INDUSTRIAL AND MANUFACTURING ENGINEERING

Abdul B. Sadat, Chair

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The department offers two ABET accredited degree programs, one in Industrial Engineering and one in Manufacturing Engineering. Each program prepares the students for both engineering practice and for graduate study. The Industrial Engineering major is concerned with the most effective methods of utilizing and integrating people, materials, and equipment in both production and service organizations. The Manufacturing Engineering major is concerned with the most effective ways of designing and developing manufacturing systems. It is possible to major in both Industrial Engineering and Manufacturing Engineering. Interested students should contact their academic advisors or the department office.

Students desiring to major in either Industrial or Manufacturing Engineering should have a particularly high aptitude for science and mathematics, and incoming freshmen should have taken substantial college preparatory courses in these disciplines in high school. Incoming transfer students should have completed at least one year of college calculus and one year of college physics (with laboratory) prior to beginning the program at Cal Poly Pomona. The community college student planning to transfer into this department should consult a school counselor or this department to determine which courses meet the program requirements.

Graduates of the program are prepared to do productive work in their first jobs as well as to grow with their profession throughout their engineering career. The curriculum is designed to prepare students for direct entry into the engineering profession as well as graduate school.

The department of Industrial and Manufacturing Engineering is concerned about the success of its graduates as they matriculate into the industrial world and during their careers as engineers. The department is also concerned about its curricula: Does it meet the demands of industry and the profession? For these reasons the department conducts both formal and informal outcome assessments of the progress of its graduates and the value of its curricula. Assessment is conducted by quarterly interaction with its Industry Advisory Council, by surveys of its graduates, and by surveys of the employers of its graduates. As areas needing change are identified, they are carefully considered by the faculty, prior to the implementation of any changes. Curriculum changes are made through the normal change channels, and the results are monitored for effectiveness. In this manner the department is able to assure itself that its curricula are state-of-the-art and remain so.

Both degree programs share the following objectives:

- Prepare the student to function and provide leadership in today’s highly technical environment;
- Enhance the student’s ability to communicate by oral, graphic, written and electronic means to describe engineering challenges and their solutions;
- Prepare students to solve unstructured problems through analytical means and to synthesize, analyze, and critically evaluate their solutions;
- Develop a knowledge of and appreciation for the solution of engineering problems through the use of teams;
- Instill the habit of life-long learning and professional growth in engineering practice;

- Develop the competence in the chosen discipline to assure that the graduate possesses the methodological and computational skills necessary to succeed in that field; and
- Assure that the graduate appreciates the moral, ethical and legal implications of engineering decisions.

INDUSTRIAL ENGINEERING

Industrial Engineering is a dynamic profession with credible growth and increasing importance. Industrial engineers use engineering principles to design, develop, implement and improve integrated systems that include people, materials, information, equipment and energy. As problem-solvers, industrial engineers are equipped with practical and scientific tools to tackle complex industrial problems and to increase the productivity of workers, capital, and facilities.

The accredited industrial engineering curriculum provides a broad background in humanities and social sciences, mathematics, physical sciences, engineering science, analysis, design, and systems. It provides a good balance between the traditional industrial engineering subjects and the most recent developments in the discipline. Industrial engineering students take courses in work analysis and design, process design, human factors, facilities planning and layout, engineering economic analysis, production planning and control, systems engineering, computer utilization and simulation, operations research, quality control, automation, robotics, and productivity engineering. The program is designed to provide the student with a good foundation of basic concepts and principles in addition to applied engineering techniques. The department and university laboratories and equipment, including computers, are integrated into the coursework throughout the program.

Industrial Engineering students are encouraged to join the Cal Poly Pomona chapter of the Institute of Industrial Engineers. Eligible students may be invited to join the student chapter of Alpha Pi Mu, the industrial engineering honor society. There are also student chapters of the American Foundrymen’s Society, the Society of Manufacturing Engineers and the American Society for Quality.

CORE COURSES FOR MAJOR

Required of all students. A 2.0 cumulative GPA is required in core courses in order to receive a degree in the major.

