0] The application of mathematics, physics and chemistry to industrial processes. The use of gas laws, chemical equations, and material balances are emphasized in solving chemical engineering problems. Prerequisites: Chem 3 or Chem 5, Math 8.

111 Professional Guidance [Lect 1.0] Professional attitudes, recent developments in the chemical industries, selected inspection trips, discussions by visiting industrialists, discussion of industrial practices and graduate programs. Reports required. Lecture, discussion, trips. First semester. Senior year only.

141 Chemical Engineering Thermodynamics I [Lect 3.0] Derivation and development of the fundamental relationships of thermodynamics along with the quantitative heat and work relationships. Emphasis is placed on properties of fluids and their applications to chemical engineering. Prerequisites: Ch Eng 27, Math 22.

143 Chemical Engineering Thermodynamics II [Lect 3.0] Continuation of the topics in Ch Eng 141 with emphasis on physical and chemical equilibrium. Prerequisites: Ch Eng 141, Chem 51, 52, Math 204, grade of "C" or better in Ch Eng 27 and 141.

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 advisor. Grade received depends on quality of reports submitted and work supervisors evaluation.

231 Principles of Chemical Engineering I [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. Prerequisites: Ch Eng 141, Math 204, accompanied or preceded by Chem 221, 241.

233 Principles of Chemical Engineering II [Lect 2.0] The process principles of heat transfer as utilized in the chemical industry are taught. Steady state and unsteady state heat conduction is studied by analytical and numerical methods. Radiation heat transfer is given special treatment. Finally, free and forced convection are treated along with aspects of condensation and boiling. Practical heat exchanger design is included throughout. Prerequisites: Ch Eng 141, Math 204, accompanied or preceded by Ch Eng 231.

234 Chemical Engineering Laboratory I [Lab 3.0] Experiments illustrate the unit operations associated with momentum and heat transfer. Experimental methods, such as 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 to effectively communicate these technical designs through oral and written reports. Prerequisites: Ch Eng 143, 231 and 233, Chem 51 and 52.

235 Principles of Chemical Engineering III [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. Prerequisites: Ch Eng 143, 231, 233, and Chem 221, 241.

236 Chemical Engineering Laboratory II [Lab 3.0] A continuation of Ch Eng 234 with experiments illustrating the unit operations listed in Ch Eng 235 and Ch Eng 237. Experimental methods introduced in Ch Eng 234 are extended to include principles of regression and model building. Improvement of communication skills is also stressed. Prerequisites: Ch Eng 235 and Ch Eng 237.

237 Principles of Chemical Engineering IV [Lect 3.0] The fundamentals of mass transfer applied to various unit operations of absorption, extraction, humidification, drying and filtration. Continuous contactors are emphasized by solution of numerous problems. Prerequisites: Ch Eng 143, 231, 233, Chem 221, 241.

238 Fundamentals of Mass Transfer and Separation for Bioprocesses [Lect 3.0] The fundamentals of mass transfer are introduced and applied to various unit operations employed in the separation of chemical compounds as well as in biomolecule separations. Both stage and continuous separation processes are studied.

Prerequisites: Ch Eng 143, 231, 233, Chem 221, 241.

240 Biochemical Engineering Laboratory I [Lab 2.0] Introduction to the unit operations employed in the separation of chemical and biochemicals. The experiments illustrate the unit operations studied in Ch Eng 238; stage and continuous separation systems are involved. Prerequisite: Ch Eng 238.

241 Biochemical Engineering Laboratory II [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. Prerequisite: Ch Eng 240.

243 Chemical Engineering Reactor Design [Lect 3.0] Introduction to basic kinetic principles and their relation to reactor design. Prerequisites: Ch Eng 143, Math 204, Chem 223, 243.

253 Chemical Engineering Economics [Lect 3.0] Capital requirements for process plants, costs, earnings, profits. The economic balance is applied to chemical engineering operations and processes. Optimization techniques are applied to process evaluation. Economic analysis of a process. Prerequisites: Ch Eng 235, 237.

255 Chemical Engineering Design [Lect 1.0 and Lab 2.0] Fundamental principles involved in the design and layout of chemical process equipment. Flow sheets, material and energy balances, equipment selection and preconstruction cost estimation, are integral parts of this course. Prerequisites: Ch Eng 243, Ch Eng 253, preceded or accompanied by Ch Eng 261.

258 Chemical Process Safety [Lect 3.0] The identification and quantification of risks involved in the processing of hazardous and/or toxic materials are studied. Prerequisite: Preceded or accompanied by Ch Eng 243.

261 Industrial Instrumentation [Lect 3.0] Study of industrial instruments used for measurement and control of temperature, pressure, liquid level, composition and flow. Emphasis is placed on the control of chemical engineering processes. Prerequisites: Math/Stat 204, or 229, Ch Eng 231, Ch Eng 233, preceded or accompanied by Ch Eng 262.

262 Industrial Instrumentation Laboratory [Lab 1.0] Study of the characteristics of primary sensing elements and pneumatic and electrical recorders, controllers and final control devices. Elementary analog computer programming to simulate instrumentation component responses and controlled chemical process systems. Prerequisites: Preceded or accompanied by Ch Eng 234 or Ch Eng 236, accompanied by Ch Eng 261. (In the summer the requirement that Ch Eng 262 be accompanied by Ch Eng 261 can be waived).

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.

331 Principles of Chemical Engineering [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. Prerequisites: Ch Eng 235, 237.

333 Separation Processes for Product Purification [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. Prerequisites: Ch Eng 235, 237.

335 Momemtum, Heat and Mass Transfer [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. Prerequisites: Ch Eng 235, 237, Math 204.

341 Physical Property Estimation [Lect 3.0] Techniques for estimating and correlating thermodynamic and transport properties of gases and liquids will be studied. Prerequisites: Ch Eng 143, 237.

342 Experimental Methods in Chemical Engineering [Lab 3.0] Several students work together as a group for the entire semester to calibrate and operate sophisticated equipment with the objective of measuring, correlating, and documenting new data. A final report in the form of a paper is required. Prerequisite: Ch Eng junior or senior status.

