

Mechanical and Industrial Engineering

The Department

The Department of Mechanical and Industrial Engineering offers Bachelor of Science degrees in Mechanical Engineering and Industrial Engineering. Both programs are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology. The department also offers a Master of Science in Engineering with an option in Mechanical Engineering. For more information see Master of Science in of Engineering program.

Mission

Our mission is to provide an educational program that will allow our students to meet or exceed the necessary level of academic preparedness for successful professional employment and for graduate study through continuous improvement in curricula and instruction.

Educational Objectives

1. Provide broad-based curriculum in mechanical and industrial engineering fundamentals.
2. Provide a basis for successful professional careers in fields associated with mechanical and industrial engineering.
3. Provide students with a strong foundation for graduate studies in mechanical and industrial engineering and related fields.
4. Provide students with hands-on experience through projects and laboratory courses.
5. Develop students' understanding of global issues.

6. Promote understanding of ethical and professional responsibilities.
7. Develop students' abilities to communicate effectively both orally and in written form.
8. Promote ability to work effectively in teams.

Faculty and Facilities

The department's faculty members have outstanding academic credentials which cover most major areas in mechanical and industrial engineering. In addition, most of the faculty have had distinguished careers in industry and are able, through their experiences, to help students develop the professional skills needed to solve engineering problems.

Excellent laboratory facilities emphasize computer interaction, the operation and use of instruments, and the experimental approach. The mechanical engineering laboratories are equipped with laser measurement systems, digital data acquisition systems and test apparatus which enable engineering students to study the effects of different parameters on the operation and performance of energy, fluid, aerospace, and other mechanical systems. The laboratory program also includes strong emphasis on computer-aided design.

Industrial engineering students gain valuable practical experience through state-of-the-art computer systems in conjunction with advanced robotics equipment used in the human factors, robotics, and manufacturing laboratories. Laboratory courses focus on computer-aided design, computer-

College of Engineering
and Computer Science

Department of Mechanical and Industrial Engineering

Satya D. Mahanty, *Chair*

Engineering East Building, Room 154
(559) 278-2368

B.S. in Mechanical Engineering

B.S. in Industrial Engineering

M.S. in Engineering,

Mechanical Engineering Option

aided manufacturing, computer-integrated manufacturing, materials handling, plant layout, and human factors engineering.

Co-op Program

The department participates in the Cooperative Education Program which allows the student to gain industrial experience — and recognize financial benefits — through projects with local companies.

Mandatory Advising

It is the policy of the department that every student see his/her assigned adviser at least once during the academic year.

Administrative Academic Probation

A minimum GPA of 2.0 must be maintained in all courses taken in the College of Engineering and Computer Science. Students who fail to maintain a 2.0 GPA in courses within their major may be placed on administrative academic probation. Failure to eliminate the grade point deficiency could result in disqualification from the College of Engineering and Computer Science.

Career Opportunities

Rapid technological advances in computers, robotics, and automation, combined with declining enrollments in engineering, have created a substantial demand for mechanical and industrial engineers. High-technology industries want mechanical and industrial engineers because of their technical versatility and adaptability to a broad range of engineering activities. Excellent



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opportunities exist in aerospace, computers, energy, manufacturing and fabrication, machine and tool design, public transportation, electronics, and a host of other industries.

Faculty

Satya D. Mahanty, *Chair*
Hamo Lalehzarian
Walter Losutoff
Prakash T. Mahajan
Masud Mansuri
William W. Peng

Mechanical Engineering Program

Mechanical engineering is the use of basic science in the design and manufacture of components and systems. This requires the application of physical and mechanical principles in the development of machines, energy conversion systems, materials, and equipment for measurement and control. Knowledge of mathematics, physics, and chemistry lies at the core of this field. Application of this knowledge uses engineering technology — a disciplined way of thinking, modeling, and testing that enables development of new systems despite incomplete information and uncertainty.