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>Fundamentals of Human Factors Engineering</td>
<td>225/L</td>
</tr>
<tr>
<td>Elements of Industrial Engineering Systems</td>
<td>327/L</td>
</tr>
<tr>
<td>Operations Research I</td>
<td>416</td>
</tr>
<tr>
<td>Operations Research II</td>
<td>417</td>
</tr>
<tr>
<td>System Simulation</td>
<td>429/L</td>
</tr>
<tr>
<td>Operations Planning and Control</td>
<td>436/L</td>
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<tr>
<td>Industrial and Manufacturing Engineering Fundamentals</td>
<td>112</td>
</tr>
<tr>
<td>Industrial and Manufacturing Engineering Computations Laboratory</td>
<td>113/L</td>
</tr>
<tr>
<td>Work Analysis and Design</td>
<td>224/L</td>
</tr>
<tr>
<td>Industrial Costs and Controls</td>
<td>239</td>
</tr>
<tr>
<td>Application of Statistics</td>
<td>301</td>
</tr>
<tr>
<td>Production Planning and Control</td>
<td>326</td>
</tr>
<tr>
<td>Facilities Planning, Layout and Design</td>
<td>331/L</td>
</tr>
<tr>
<td>Quality Control by Statistical Methods</td>
<td>415/L</td>
</tr>
<tr>
<td>Senior Project</td>
<td>461, 462</td>
</tr>
<tr>
<td>or Team Senior Project</td>
<td>471, 472</td>
</tr>
<tr>
<td>Manufacturing Systems Processes</td>
<td>201/L</td>
</tr>
<tr>
<td>IE electives (from approved list)</td>
<td>...</td>
</tr>
</tbody>
</table>

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SUPPORT AND ELECTIVE COURSES

General Chemistry ............................. CHM 121/L (4)
General Chemistry ............................. CHM 122/L (4)
Elements of Electrical Engineering ............... ECE 231/251L (4)
Engineering Probability and Statistics ............... IME 312 (3)
Undergraduate Seminar .......................... IME 460 (1)
Analytic Geometry and Calculus II ................ MAT 115 (4)
Analytic Geometry and Calculus III ................ MAT 116 (4)
Intro to Linear Alg ................................ MAT 208 (4)
Calculus of Several Variables I .................... MAT 214 (3)
Calculus of Several Variables II .................... MAT 215 (3)
Differential Equations ............................. MAT 216 (4)
Vector Statics .................................... ME 214 (3)
Strength of Materials .............................. ME 218 (3)
Engineering Graphics I ............................ MFE 126/L (3)
Introduction to Computer Integrated Manufacturing ........................ MFE 450/L (4)
Materials Science and Engineering ................... MTE 207 (3)
General Physics ................................ PHY 132 (3)
General Physics ................................ PHY 133/133L (4)
Engineering Science Electives ................. (7)
Freshman English I* (A1) ........................ ENG 104 (4)
Analytic Geometry and Calculus I* (B1) .......... MAT 114 (4)
General Physics and Lab* (B2) ................. PHY 131/L (4)
General Physics Lab* (B2) ........................ PHY 132L (1)
Ethical Considerations* (C4) ....................... EGR 402 (4)
American Government* (D1a) ................. PLS 201 (4)
United States History* (D1b) ..................... HST 202 (4)
Principles of Economics* (D2) .................... EC 201 or 202 (4)
Assett Allocation in Technical Decision Making* (D4) .......... EGR 403 (4)

*Courses marked with an * may be used to satisfy GE requirements. If these courses are not used to satisfy GE, the total units to degree may be more than 198 units.

GENERAL EDUCATION COURSES

An alternate pattern from that listed here for partial fulfillment of Areas A, C, and D available for students in this major is the Interdisciplinary General Education (IGE) Program. Please see the description of IGE elsewhere in this catalog.