343 Chemical Engineering Kinetics [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 243.

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. Prerequisites: Senior standing and permission of instructor. (Co-listed with Mc Eng 344, Eng Mg 344)

345 Chemical Engineering in Biochemical Technology [Lect 3.0] An introduction to the use of chemical engineering principles in the areas of fermentation, enzyme catalysis, and biological transport phenomena, with emphasis on food, chemicals, medicine and pharmaceuticals, fuels, and waste treatment. Prerequisites: Ch Eng 235, 237.

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.

353 Unit Processes - Organic Chemical Industry [Lect 3.0] A detailed study of the fundamental unit processes of organic chemistry. Prerequisites: Ch Eng 235, 237, Chem 221. (Co-listed with Chem 325)

357 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. Prerequisites: Ch Eng 235, 237.

361 Environmental Chemodynamics [Lect 3.0] The objective of the course is to introduce students to interphase transport of chemicals and energy in the environment. The process oriented aspects of chemical engineering - fundamental chemistry, thermodynamics, fluid mechanics, mass transport, heat transport, equilibrium and separations - are extended to the situations found in the environment where the same principles apply. This course is designed to complement Ch Eng 351, Environmental Monitoring. Prerequisites: Ch Eng 141 or equivalent, Ch Eng 231 or equivalent, Ch Eng 233 or equivalent, Chem 1, 2, and 3 or Chem 5.

362 Pollution Prevention via Process Engineering [Lect 3.0] In the context of environmental process design each processing system is considered as an inter-connection of elementary units. Systematic process integration methods are then employed that capitalize on synergistic process interactions in order to arrive at environmentally benign process designs. The proposed course on Pollution Prevention via Process Engineering introduces paradigms such as: linear, nonlinear and integer optimization, mass/heat exchange networks, reactor and reaction networks that are instrumental in the analysis, synthesis and design of environmental systems. Pollution prevention case studies that employ the aforementioned concepts will be incorporated in the presentation.

365 Process Dynamics [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. Prerequisites: Ch Eng 235, 237, 261.

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.

367 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. Prerequisites: Ch Eng 261 or El Eng 231. (Co-listed with El Eng 332)

368 Chemical Process Flowsheeting [Lect 3.0] 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. Prerequisites: Cmp Sc 73, Math 204.

375 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. Prerequisites: Chem 223, Chem 243.

377 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)

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.

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 Eng 237, Math 204.

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, environmental and sanitary, fluid mechanics and hydraulics, geotechnical engineering, structural analysis and design, and transportation and planning engineering.

Civil engineer's 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. Hydraulic engineering and hydrology are related to water resources, flood control, rainfall, and runoff prediction and the transportation of fluids. 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.

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 working with engineers in the 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 programming ability and usage of computer hardware and software related to the different areas of study.

Mission Statement

The Civil Engineering Program will provide students with the tools necessary to solve civil engineering problems critical to our society's well-being. This will be accomplished through a comprehensive, forward-looking and broad-based civil 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 civil engineering profession, for life-long learning, and to function as civil engineers in a global society.

BSCE 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 civil engineering problems, and to analyze and design civil 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 civil 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:
William Andrews[1] (Emeritus), D.Sc., Washington University
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
Roger LaBoube[1] (Distinguished Teaching Professor), Ph.D., University of 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., University of 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 (John and Susan Mathes Professor), Ph.D., Kansas
Jerry Bayless[1] (Associate Dean of Engineering), M.S., University of Missouri-Rolla
Abdeldjelil Belarbi, Ph.D., Houston
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., University of Missouri-Rolla
Gary Spring, Ph.D., Massachusetts
Purush TerKonda (Emeritus), Ph.D., Texas

Assistant Professors:
Joel Burken, Ph.D., Iowa
Frank Capek[1] (Emeritus), M.S., University of Missouri-Rolla
Genda Chen[1], Ph.D., Suny-Buffalo
Mark Fitch, Ph.D., Texas
John Myers[1], Ph.D., Texas
Mohammad Qureshi, Ph.D., University of Tennessee-Knoxville
William Eric Showalter, Ph.D., Purdue University, W. Lafayette, IN
Pedro F. Siva[1], Ph.D., University of California, San Diego
Xiaoqui Zhang, Ph.D., Cincinnati

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

Teaching Fellow:
Lelia Flagg[1], M.S., University of California-Berkele

[1] Registered Professional Engineer

Bachelor of Science Civil Engineering

FRESHMAN YEAR
(See Freshman Engineering Program)

SOPHOMORE YEAR

First Semester	Credit
Cv Eng 1-Fund of Surveying & Intro to Cv Eng[2]	4
Cmp Sc 73-Basic Scientific Prog	2
Cmp Sc 77-Computer Prog lab	1
Bas En 50 or Bas En 51-Eng Mech-Statics[2]	3
Math 22-Calculus w/Analytic Geometry III	4
Physics 24-Engineering Physics II	4
	18

Second Semester	
Cv Eng 230-Elem Fluid Mech[2]	3
Cv Eng 241-Economy of Eng Design[2]	3
Cv Eng 261-Intro to Env Eng & Science	3
Bas En 110-Mechanics of Materials[2]	3
Bas En 120-Materials Test Lab	1
Math 204-Elementary Differential Equations	3
Electives-Communications[3]	3
	19

JUNIOR YEAR

First Semester	Credit
Cv Eng 211-Transportation Engineering	3
Cv Eng 217-Structural Analysis I[2]	3
Cv Eng 233-Engineering Hydrology	3
Ge Eng 50-Geology for Engineers	3
Bas Eng 150-Eng Mech Dynamics	2
Electives-Hum or Soc Sci[1]	3
	17

Second Semester

Cv Eng 215-Elementary Soil Mechanics	3
Cv Eng 223-Reinforced Concrete Design	3
Cv Eng 235-Hydraulic Engineering	3
Cv Eng 247-Ethical, Legal, & Prof Eng Practice	2
Cv Eng 265-Water & Waste Water Eng	3
Stat 213-Applied Eng Statistics	3
	17

SENIOR YEAR

First Semester	Credit
Cv Eng 216-Construction Materials, Prop & Testing	3
Cv Eng 221-Structural Design in Metals	3
Cv Eng 229-Foundation & Pavement Eng	3
Cv Eng 248-Intro to Contracts & Construction Eng	3
Cv Eng 3XX-Cv Eng Technical Elective[4]	3
Elective-Hum or Soc Sci[1]	3
	18

Second Semester

Cv Eng 298-Civil Engineering Design Project	3
Cv Eng 3XX-Cv Eng Tech Elective[4]	3
El Eng 281-Electrical Circuits	3
Mc Eng 227-Thermal Analysis	3
Elective-Hum or Soc Sc[1]	3
Elective-Hum or Soc Sc[1]	3
	18

NOTE: Students must satisfy the common engineering freshman year requirements in addition to the sophomore, junior and senior year requirements listed above with a minimum of 139 credit hours.