The program in mechanical engineering provides basics in design and in thermal and fluid mechanics. All areas include statics, dynamics, materials, fluid mechanics, thermodynamics, and experimental methods. Application areas in design include mechanics of materials, applied mechanics, structural and manufacturing aspects of producing equipment, and vibrations. Application areas in thermal and fluid mechanics focus on energy conversion and include combustion, heat engines, refrigeration, and fluid flow.

Students should consult with their advisers to select the proper courses that emphasize their areas of interest.

Engineer-in-Training and Professional Engineering registration is strongly recommended as a first step in professional life-long learning.

Bachelor of Science Degree Requirements

Mechanical Engineering Major Units

Major requirements..... 71

ME 1, 26, 31, 32, 116, 118,
134, 136, 140, 144, 145, 154,
155, 156 (36)

CE 20, 121 (6)
ECE 70, 90L, 91 (7)
IE 90, 110, 160, 182W (11)
Design Applications (5)

Design Application Lab:

ME 143 (Mech Design Area)
or ME 158
(Energy Area) (2)

Design Application Area:

ME 164 (Machine Design)
or ME 166 (Energy Systems
Design) (3)

Technical Area Courses (6)

Take a minimum of six units from a combination of courses in *Group A* (Energy) and *Group B* (Machine Design).

Group A (Energy): ME 137,
146

Group B (Machine Design):
ME 142, 162

A maximum of three units from *Group C* may be substituted for a course in either *Group A* or *Group B* with faculty adviser's approval.

Group C (General): ME 180,
190, 191T; IE 145, 155;
ECE 121, 121L, 155

Other requirements 64

General Education

Select one course from each of the G.E. areas: Area A1, A2, B2, C1, D1, D2, D3. (See pages 93-96 for G.E. listings.)

The following courses are required to satisfy both G.E. and major requirements:

MATH 75 [B4], CHEM 1A [B1], PHIL 20 [C2], ME 112 [IB], PHIL 120 [IC], PLSI 120 [M/I]

Additional requirements

MATH 76, 77, 81; PHYS
4A, 4AL, 4B, 4C

Total 135

Note: Engineering majors are exempt from G.E. Area A3, third course Area C, Area E, and Area ID.

See the catalog Web Site for recommended program at <http://www.csufresno.edu/catoffice/current/engmechrec.html>.

Advising Notes

1. Courses in mathematics, the physical sciences, or engineering taken *CR/NC* are not counted toward fulfillment of degree requirements in mechanical engineering.
2. Mechanical engineering majors might consider a math, physics, or business minor.
3. Since the mechanical engineering major curriculum is very demanding, many students, especially those not fully prepared in mathematics, chemistry, and/or physics, take 4½ or more years to graduate rather than the traditional 4 years. Students not fully prepared in chemistry should consider taking CHEM 3A and 1A (lecture only) in lieu of CHEM 1A. If needed, students also may go to the Learning Resource Center in Lab School, Room 137 and request tutorial assistance.

COURSES

Mechanical Engineering (ME)

1. Introduction to Mechanical Engineering (1)

Introduction to engineering design; case studies in mechanical engineering; problem-solving using the engineering approach; introduction to engineering code of ethics, mechanical engineering profession, and career opportunities.

26. Engineering Graphics (3)

Basic computer literacy required. Principles of orthographic projection, dimensioning, and descriptive geometry. Applications to the solution of engineering problems including the use of interactive computer graphics. (Two 3-hour lecture labs) (CAN ENGR 2)

29. Engineering Mechanics (3)

(Same as CE 29.) Prerequisites: MATH 77 (or concurrently); PHYS 4A. Not open to mechanical or civil engineering majors. Study of fundamental principles of statics and dynamics by scalar and vector methods.

31. Engineering Materials (3)

Prerequisites: CHEM 1A, PHYS 4A. Fundamental nature and properties of engineering materials; structure of matter and its effect on mechanical, electrical, magnetic, and thermal properties. (CAN ENGR 4)

32. Engineering Materials Laboratory (1)
Prerequisite: ME 31. Application of experimental methods to engineering materials. Study of stress and strain in metals; fatigue; hardness; toughness. (3 lab hours)

112. Engineering Mechanics: Dynamics (3)

Prerequisite: CE 20. Development of principles of kinematics and kinetics in engineering.