Area A (12 units)
1. Written Communication
2. Oral Communication
3. Critical Thinking

Area B (16 units)
1. Math/Quantitative Reasoning
2. Physical Science
3. Biological Science
4. Science and Technology Synthesis

Area C (16 units)
1. Fine and Performing Arts
2. Philosophy and Civilization
3. Literature and Foreign Languages
4. Humanities Synthesis

Area D (20 units)
1a. and 1b. U.S. History, Constitution, and American Ideals
2. History, Economics, and Political Science
3. Sociology, Anthropology, Ethnic, and Gender Studies
4. Social Science Synthesis

Area E (4 units)
Lifelong Understanding and Self-development

MANUFACTURING ENGINEERING

The Manufacturing Engineering program contains a unique, well-balanced curriculum designed to prepare the student for a fast and productive entry into today's complex manufacturing environments. The program is one of only two of its kind in California and is well-received by the industrial community. Manufacturing engineers plan, design, and optimize the process and systems of production. They improve manufacturing productivity by developing better methods of assembling, testing, and fabricating systems and products.

Manufacturing Engineering students are given a solid foundation in production processes and techniques, properties of materials, computers and automation management, and professional communication. These building blocks are then combined and studied as manufacturing systems and then related to the most recent manufacturing technologies. Integrated sequences of courses are provided in: (1) Engineering Design Graphics; (2) Materials and Manufacturing Processes; (3) Process, Assembly and Product Engineering; (4) Manufacturing Productivity and Quality; and (5) Manufacturing Integration Methods and Systems Development. What makes the manufacturing engineering program unique is the fact that it is designed to help the students apply what they have learned through laboratory assignments, projects, field trips, trade shows, and co-op work. Students get laboratory experience in metal-removal processes, metal casting, forming and assembly, computer numerical control, robotics, and CAD/CAM.

Manufacturing Program Objectives

Manufacturing Engineering graduates will:

a. Enjoy successful careers in industry, research or academia.
b. Continue to pursue knowledge and professional growth.
c. Perform leadership roles by enhancing collaboration between engineers, scientists, professional and business people.
d. Contribute as professionally, ethically, and globally aware members of society.
e. Engage in the design and integration of materials transformation and production processes.

Manufacturing engineering graduates are in demand by all types and sizes of manufacturing companies because of their diversified training in traditional as well as new areas of manufacturing knowledge. The rapid growth of new technologies in computer-integrated manufacturing, robotics, lasers, rapid prototyping, artificial intelligence, and composites have opened a whole new world of opportunities for manufacturing engineers. The trend in industry is toward utilizing design engineers and manufacturing engineers as a team in order to produce more economical and functional products.

The department is fortunate in having an Industrial Advisory Council composed of professionals from local industry. The council assists the department in many ways; reviewing the program to assure its applicability, providing opportunities for student internships or summer work, acting as a source for new processes and techniques, and providing financial support either directly or through providing material and equipment. The council and the department have regular meetings each quarter to discuss the progress of the program.

The Manufacturing Engineering curriculum detailed below prepares the graduate to excel in today's highly technical industrial environment. The
Educational objectives reflect outcomes as assessed by employers, graduates, and the industrial community. Program emphasis is placed on developing competence in manufacturing engineering functions, written and oral communications, teamwork, and the ability to integrate complex, interdisciplinary, manufacturing systems.

Manufacturing engineering students are encouraged to join the student chapter of the Society of Manufacturing Engineers. They can also join student chapters of the American Foundrymen's Society, the Institute of Industrial Engineers, and the American Society for Quality. Eligible students may be invited to join Alpha Pi Mu, the industrial engineering honor society.

The Manufacturing Engineering Program consists of 198 quarter units: 75 or 76 quarter units of Core Courses, 54 or 55 quarter units of Support and Directed Elective Courses, and 68 quarter units of General Education. 12 quarter units of upper division General Education must be completed at Cal Poly Pomona. The difference in the number of quarter units in Core and Support is caused by the student's choice of Fluid Mechanics or Thermodynamics.

**CORE COURSES FOR MAJOR**

Required of all students. A 2.0 cumulative GPA is required in core courses for the major in order to receive a degree in the major.