1 Select to meet School of Engineering requirements.

2 A grade of "C" or better required in Bas Eng 50 or Bas Eng 51, Bas Eng 110, Cv Eng 001, Cv Eng 217, Cv Eng 230 and Cv Eng 241 to satisfy graduation requirements.

3 Select from English 60, 160 or SP&MS 85; or the complete four course sequence in Adv ROTC (Mil Sc 105, 106, 107 and 108 or Aerospace Studies 350, 351, 380 and 381.)

4 A grade of "C" or better may be required in Cv Eng Technical Elective prerequisite courses. Refer to the UMR Undergraduate Catalog for these prerequisites.

5 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 score.

Emphasis Area Programs for Civil Engineering Students

Construction

Cv Eng 311-Geometric Design of Highways
Cv Eng 345-Construction Methods
Cv Eng 346-Management of Construction Costs
Cv Eng 349-Engineering and Construction Contract Specifications
Cv Eng 373-Air Transportation

Transportation

Cv Eng 311-Geometric Design of Highways
Cv Eng 317-Pavement Design
Cv Eng 337-River & Harbor Engineering
Cv Eng 353-Traffic Engineering
Cv Eng 373-Air Transportation

Planning

Cv Eng 373-Air Transportation
Cv Eng 380-Water Resources & Wastewater Engineering

Geotechnical Engineering

Cv Eng 312-Bituminous Materials
Cv Eng 315-Intermediate Soil Mechanics
Cv Eng 317-Pavement Design
Cv Eng 327-Advanced Concrete Structures Design
Cv Eng 329-Foundation Engineering II

Fluid Mechanics and Hydraulics

Cv Eng 331-Hydraulics of Open Channels
Cv Eng 332-Experimental Fluid Mechanics and Hydraulics
Cv Eng 337-River and Harbor Engineering
Cv Eng 338-Hydrologic Techniques
Cv Eng 380-Water Resources and Wastewater Engineering

Environmental and Sanitary

Cv Eng 362-Public Health Engineering
Cv Eng 363-Solid Waste Management
Cv Eng 365-Environmental Engineering Analysis Lab
Cv Eng 367-Introduction to Air Pollution
Cv Eng 369-Sanitary Engineering Design

Structural Analysis and Design

Cv Eng 322-Analysis and Design of Wood Structures
Cv Eng 323-Classical and Matrix Methods of Structural Analysis
Cv Eng 324-Numerical Methods of Structural Analysis
Cv Eng 326-Advanced Steel Structures Design
Cv Eng 327-Advanced Concrete Structures Design
Cv Eng 328-Prestressed Concrete Design
Cv Eng 329-Foundation Engineering II

Civil Engineering Courses

001 Fundamentals of Surveying and Introduction to Civil Engineering [Lect 3.0 and Lab 1.0] Theory and application of principles of plane surveying, and introduction to Civil Engineering. Includes use of conventional, and electronic surveying instruments and techniques, computations, and construction surveying. Introductions provided for areas of Civil Engineering and expectations for students and graduates. Prerequisite: Preceded or accompanied by Math 8.

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 Seminar [0.0 Hours] Discussion of current topics. Prerequisite: Senior standing.

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, Cv Eng 241, Bas En 50, Stat 213, all 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.

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.

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 218 with grade of "C" or better.

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 218 with grade of "C" or better.

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 50 with 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.

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 3.0] A study of the economic relationships between engineering design alternatives and economic factors such as the time value of money, risk, uncertainty, and allowable depreciation methods. Prerequisite: Junior standing.

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.

248 Introduction to Contracts and Construction Engineering [Lect 3.0] Introduction to 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 and analysis. Prerequisite: Preceded or accompanied by Cv Eng 247.

261 Introduction to Environmental Engineering and Science [Lect 2.0 and Lab 1.0] Course provides an introduction to 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.

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 asphalt 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 Soil Dynamics I [Lect 3.0] Damage to structures during earthquakes, magnitude and intensity scales, theory of vibrations, single and two degrees of freedom, earthquake spectrum, dynamic soil properties, simple solutions of liquefaction, retaining structures, piles and embankments. 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 218.

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. Prerequisites: Cv Eng 218 with grade of "C" or better.

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. Prerequisites: Cv Eng 218 with grade of "C" or better.

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. Prerequisites: Cv Eng 218 with grade of "C" or better.

326 Advanced Steel Structures Design [Lect 2.0 and Lab 1.0] 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.

327 Advanced Concrete Structures Design [Lect 2.0 and Lab 1.0] 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. Prerequisites: Cv Eng 223 with a grade of "C" or better.

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. Prerequisites: Cv Eng 223 with a grade of "C" or better.

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.

330 Hydraulic Transients [Lect 3.0] The study of unsteady flow and its effect on closed water distribution systems, water power and irrigation systems. Relationships between unsteady flow and open channel controls. 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, shooting flow, backwater curves, hydraulic jump, 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 and Harbor Engineering [Lect 3.0] Formation of rivers and the laws governing river regulation and improvements, including navigation and flood protection. Principles governing harbor design. Prerequisites: Cv Eng 230 with a grade of "C" or better.

338 Hydrologic Techniques [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 233 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.

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.

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.

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)

365 Environmental Engineering Analysis Laboratory [Lect 1.0 and Lab 2.0] Environmental Engineering analytical principles and techniques applied to the quantitative measurement of water, wastewater and natural water characteristics, and application of advanced instrumental methods in environmental engineering. Prerequisites: Cv Eng 265 with grade of "C" or better; or graduate standing. (Co-listed with Env En 365)

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-of-the-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 Airport Planning and Design [Lect 1.0 and Lab 1.0] Lectures and reports on location, layout, design, construction, operation and maintenance of airports. Design problems assigned. Prerequisites: Cv Eng 211 with a grade of "C" or better.