116. Fluid Mechanics (3)

Prerequisites: CHEM 1A; ME 29 or CE 29 or ME 112 (or concurrently). Fundamentals of fluid mechanics as applied to engineering problems.

118. Fluid Mechanics Laboratory (1)

Prerequisites: IE 182W, ME 116 (or concurrently). Applications of experimental methods used in engineering practice to fluid systems. (One 3-hour lab)

134. Dynamics in Machine Design (3)

Prerequisites: ME 26, 112, CE 121 (or concurrently); MATH 81. Analytical, graphical, and computer solutions applied to design problems of machinery, mechanisms, and gears. Both closed- and open-ended homework problems plus a design project and report are required. (2 lecture, 3 lab hours)

136. Thermodynamics (3)

Prerequisites: CHEM 1A; ME 29 or CE 29 or ME 112 (or concurrently). Fundamentals of thermodynamics and heat transfer as applied to engineering problems.

137. Turbomachinery (3)

Prerequisites: ME 118 and 136. Applications of fluid mechanics and thermodynamics and rotor-fluid energy interchange. Steady flow problems of pumps, compressors, and turbines with incompressible and compressible fluids. Both closed- and open-ended homework problems.

140. Advanced Engineering Analysis (3)

Prerequisites: MATH 81, ECE 70, ME 112 (or concurrently), ME 116 (or concurrently), ME 136 (or concurrently). Development of the finite element method of engineering analysis; specific applications to heat flow, fluid flow, vibrations in mechanical systems, and stresses in mechanical component design using appropriate numerical techniques, closed-form solutions of partial differential equations and the digital computer.

142. Mechanical Vibration (3)

Prerequisites: ME 112, CE 121. Mathematical and physical basis of vibration theory with applications to engineering analysis and design. Includes transient and steady state phenomena, distributed and lumped parameter systems, coupled systems, and computer solutions.

143. Mechanical Design Laboratory (2)

Prerequisites: CE 121, IE 182W, ME 134. Application of theory and techniques of experimental stress analysis to the design of machine components, mechanical structures, and dynamic transducers. Group-design teams design and test a mechanical device or structure to simulate real-life client-engineer relationships. A final project report and an oral presentation are required. (1 lecture, 3 lab hours)

144. Advanced Mechanics of Materials (3)

Prerequisites: CE 121, ECE 70, MATH 81. Advanced topics in mechanics of materials.

145. Heat and Mass Transfer (3)

Prerequisites: ECE 70, MATH 81, ME 116, 136, 140. Analytical, numerical, and electrical analogy methods are used to solve a variety of heat transfer and mass transfer problems. Advanced topics in radiation, boundary layer flow, and heat exchanger design.

146. Air Conditioning (3)

Prerequisites: ME 116, 136. Theory and practice in air conditioning including psychrometrics, load estimating, heating and cooling systems, fluid design and controls.

154. Design of Machine Elements (3)

Prerequisites: IE 90; ME 134, 144. Design of machine elements and components using theory learned in prerequisite courses. Both individual and team-type open-ended design projects are required. Use of computers for design is required. (2 lecture, 3 lab hours)

155. Elements of Systems Design (3)

Prerequisites: ME 154 (or concurrently), senior standing. Introduction to the concepts and practice of the design of engineering systems. Students are required to complete preliminary designs of specified engineering systems. Experience in design is gained through setting specifications, innovation, design optimization, and social and economic aspects.

156. Advanced Thermodynamics — Fluid Mechanics (3)

Prerequisites: ME 116, 136. Advanced topics in thermodynamics and fluid mechanics including analysis of solar and nuclear systems as applied to engineering problems.

158. Energy Systems Laboratory (2)

Prerequisites: ME 118, 145, 156; IE 182W. Design of experiments to evaluate and/or simulate energy systems. Selection and calibration of instruments. Computer-aided data acquisition and data processing. Group projects and technical reports. (1 lecture, 3 lab hours)

162. Computer-Aided Design (3)

Prerequisites: ME 26, 140. Survey of computer applications for design, analysis of mechanical systems, and manufacturing of mechanical components. Typical programming language software packages used in industry (CAD/CAM and FEA) will be introduced.