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)

386 Groundwater Hydraulics [Lect 3.0] A comprehensive study of fundamentals of groundwater hydraulics. Basic hydraulics of confined and unconfined aquifers. Design criteria for well strainers, pumping equipment, and practical aspects of well drilling. Evaluation of water supply based upon consumptive use and other water needs of the community. Hydraulics of recharge wells as affected by storm drains and return water from irrigation. Fundamental treatment of water rights. Integration of groundwater and surface water use. Prerequisites: Cv Eng 233 with a grade of "C" or better.

387 Drainage [Lect 3.0] Soil properties for drainage of agricultural lands. Tile and porous drain system, plastic drains, model studies for drains. Theory of open drain system and introduction to drainage by deep well turbine pumps. Urban and rural drainage. Highway and airport drainage. Prerequisites: Cv Eng 233 with a grade of "C" or better.

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

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.

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)

365 Environmental Engineering Analysis Laboratory [Lect 1.0 and Lab 2.0] Environmental Engineering analytical principles and techniques applied to the quantitative measurement of water, wastewater and natural water environmental engineering. Prerequisites: Cv Eng 265 with grade of "C" or better; or graduate standing. (Co-listed with Cv Eng 365)

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

368 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-of-the-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)

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], 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, Ph.D., University of Missouri-Rolla

Assistant Professors:

Daryl Beetner, D.Sc., Washington University

Ronald Joe Stanley, Ph.D., University of Missouri-Columbia

Electrical Engineering Faculty

Professors:
David R. Cunningham[1] (Emeritus), Ph.D., Oklahoma State University
Kelvin T. Erickson, 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
James Drewniak, Ph.D., University of Illinois at Urbana-Champaign
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
(See Freshman Engineering Program)

SOPHOMORE YEAR

First Semester	Credit
El Eng 151-Circuits I[4]	3
El Eng 152-Circuit Analysis Lab	1
Math 22-Calculus w/Analytic Geometry III[4]	4
Cmp Sc 53-Intro to Programming[4,5]	3
Physics 24-Eng Physics II[4,6]	4
Elective Hum or Soc Sc[7]	3
	18

Second Semester	
Cp Eng 111-Intro to Cmp Eng	3
Cp Eng 112-Cmp Eng Lab I	1
El Eng 153-Circuits II[4,8]	3
El Eng 154-Circuit Analysis Lab II[8]	1
Math 204-Elementary Diff Equations[4]	3
Cmp Sc 153-Data Structures I	3
Cmp Sc 158-Discrete Math	3
	17

JUNIOR YEAR

First Semester	Credits
Elective –Mathematics[11]	3
SP&M S 85 or SP&M S 283-	3
Cp Eng 213-Digital Systems Design	3
Cp Eng 214-Cp Eng Lab II	1
Cmp Sc 253-Data Structures II	3
Elective-Hum or Soc Sci[7]	3
	16

Second Semester	
Cp Eng Sci Elective I[12]	3
English 160-Technical Writing[13]	3
Statistics 217-Intro to Prob & Stat[14]	3
Cmp Sc 284-Intro to Operating Systems[18]	3
Cp Eng Science Elective II[12]	3
Cp Eng Cmp Organization Elective[15]	3
	18

SENIOR YEAR

First Semester	Credit
Elective-Hum or Soc Sci (upper level)[7]	3
El Eng-Cp Eng 391-Senior Project I	1
Cp Eng 210-Senior Seminar	0.5
Cp Eng-Core Elective[9,10]	4
Cmp Sc 285-Cmp Network Concepts & Tech[20]	3
Cp Eng Senior Elective A[16]	3
Cp Eng Senior Elective B[17]	3
	17.5

Second Semester	
Elective-Hum or Soc Sci (upper level)[7]	3
El Eng-Cp Eng 392-Senior Project II	3
Cp Eng-Senior Elective C[17]	3
Cp Eng-Senior Elective D[17]	3
Cp Eng-Senior Elective D[17]	3
	15

NOTES:

1. The minimum number of hours required for a degree in Computer Engineering is 134.5.
2. Prior to graduation all students must complete a U.S. History course (Hist 112,175,176 or Pol Sc 90) and an economic course (Econ 121 or 122). These courses can be taken during the freshman year.
3. Students that transfer to UMR after their freshman year are not required to enroll in Freshman Engineering Seminars.
4. A minimum grade of "C" must be attained in Math 8,21,22 and 204, Physics 23 and 24 (or their equivalents), El Eng 151, 153 and Cmp Sc 53 (or its equivalent).
5. Students may take Cmp Sc 74 and 78 (C++ for engineering majors) in place of Cmp Sc 53.
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. Six Humanities and Social Sciences courses are required for a total of eighteen credit hours, six hours of which are normally taken in the Freshman Engineering program. Students must complete an U.S. History course (Hist 112,175,176, or Pol Sc 90) and an economics course (Econ 121 or 122). The remaining four course must be selected from an approved list published by the School of Engineering. Two of these four courses must be upper division courses that have as a prerequisite one of the other courses taken in the group of six courses. At least one of these four courses must be

classified as a humanities course. The remaining three courses may be either Humanities or Social Sciences courses. 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. Cp Eng core elective 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.
10. 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.
11. 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.
12. The six hours of Science Electives to be selected from an approved list which include Bas Eng 140, Mc Eng 227, Mc Eng 219, Physics 107, Chem 221, Bio Sc 110,112,211,231,235,251.
13. English 60, Writing and Research may be taken in place of English 160, Technical Writing.
14. Stat 215, Engineering Statistics or Stat 343, Probability and Statistics, may be taken in place of Stat 217, Introduction to Probability and Statistics.
15. 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.
16. Senior Elective "A" to be selected from Cp Eng 3xx, El Eng 3xx, or Cmp Sc 3xx courses.
17. Senior Electives B, C, D, and E are to be selected from an approved list. This list contains most 200 and 300 level science, mathematics and engineering courses.
18. Cp Eng 111 and Cp Eng 213 can be used in place of Cmp Sc 234 as the requirement for Cmp Sc 284.
19. 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.
20. Students may take Cp Eng 319 or Cmp Sc 385 in place of Cmp Sc 285.

COMPUTER ENGINEERING COURSES

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 flip flops, 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 computer 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.

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 [Lab 1.0] 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, Econ 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. Prerequisites: Cp Eng 391, Cp Eng 210.