164. Machine Design (3)

Prerequisites: ME 116, 136, 154, 155; IE 182W, 160 (or concurrently). Open-ended design problems of complete machine systems. Integration of prerequisite course material into final design project. Satisfies the senior major requirement for the B.S. in Mechanical Engineering. (Two 3-hour lecture-labs)

166. Energy Systems Design (3)

Prerequisites: ME 145, 156; IE 160, 182W. Design of conventional and alternative energy conversion systems; selection and integration of components of the system; use of codes and standards. Group project report required. Satisfies the senior major requirement for the B.S. in Mechanical Engineering.

180. Special Projects (1-3; max total 3)

Prerequisites: senior standing in mechanical engineering, approved subject, IE 182W. Study of a problem under supervision of a faculty member; final typewritten report required. Individual project except by special permission.

190. Independent Study (1-3; max total 6)

See *Academic Placement — Independent Study*. Approved for *SP* grading.

191T. Topics in Mechanical Engineering (1-3; max total 6)

Prerequisite: permission of instructor. Investigation of selected mechanical engineering subjects not in current courses.

Mechanical and Industrial Engineering

193. Mechanical Engineering Cooperative Internship (1-6; max total 12)

Prerequisite: permission of adviser. Engineering practice in an industrial or government installation. Each cooperative internship period usually spans a summer-fall or spring-summer interval. This course cannot be used to meet graduation requirements. *CR/NC* grading only.

GRADUATE COURSES

(See *Course Numbering System*.)

Mechanical Engineering (ME)

211. Advanced Dynamics (3)

Prerequisite: ME 134 or permission of coordinator. Dynamics of mechanical systems with emphasis on equations of motion. Kinematics of particles, energy and momentum methods, variational methods, LaGrange's method, kinematics and plane motion of rigid bodies, kinetics of rigid bodies in three dimensions, mechanical vibrations.

220. Compressible Fluids (3)

Prerequisite: ME 156 or permission of coordinator. Review of the foundations of fluid mechanics and thermodynamics. The velocity of sound, mach number and angle, differences between incompressible, subsonic, and supersonic flow. Isentropic flow, working charts and tables, choking, operation of nozzles. Normal shock waves, ducts, shock tube analysis. Fanno and Rayleigh analysis, oblique shock waves, the Prandtl-Meyer equation. Lift and drag on bodies in supersonic flow. Method of characteristics.

221. Incompressible Fluids (3)

Prerequisite: ME 156 or permission of coordinator. The kinematics of liquids and gases, the LaGrangian and Eulerian methods, streak lines, stream tubes. Geometry of the vector field, Stokes, and Gauss's theorems, acceleration of a fluid particle, homogeneous fluids and the equation of continuity. Integration of Euler's equation, Bernoulli's equation. Potential motion and potential functions, source and sink potentials, the stream function. Vortex theory, surfaces of discontinuity.

223. Jet Engine Propulsion (3)

First-year graduate course in mechanics and thermodynamics of jet engine propulsion. Thermodynamics of fluid flow and engines, boundary layer theory, subsonic and supersonic inlets, combustors, fans,

compressors, turbines, nozzles, inlet distortion, fuel controls, noise reduction, ramjets and scramjets.

224. Rocket Propulsion (3)

First-year graduate course in mechanics and thermodynamics of rocket engine propulsion. Nozzle theory and thermodynamics, heat transfer, flight performance, chemical rocket propellant performance, liquid propellants, solid propellants, rocket testing, advanced propulsion concepts.

225. Heat Transfer (3)

Conduction, convection, and radiation. One and two dimensional steady-state conduction, LaPlace's equation, numerical techniques. Transient heat transfer. Heisler charts, multiple-dimensional systems, boundary layers, Reynold's analogy. Forced and natural convection radiation heat transfer, Kirchoff's and Wien's laws, radiation shields.