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], 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
Richard E. DuBroff[1], Ph.D., 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
Robert Nau[1] (Emeritus), M.S. Texas A & M
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] (Department Chair), (*Fred Finley Distinguished Professor*), Ph.D., Illinois Institute of Technology
Paul Stigall[1], 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 Drewniak, Ph.D.,
University of Illinois at Urbana-Champaign
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
Hardy J. Pottinger, Ph.D., UMR
Steve Watkins, Ph.D., University of Texas at Austin

Assistant Professors:
Daryl Beetner, D.Sc., Washington University
Steven D. Pekarek, Ph.D., Purdue University
Ronald Joe Stanley, Ph.D.,
University of Missouri-Columbia
William Weeks IV, Ph.D., University of Illinois at Urbana-Champaign

[1] Registered Professional Engineer

Bachelor of Science Electrical Engineering

FRESHMAN YEAR
(See Freshman Engineering Program)

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
Elective-Hum or Soc Sci (lower or upper level)[7]	3
	18

Second Semester	
Cp Eng 111-Intro 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 Diff Equations[3]	3
Bas En 140-Intro to Statics & Dynamics[9]	3
SP&M S 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[4,10]	1
El Eng 265-Linear Systems I[4,10]	3
El Eng 266-Linear Systems I Lab[4,10]	1
El Eng 271-Electromagnetics[4,8,10]	3
El Eng 272-Electromagnetics Lab[4,8,10]	1
Elective-Mathematics[11]	3
Elective-Hum or Soc Sci (lower or upper level)[7]	3
	18

Second Semester	
El Eng 267-Linear Systems II[4,10]	3
El Eng 268-Linear Systems II Lab[4,10]	1
El Eng Power Elective[4,10,12]	4
El Eng Power Elective Lab[4,10,12]	1
Stat 217-Prob & Stat for Eng & Scientists[13]	3
English 160-Technical Writing[14]	3
El Eng Science Elective[15]	3
	17

SENIOR YEAR

First Semester	Credit
El Eng Elective A[16]	3
El Eng Elective B[16]	3
El Eng Elective C[16]	3
El Eng 391-El Eng Senior Project I	1
El Eng 210-El Eng Senior Seminar[17]	0.5
Mc Eng 227-Thermal Analysis[18]	3
Elective-Hum Soc Sci (upper level)[7]	3
	16.5

Second Semester	
El Eng Elective D[19]	3
El Eng Elective E[20]	3
El Eng Elective F[21]	3
El Eng 392-El Eng Senior Project II	3
Elective-Hum or Soc Sci (upper level)[7]	3
	15

1. The minimum number of hours required for a degree in Electrical Engineering is 133.5.
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 8,21,22 and 204, Physics 23, and 24 (or their equivalents) and El Eng 151 and 153.
4. Students who drop a lecture course 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. Six Humanities and Social Sciences courses are required, for a total of eighteen credit hours, six hours of which are normally taken in the Freshman Engineering Program. Students must complete an U.S. History course (Hist 112,175,176, or Pol Sc 90) and an economics course (Econ 121 or 122). The remaining four courses must be selected from an approved list published by the School of Engineering. Two of these four courses must be upper division courses that have as a prerequisite one of the other courses taken in the group of six courses. At least one of these four courses must be classified as a humanities course. The remaining three courses may be either Humanities or Social Sciences courses. 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 Eng 150 or the pair Bas En 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. All El Eng students must complete at least one of the following courses: Math 203, 208, 302, 303, 305, 307, 309, 315, 322, 330, 351, 358, 371, 381, 383, Stat 344, or Cmp Sc 228.
12. The El Eng Power Elective may be satisfied with El Eng 205 and El Eng 208 or El Eng 207 and El Eng 209.
13. Stat 217 may be replaced by Stat 215 or Stat 343.
14. English 160 may be replaced by English 60.
15. The El Eng science elective may be satisfied by Physics 107, Chem 221 or Bio Sc 110.
16. El Eng electives A, B, and C must be chosen from El Eng 205 and 208, 207 and 209, El Eng 225, 231, 235, 243, 254, or Cp Eng 213.
17. All Electrical Engineering students must take the Fundamentals of Engineering (FE) Examination prior to graduation. Students must sign a release form giving the University access to their FE examination score. This requirement is part of the UMR assessment process as described in Assessment Requirements found elsewhere in this undergraduate catalog. A passing grade on Fundamentals of Engineering (FE) Examination is not required to earn a B.S. degree in Engineering, however, passing the exam is the first step toward becoming a registered professional engineer.
18. Mc Eng 227 may be replaced by Mc Eng 219.
19. El Eng elective "D" must be a 300 level El Eng or Cp Eng course with at least a three 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.
20. 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.
21. El Eng elective "F" must be a technical course selected from an approved list. This list contains most 200 and 300 level science, mathematics and engineering courses. Specifically excluded are El Eng 281,282, and 283.

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.

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 255-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

Circuits

Highly Recommended
El Eng 225-Electronic & Photonic Devices
El Eng 254-Electronics II
El Eng 255-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

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-Expert Systems with Applications to Engineering Problems
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 Theory & Techniques
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
El Eng 327-Intro to Fiber Optic Communications Systems
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

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 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 behavior, 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, flip flop 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, flip flop circuits and waveshaping. Prerequisites: El Eng 253 and El Eng 255. Coreq 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.

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 Physics 326)

327 Fiber Optic Communication Systems [Lect 3.0] Ideal and non-ideal optical fibers, transmission characteristics of optical fibers, optical sources, LED and laser sources, modulation formats, direct and external modulation, optical detectors, optical amplifiers, noncoherent and coherent optical receiver's, wavelength division multiplexing, system performance. Prerequisites: El Eng 265 and El Eng 253, preceded or accompanied by El Eng 243 and El Eng 225.

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, E Mech, Mc Eng 329 and Cv Eng 318)

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 261 or El Eng 231. (Co-listed with Ch Eng 367)

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.

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

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.

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 Circuit Design [Lect 3.0] Computer-aided design of microwave circuits such as couplers, isolators, circulators, mixers, filters, switches, quadrature hybrids, amplifiers, oscillators and microstrip antennas using industry-standard software packages. Microwave integrated circuits. Emphasis on industrial applications. Prerequisites: El Eng 253, 271.

379 Microwave Theory and Techniques [Lect 3.0] Microwave systems; coupled transmission lines, waveguides and resonators; klystron, magnetron and traveling wave tubes; microwave integrated circuits and semiconductor devices. Prerequisite: El Eng 271.

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 [Lab 1.0] 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, Econ 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. Prerequisites: El Eng 391, El Eng 210.

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, thirty one percent of Engineering Management alumni have risen to top 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 30 hours of course work.

Engineering Management Core

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

As a senior you will take a senior design course to integrate both technical and managerial skills that you have acquired. Students complete their Bachelor of Science degree requirements by taking the Fundamentals of Engineering Examination prior to graduation.

Emphasis Areas in Engineering Management

Manufacturing Engineering and **Packaging Engineering** focuses on the design and improvement of manufacturing and packaging systems.

Industrial Engineering and **Quality Engineering** focuses on the productivity analysis and optimization of systems and on the implementation and design of high performance quality management systems for manufacturing and service organizations.

Management of Technology focuses on administrative aspects and decision-making in an organization including human relations, management principles, accounting, finance and marketing in a technological enterprise.

Specialized Emphasis Areas allow students to customize their degree program and create a unique program, with the approval of their advisor, that focuses in 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:
John Amos (Emeritus), Ph.D., Ohio State
Daniel Babcock[1] (Emeritus), Ph.D., California-Los Angeles
William Brooks (Emeritus), Ph.D., Kansas
Cihan Dagli, Ph.D., University of Birmingham, England
Madison Daily (Emeritus), Ph.D., UM-Rolla
Donald Myers[1], J.D., Saint Louis University
Yildirim Omurtag[1] (Emeritus), Ph.D., Iowa State
Kenneth Ragsdell[1], Ph.D., Texas
Henry Sineath[1] (Emeritus), Ph.D., Georgia Institute of Technology
Henry Wiebe (Department Chair) Ph.D., Arkansas

Associate Professors:
Venkat Allada, Ph.D, Cincinnati
Melvin Garner (Emeritus), M.B.A., Washington University
Raymond Kluczny, Ph.D., Arizona State
Henry Metzner, Ph.D., Utah
Susan L. Murray, Ph.D., Texas A & M
Stephen Raper, Ph.D., University of Missouri-Rolla

Assistant Professors:
Tony Ammeter, Ph.D., University of Texas-Austin
David Enke, Ph.D., University of Missouri-Rolla
Scott E. Grasman, Ph.D., University of Michigan
Timothy S. Meinert, Ph.D., University of Arkansas-Fayetteville

Halvard E. Nystrom, Ph.D., Arizona State University
Can Saygin, Ph.D., The University of Toledo
Peter Schmidt, Ph.D., University of Missouri-Rolla
David Shaller (Emeritus), J.D., Cleveland State University
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

[1] Registered Professional Engineer

Bachelor of Science Engineering Management

FRESHMAN YEAR
(See Freshman Engineering Program)

SOPHOMORE YEAR

First Semester	Credit
Math 22-Calculus w/Analytic Geometry III[1]	4
Physics 24-Engineering Physics II[1]	4
Bas En 50 or Bas En 51-Eng of Mech-Statics[1]	3
Cmp Sc 74-Intro to Programming Methodology[1]	2
Cmp Sc 78-Programming Methodology Lab	1
Econ 121-Prin of Microecon or Econ 122-Prin of Macro Econ	3
	17

Second Semester	
Math 229-Diff Equa & Matrix Algebra[1]	3
Stat 211, 213 or 215[1]	3
Bas En 110-Mechanics of Materials	3
Bas En 120-Materials Testing	1
Eng Mg 211-Mgt Eng & Tech	3
Psych 50-General Psychology	3
	16

JUNIOR YEAR

First Semester	Credit
Eng Mg 230-Mgt Accounting Systems	3
Eng Mg 251-Marketing Management	3
Mt Eng 121-Mt for Eng or Mt Eng 377-Prin of Eng Mat	3
Bas En 150-Eng Mech-Dynamics	2
Mc Eng 227-Thermal Analysis	3
Hum/Soc Sc 2xx Elective	3
	17

Second Semester	
Eng Mg 252-Financial Mgt	3
Eng Mg 282-Operations & Production Mgt	3
El Eng 281-Electrical Circuits	3
English 160-Technical Writing	3
Hum/Soc Sc 2xx Elective	3
	15

SENIOR YEAR

First Semester	Credit
Emphasis Area Required & Elective Courses[2]	18

Second Semester	
Eng Mg 260-Gen Mgt-Design Integration	3
Emphasis Area Required & Elective Courses[2]	15
	18

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 specialized emphasis. Three examples of established emphasis areas are shown below. Packaging Engineering and Quality Engineering are also available as focused emphasis areas in the Department.

Industrial Engineering

(7) 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 375-Total Quality Mgt	3
Eng Mg 380-Work Design	3
Eng Mg 382-Methods of Ind Eng	3
Eng Mg 385-Stat Process Control	3
	21

(3) Elective Courses ..... 9 hours

(In consultation with your advisor, from approved elective clusters.)

Management of Technology

(7) Required Courses:

	Credit
Eng Mg 208-Eng Economy	3
Eng Mg 313-Managerial Decision Making	3
Eng Mg 320-Tech Entrepr	3
Eng Mg 327-Legal Environ	3
Eng Mg 333-Mgt Info Sys	3
Eng Mg 361-Project Mgt	3
Eng Mg 366-Bus Log Sys Anal	3
	21

(3) Elective Courses ..... 9 hours

(In consultation with your advisor, from approved elective clusters.)

Manufacturing Engineering

(7) Required Courses:

	Credit
Eng Mg 334-Cmp Integrated Mfg Sys	3
Eng Mg 344-Interdis Prob in Mfg Auto	3
Eng Mg 354-Integrated Product/Process Design	3
Eng Mg 364-Value Analysis	3
Eng Mg 372-Prod Plan & Schd	3
Eng Mg 379-Packaging Machinery	3
Eng Mg 383-Packaging Mgt	3
	21

(3) Elective courses..... 9 hours
(In consultation with your advisor, from approved elective clusters.)