227. Advanced Thermodynamics (3)

Prerequisite: ME 156 or permission of coordinator. Review of classical thermodynamics, Maxwell relations, equations of state, nonideal gases, experimental methods. The molecular theory of gases, Clausius and Van der Waals equations of state, velocity distribution. LaGrange's method, the principle of equipartition. Maxwell-Boltzmann statistics, micro- and macrostates. Quantum statistics based on the Bose-Einstein, Maxwell-Boltzmann, and Fermi-Dirac statistics.

229. Advanced Gas Dynamics (3)

Review of supersonic flow. Vibrational and chemical rate processes, nonequilibrium chemical rate equations, rate equations for dissociation and recombination. Flow with vibrational or chemical nonequilibrium. Nonequilibrium kinetic theory; evaluation of collision cross sections. Flow with translational nonequilibrium. Radiative transfer in gases, and approximate solutions of the equation of radiative transfer.

230. Aircraft Stability and Control (3)

First-year graduate course covering analytical tools, system theory, reference frames, and transformations, equations of unsteady motion, longitudinal aerodynamics, lateral aerodynamics, stability of steady flight, and response to control actuation. All stability derivatives will be discussed in detail, and examples and problems based on actual airplanes will be used.

232. Advanced Aircraft Stability and Control (3)

Prerequisite: ME 230. Continuation of ME 230. Validity of small disturbance theory, nonlinear equations of motion, steady state and dynamic stability and control of elastic airplanes. Frequency response methods, response to turbulence. Automatic flight control analysis and design, the human pilot in the control loop, stability augmentation, digital flight control systems, state vector methods.

241. Structural Analysis (3)

Prerequisite: ME 134 or permission of coordinator. Graduate-level course in the principles of structural mechanics. Stress, strain and displacements, static and dynamic loads, energy methods, virtual work, discrete and continuous system analysis, finite element analysis, elastic beams, plates, and frames; single and multi degree-of-freedom modal analysis.

243. Structural Dynamics (3)

Prerequisite: ME 241 or permission of instructor. Continuation of ME 241. Von Karman theory, shear deformation, geometry and equilibrium of shells, theory of vibrations, vibrations of aircraft structures, coupling with the aerodynamic equations, flutter, ground and flight structural test techniques.

250. Astrodynamics (3)

Introductory course in astrodynamics. Two-body orbital mechanics, orbit determination, basic orbital maneuvers, rendezvous, ballistic missile trajectories, lunar and interplanetary trajectories, orbital perturbations, launch trajectories, reentry, spacecraft dynamics and attitude control.

290. Independent Study (1-3; max total 6)

Prerequisite: graduate status in engineering. See *Academic Placement — Independent Study*. Approved for *SP* grading.

291T. Topics in Mechanical Engineering (1-3; max total 6)

Prerequisite: graduate status in engineering or permission of instructor. Selected mechanical engineering subjects not in current courses.

298. Project (3; max total 3)

Prerequisite: graduate status in engineering. See *Criteria for Thesis and Project*. Independent investigation of advanced character such as analysis and/or design of

special engineering systems or projects; critical review of state-of-the-art special topics, as the culminating requirement for the master's degree. Abstract required. Approved for *SP* grading.

299. Thesis (3; max total 6)

Prerequisite: see *Criteria for Thesis and Project*. Preparation, completion, and submission of an acceptable thesis for master's degree. Approved for *SP* grading.

Industrial Engineering Program

Industrial engineering deals with the design, improvement, and installation of integrated systems of people, materials, equipment, and energy. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems.

The industrial engineering faculty are committed to providing all students the advanced technology background necessary for success and growth in their selected professions. A program of study is offered to all students through a carefully designed curriculum which includes engineering analyses for the design of man-machine systems, optimization of industrial systems, and the scientific management of engineering activities. Specialized training is available in the use of modern engineering tools and techniques such as computer assisted design (CAD), robotics, computer integrated manufacturing (CIM), quality engineering, and ergonomic (human factors) engineering.