Packaging Engineering

(7) Required Courses:

	Credit
Eng Mg 334-Cmp Int Mfg Sys	3
Eng Mg 354-Int Product/Process Design	3
Eng Mg 366-Bus Log Sys Analy	3
Eng Mg 379-Pkg Mach	3
Eng Mg 383-Pkg Mgt	3
Eng Mg 384-Pkg Mat I	3
Eng Mg 388-Pkg Sys Design	3
	21

(3) Elective courses..... 9 hours

(In consultation with your advisor, from approved elective clusters.)

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 134 hours. Students with Chem 5 in place of Chem 1,2, and 3 in the freshman year must take 3 hours of Basic Science from an approved list.

1. Must have a grade of "C" or better in these courses.
2. Students are required to select an emphasis area and maintain a minimum 2.0 GPA for these courses.
3. 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 carrer and the transition to engineering management.

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.

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.

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.

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. (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.

265 Management Practices [Lect 1.0] Presentation of distinguished lecturers from private and public enterprises on methods of operation of management functions, analysis of complex management problems.

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.

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.

317 Comparative and Multi-National Management [Lect 3.0] To provide management knowledge of multinational business and entrepreneur skills for technically oriented students to manage innovative technologies in a global setting. Prerequisite: Senior or graduate standing.

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.

322 Accounting for Engineering Management [Lect 3.0] Study of accounting principles, procedures, and the application of accounting principles to management planning, control and decision making. Includes financial statement analysis and cost and budgetary procedures.

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.

328 Government Regulations; Business & Industry [Lect 3.0] A course which presents the administrative process of government and its present day relationships to the business and industrial world through regulations. Prerequisite: Senior or graduate standing.

330 Industrial Ecology [Lect 3.0] Effective Managerial decision making in manufacturing or service sectors requires familiarity with industrial activities, their impacts on environmental processes and societal interactions. This course will describe interactions between environment and economy. Prerequisite: Stat 213 or 215.

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.

335 Labor Management Relations [Lect 3.0] Orientation on labor law. Emphasizes history and development of the federal labor statutes. Gives basic understanding of organizational and operational procedures of unions in conjunction with the legal techniques employed by labor and management. Prerequisite: Senior or graduate standing.

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 344)

345 Energy Management Engineering [Lect 2.0 and Lab 1.0] Appraisal of energy conservation management, economic efficiency of energy sources, and energy productivity analysis. Principles of energy efficiencies and energy balance analysis interfaced with engineering management theory. Prerequisite: Senior or graduate standing.

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. (Co-listed with Ae Eng 350 and Mc Eng 350)

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/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: Senior or graduate standing.

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.

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.

363 Environmental and Solid Waste Issues in Packaging [Lect 3.0] Packages which are currently very successful in meeting the environmental challenges shall be contrasted against those which are not as successful. The design criteria for the development of environmentally friendly packaging as well as current issues shall be examined. Prerequisites: Junior or senior standing.

364 Value Analysis [Lect 3.0] An organized effort directed at analyzing the hardware and processes used in manufacturing a product to achieve the required product function at the lowest overall cost. Covers the basic philosophy, methodology and procedures which draw together and utilize techniques from various fields. It is a logical method used in solving value problems. 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.

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 2.0 and Lab 1.0] 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 Expert Systems in Manufacturing & Engineering [Lect 3.0] Intelligent engineering system design using knowledge bases, knowledge based problem solving, symbolic models, knowledge representation, inferencing are the topics covered. Students develop these skills through semester projects based on a specific engineering application using an expert system shell of their choice. 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 2.0 and Lab 1.0] 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.

384 Packaging Materials I [Lect 3.0] The objective is to explore in depth the major packaging materials used by industry and to give the student an understanding of material characteristics, application, economics, design consideration and their relationship in the total productive system. Prerequisite: Eng Mg 383.

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.

388 Packaging System Design [Lect 3.0] A study of packaging design problems related to the packaging system through case studies. Emphasizes problem solving techniques using latest materials, technologies, marketing and distribution processes to develop and design a total packaging system. Prerequisite: Eng Mg 383.

389 Packaging Materials II [Lect 2.0 and Lab 1.0] This course is an extension of Eng Mg 384 (packaging materials). The objective is to provide in-depth treatment of material and systems not covered in 384. Prerequisite: Eng Mg 383.

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

UMR no longer offers a separate undergraduate degree in engineering mechanics. The 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 Theory of Stability I [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, Bas En 150 or E Mech 160, Math 204. (Co-listed with Mc Eng 334, 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 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 in-equalities. 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:

Jeffrey D. Cawlfield (Associate Director of Freshman Engineering Program), Ph.D., University of California-Berkeley

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 8 and 21
Freshman Chemistry Requirement[1]
English 20
Humanities/Social Sciences-2 courses[2]
Basic Engineering 10
Basic Engineering 20
Physics 23

1 Chemistry 1,2, and 3 or Chemistry 5, depending on placement; and Chemistry 4 or an equivalent training program approved by UMR.

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 nine 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
Clark Barker (Emeritus), Ph.D., Illinois
Ta-Shen Chen (Curators'), (Emeritus), Ph.D., Minnesota
Donald Cronin (Emeritus), Ph.D., California Institute of Technology
Alfred Crosbie (Curators'), Ph.D., Purdue
Walter Eversman[1] (Curators'), Ph.D., Stanford
Virgil Flanigan[1], Ph.D., UMR
Ronald Howell[1], (Emeritus), Ph.D., Illinois
Leslie Koval[1], (Emeritus), Ph.D., Cornell
K. Krishnamurthy, Ph.D., Washington State
Shen Ching Lee[1] (Emeritus), Ph.D., Washington
Terry Lehnhoff[1] (Emeritus), Ph.D., Illinois
Ming Leu, Ph.D., California-Berkeley
Fue-Wen Liou, Ph.D., Minnesota
Dwight Look (Emeritus), Ph.D., Oklahoma
Ashok Midha (Department Chair), Ph.D., Minnesota

Robert Oetting[1] (Emeritus), Ph.D., Maryland
Josef Podzimek (Emeritus), Ph.D., Charles University, Prague
Charles Remington[1] (Emeritus), M.S., UMR
Harry Sauer[1], Ph.D., Kansas State
Ralph Schowalter[1] (Emeritus), M.S., UMR
John Sheffield, Ph.D., North Carolina State
Hai-Lung Tsai, Ph.D., California-Berkeley