Bachelor of Science Degree Requirements

Industrial Engineering Major *Units*

Major requirements..... 63

IE 75, 85, 90, 95, 110, 111,
113, 115, 127, 130, 160, 165,
180, 182W (35)
CE 29 or ME 29 (3)
ECE 70, 90L, 91 (7)
ME 26, 31, 136 (9)

Select at least one course from each of the following groups (9)

Group A (Quality Engineering Science): IE 112, 120, 170

Group B (Design): IE 145, 148, 155

Group C (Engineering Science): CE 142; ECE 121; ME 116; IE 190, 191T

Other requirements..... 57

General Education

Select one course from each of the G.E. areas: Area A1, A2, B2, C1, D1, D2, D3. (See pages 93-96 for G.E. listings.)

The following courses are required to satisfy both G.E. and major requirements: MATH 75 [B4], CHEM 1A [B1], PHIL 20 [C2], IE 114 [IB], PHIL 120 [IC], PLSI 120 [M/I]

Additional requirements

MATH 76, 77; PHYS 4A, 4AL, 4B

Total..... 120

Note: Engineering majors are exempt from G.E. Area A3, third course Area C, Area E, and Area ID.

See the catalog Web Site for recommended program at <http://www.csufresno.edu/catoffice/current/engindrec.html>.

Advising Notes

1. Courses in mathematics, the physical sciences, or engineering taken *CR/NC* are not counted toward fulfillment of degree requirements in industrial engineering.
2. Industrial engineering majors might consider a math or business minor.
3. Since the industrial engineering major curriculum is very demanding, many students, especially those not fully prepared in mathematics, chemistry, and/or physics, take 4½ or more years to graduate rather than the traditional four years. Students not fully prepared in chemistry should consider taking CHEM 3A and 1A (lecture only) in lieu of CHEM 1A. If needed, students also may go to the Learning Resource Center in Lab School, Room 137 and request tutorial assistance.

COURSES

Industrial Engineering (IE)

10. Engineering Skills (2)

Provides engineering students with experience in solving problems and presenting solutions in a logical manner, introduces students to subject areas common to most engineering disciplines and develops basic skills for solving problems through an en-

gineering approach. *CR/NC* grading only; not applicable toward baccalaureate degree requirements.

75. Introduction to Industrial Engineering (1)

An overview of the field of industrial engineering. Brief discussion of plant layout, work measurement, engineering economy, quality control, production control, human factors, and operations research. A brief survey of the current status of industrial engineering. (Field trips required)

85. Computer Methods Laboratory (1)

Prerequisite: MATH 76 (or concurrently). Application of existing microcomputer software and the development of new programs to solve frequently encountered problems in engineering practice. Includes Excel and Access. (3 lab hours)

90. Manufacturing Processes (3)

Prerequisites: ME 26, 31. Processing techniques, including casting, welding, forming, and machining; capabilities and limitations of these techniques. (2 lecture, 3 lab hours; field trips required)

95. Human Factors in Ergonomics (3)

Introduction to principles of human factors in ergonomics, analysis of information processing, controls and displays, hand tools, physical work, anthropometry, workspace design, and environmental factors to improve quality of life and foster life-long learning. G.E. Breadth E1. (Formerly IE 125)

110. Statistical Analysis in Engineering (3)

Prerequisite: MATH 76. Fundamentals of probability and statistics. Applications of statistical methods to engineering problems.

111. Work Measurement (3)

Prerequisite: IE 110 (or concurrently). General approach to the design process; application of design process to problem solving. Methods evaluation techniques; motion and time study, work sampling, and simulation. (2 lecture, 3 lab hours; field trips required)

112. Statistical Design of Experiments (3)

Prerequisites: IE 85, 110. Analysis of variance; regression and correlation; analysis of covariance; randomized blocks and Latin

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squares; design of experiments; response surface analysis and determination of optimum conditions.

113. Operations Analysis (3)

Prerequisites: IE 85, 110, MATH 81. Application of quantitative and numerical techniques for analysis of complex operational problems.

114. Facilities Engineering (3)

Prerequisite: IE 90, 111 or permission of instructor. Feasibility study, process planning, material flow system design, materials handling system planning, facilities layout, location of facilities, economic analysis, implementation planning. (2 lecture, 3 lab hours)

115. Quality Control and Reliability Engineering (3)

Prerequisite: IE 110. Fundamentals of statistical quality control and reliability engineering. Sampling plans. Control charts. Reliability techniques.

120. Systems Safety Engineering (3)

Prerequisite: IE 110. Principles of system safety engineering. Selected topics include: human factors engineering, key system interfaces, logic trees, fault and risk tree analyses, hazard identification and analysis, safety review system trees, statistical analysis, product safety.

127. Human Factors Engineering Design Laboratory (1)

Prerequisites: IE 95, 182W (or concurrently). Expands principles developed in the introductory human factors course for use in engineering design. (3 lab hours)

130. Production and Inventory Control (3)

Prerequisite: IE 113 or permission of instructor. Fundamental concepts of production and inventory planning, analysis and control; inventory and production costs; analysis of variations in demands, availability of supplies and optimum production schedules; use of computer simulation techniques; case studies.

145. Design of Automated Systems (3)

Prerequisite: IE 85 or permission of instructor. Study of fundamentals of manufacturing automated systems. Techniques and applications of computer to monitor and control industrial processes. Included topics are characteristics and applications

of sensors and actuators, programming considerations, integration of CNC, CAD, CAM, etc. (2 lecture, 3 lab hours; field trips required)

148. Simulation of Industrial Systems (3)

Prerequisite: IE 110. Application of discrete-event simulation techniques for the solution of complex industrial problems; use of various computer simulation languages; review of Monte Carlo processes and digital simulation of continuous processes.

155. Design and Applications of Robotic Systems (3)

Prerequisites: IE 85, 90, senior standing. Introduction to the use of robotics for industrial automation. Components and operation of robot systems; programming of robots; robot implementation and industrial applications of robots. (2 lecture, 3 lab hours)

160. Engineering Economy (2)

Prerequisite: upper-division standing in engineering. Importance of economic analyses of problems in engineering and in management decision making; interest, depreciation, income tax, classification of costs, break-even and minimum cost points, economic comparisons of alternatives, economy of replacement.

165. Computer-Integrated Manufacturing (3)

Prerequisite: IE 145 or permission of instructor. Review the role of computers in manufacturing automation. Evolution and implementation techniques. CIM perspective and integrating technology. Includes CAD/CAM, FMS, robotics, MRPII, MIS, etc. Economic and social impact of CIM. (2 lecture, 3 lab hours)

170. Engineering Management (3)

Prerequisite: junior standing. Study of modern management techniques in engineering. A systems approach to planning and controlling of product/production costing. The computational techniques and the behavioral aspects of management/engineering decision-making are considered.

180. Senior Design Project and Seminar (3)

Prerequisites: senior standing in industrial engineering or permission of instructor; approved subject; IE 182W (or concurrently). A meaningful major design project which focuses on engineering practice and draws on past coursework, under the supervision of a faculty member. Final report and presentation is required, including evaluation of the design requirements, economic, and social considerations. Satisfies the senior major requirement for the B.S. in Industrial Engineering.

182W. Engineering Writing (3)

Prerequisites: satisfactory completion (C or better) of the ENGL 1 graduation requirement; junior standing. The use of critical thinking in the engineering problem-solving process and documentation of the process through letters, reports, and engineering specifications. The use of oral technical presentation techniques typical of the engineering practice. Meets the upper-division writing skills requirement for graduation.

190. Independent Study (1-3; max total 6)

See *Academic Placement — Independent Study*. Approved for *SP* grading.

191T. Topics in Industrial Engineering (1-3; max total 6)

Prerequisite: permission of instructor. Investigation of selected industrial engineering subjects not in current courses.

193. Industrial Engineering Cooperative Internship (1-6; max total 12)

Prerequisite: permission of adviser. Engineering practice in an industrial or government installation. Each cooperative internship period usually spans a summer-fall or spring-summer interval. This course cannot be used to meet graduation requirements. *CR/NC* grading only.