Associate Professors:
James Drallmeier, Ph.D., Illinois
Charles Edwards[1] (Emeritus), Ph.D., Arkansas
Umit Koylu, Ph.D., University of Michigan
Wen Lu, Ph.D., Minnesota
Robert Medrow (Emeritus), Ph.D., Illinois
J. Keith Nisbett (Associate Chair), Ph.D., Texas-Arlington
Anthony Okafor, Ph.D., Michigan Tech.
Daniel Stutts, Ph.D., Purdue

Assistant Professors:
Joohyun Choi, Ph.D., Illinois
Kelly Homan, Ph.D., University of Illinois at Urbana-Champaign
Robert Landers, Ph.D., University of Michigan
Nancy Ma, Ph.D., Illinois
Daniel McAdams, Ph.D., Texas
Brad Miller, Ph.D., Georgia Instititue of Technology

[1] Registered Professional Engineer

Bachelor of Science Mechanical Engineering

FRESHMAN YEAR
See Freshman Engineering Program

SOPHOMORE YEAR

First Semester	Credit
Cmp Sc 73-Basic Scientific Programming	2
Cmp Sc 77-Cmp Programming Lab	1
Bas En 50 or Bas En 51-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	2
Mc Eng 219-Thermodynamics[a,b]	3
EMech 160-Eng Mech-Dynamics[b]	3
Math 204-Elementary Differential Equations	3
Mt Eng 121-Metallurgy for Engineers	3
Elective-Communications[d]	3
	17

JUNIOR YEAR

First Semester	Credit
Mc Eng 213-Machine Dynamics[a]	3
Mc Eng 221-Applied Thermodynamics	3
Mc Eng 231-Thermofluid Mechanics I	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 240-Mechanical Instrumentation	2
El Eng 281-Electrical Circuits	3
Elective-Hum or Soc Sci[f]	3
	17

SENIOR YEAR

First Semester	Credit
Mc Eng 242-Mech Engineering Systems	2
Mc Eng 279-Automatic Control of Mech Systems	3
El Eng 283-Electronics for Instrumentation	3
Elective-Technical[g]	6
Elective-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
Electives-Technical[g]	3
Electives-Hum or Soc Sci[f]	6
	16

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 132 hours.

(a) A grade of "C" or better in Math 8,21,22 and Physics 23 is required both for enrollment in Mc Eng 211, Mc Eng 213 and Mc Eng 219 and for graduation.
(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) 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 social science and humanities

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. The remaining three hours may consist of: Ae Eng/EMech/Mc Eng 202, 300, or 390; or some other departmental course; or a suitable out-of-department technical elective. 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.

Manufacturing Processes Emphasis Area for Mechanical Engineering

Students desiring to complete degree requirements for a Bachelor of Science in Mechanical Engineering with an emphasis area in Manufacturing Processes must satisfy the junior and senior year requirements listed below with a minimum of 132 hours. Except as modified below, all other requirements of the Bachelor of Science in Mechanical Engineering program still apply.

JUNIOR YEAR

First Semester	Credit
Mc Eng 213-Machine Dynamics[a]	3
El Eng 281-Electrical Circuits	3
Mc Eng 231-Thermofluid Mechanics I	3
Bas En 110-Mechanics of Materials[c]	3
Bas En 120-Materials Testing 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 208-Machine Design I[c]	3
Mc Eng 225-Heat Transfer	3
Mc Eng 240-Mechanical Instrumentation	2
Mc Eng 253-Manufacturing[c]	3
Elective-Hum or Soc Sci[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 221-Applied Thermodynamics	3
Elective Technical[e]	6
Elective-Hum or Soc Sci[d]	3
	17

Second Semester	
Eng Mg 209-Eng Economy & Mgt	3
Mc Eng 261-Analysis & Synthesis in Eng Design[f]	3
Mc Eng 280-Control System Lab	1
Electives-Technical[e]	3
Electives-Hum or Soc Sci[d]	6
	16

NOTES:

(a) A grade of "C" or better in Math 8,21,22, and Physics 23 is required both for enrollment in Mc Eng 211, Mc Eng 213 and Mc Eng 219 and for graduation.

(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) 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 social science and humanities requirements with respect to selection and depth of study. These requirements are specified in the current catalog.

(e) Electives must be approved by the student's advisor. All nine hours must be selected from among the courses listed in the following seven sub areas:
   1. Manufacturing/Automation (Mc Eng 353, Mc Eng 355, Mc Eng 349, Mc Eng 306)
   2. Design (Mc Eng 363, Mc Eng 308, Mc Eng 356, Mc Eng 302)
   3. Dynamic Systems (Mc Eng 307, Mc Eng 381)
   4. Energy Systems (Mc Eng 325, Mc Eng 331)
   5. Materials (EMech 381, EMech 303, EMech 307, EMech 341, Mt Eng 305, Mt Eng 307, Mt Eng 311)
   6. Quality Control (Eng Mg 375, Eng Mg 385, Eng Mg 372)
   7. Electronics (El Eng 283, El Eng 205 and 208

(f) The design project in Mc Eng 261 must be in the manufacturing area.
At least one of the courses must be from sub area I. At least one of the courses must be from sub area II. Honors students have special requirements for technical electives.

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 1.0 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 8, Physics 23, Mc Eng 153.

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 8, 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 8, 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 73, and a grade of "C" or better in Math 8, 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 73.

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 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 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: 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.

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 Theory of Combustion [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 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 Theory of Stability I [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 E Mech 334, 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 344, 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. Manipulator kinematics; hand location, velocity and acceleration. Basic formulation of manipulator dynamics and control. Introduction to machine vision. Projects include robot programming, vision-aided inspection and guidance, and system integration. Prerequisites: Cmp Sc 73, Mc Eng 213. (Co-listed with Ae Eng 349)

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. (Co-listed with Ae Eng 350 and Eng Mg 350)

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] Current topics in manufacturing automation. Areas covered include: fixed automation, flexible automation, CNC devices, process planning and part programming, group technology, factory networks, and computer integrated manufacturing. Prerequisite: Mc Eng 253.

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.

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 Computer Applications in Mechanical Engineering Design [Lect 2.0 and Lab 1.0] Introduction to computer aided design, personal computer graphics to introduce main frame graphics and analysis programs. Fundamentals of finite element analysis are discussed. Projects include basic graphics, drafting, area, mass and inertia properties analysis, matrix algebra and finite element analysis of solid mechanics problems using educational and commercial software.

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