**Industrial and Manufacturing Engineering**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>Fundamentals</td>
<td>112</td>
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<tr>
<td>Industrial and Manufacturing Engineering</td>
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</tr>
<tr>
<td>Computation/Laboratory</td>
<td>113/L</td>
</tr>
<tr>
<td>Industrial Costs and Controls</td>
<td>239</td>
</tr>
<tr>
<td>Application of Statistics</td>
<td>301</td>
</tr>
<tr>
<td>Production Planning and Control</td>
<td>326</td>
</tr>
<tr>
<td>Facilities Planning, Layout and Design</td>
<td>331/L</td>
</tr>
<tr>
<td>Quality Control by Statistical Methods</td>
<td>415/L</td>
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<tr>
<td>Senior Project</td>
<td>461, 462</td>
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<td>or Team Senior Project</td>
<td>471, 472</td>
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<tr>
<td>Engineering Graphics</td>
<td></td>
</tr>
<tr>
<td>Manufacturing Processes-Materials, Metrology and Treatments</td>
<td>126/L</td>
</tr>
<tr>
<td>Manufacturing Processes I-Material Removal</td>
<td>217/L</td>
</tr>
<tr>
<td>Engineering Graphics II</td>
<td>226/L</td>
</tr>
<tr>
<td>Manufacturing Processes II-Form, Cast, and Join</td>
<td>230/L</td>
</tr>
<tr>
<td>Measurement and Methods/Laboratory</td>
<td>320/L</td>
</tr>
<tr>
<td>Production Engineering/Laboratory</td>
<td>326/L</td>
</tr>
<tr>
<td>Principles of Numerical Control</td>
<td>250/L</td>
</tr>
<tr>
<td>CAD/CAM/Lab</td>
<td>375/L</td>
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<tr>
<td>Introduction to Computer Integrated</td>
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<tr>
<td>Manufacturing</td>
<td>450/L</td>
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<tr>
<td>Metal Working Theory and Applications</td>
<td>465</td>
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<tr>
<td>Advanced CAM Systems/Laboratory</td>
<td>476/L</td>
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<tr>
<td>Discrete Systems Simulation</td>
<td>429/L</td>
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<tr>
<td>Manufacturing Electives (selected with advisor's approval)</td>
<td>(3-4)</td>
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</table>

**SUPPORT AND DIRECTED ELECTIVE COURSES**

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>General Chemistry</td>
<td>121/L</td>
</tr>
<tr>
<td>General Chemistry</td>
<td>122/L</td>
</tr>
<tr>
<td>Elements of Electrical Engineering</td>
<td>231/251/L</td>
</tr>
<tr>
<td>Engineering Probability and Statistics</td>
<td>312</td>
</tr>
<tr>
<td>Undergraduate Seminar</td>
<td>460</td>
</tr>
<tr>
<td>Analytic Geometry and Calculus II</td>
<td>115</td>
</tr>
<tr>
<td>Analytic Geometry and Calculus III</td>
<td>116</td>
</tr>
<tr>
<td>Calculus of Several Variables I</td>
<td>214</td>
</tr>
<tr>
<td>Calculus of Several Variables II</td>
<td>215</td>
</tr>
<tr>
<td>Differential Equations</td>
<td>MAT 216</td>
</tr>
<tr>
<td>Vector Statics</td>
<td>ME 214</td>
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<td>General Physics</td>
<td>PHY 132</td>
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<tr>
<td>Freshman English*</td>
<td>ENG 104</td>
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<td>Analytic Geometry and Calculus I*</td>
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<tr>
<td>General Physics Lab*</td>
<td>PHY 132L</td>
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<tr>
<td>Ethical Considerations*</td>
<td>EGR 402</td>
</tr>
<tr>
<td>American Government*</td>
<td>PLS 201</td>
</tr>
<tr>
<td>United States History*</td>
<td>HST 202</td>
</tr>
<tr>
<td>Principles of Economics*</td>
<td>EC 201 or 202</td>
</tr>
<tr>
<td>Asset Allocation in Technical Decision Making*</td>
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2. Physical Science  
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4. Science and Technology Synthesis

**Area C (16 units)**

1. Fine and Performing Arts  
2. Philosophy and Civilization  
3. Literature and Foreign Languages  
4. Humanities Synthesis

**Area D (20 units)**

1a. and 1b. U.S. History, Constitution, and American Ideals  
2. History, Economics, and Political Science  
3. Sociology, Anthropology, Ethnic, and Gender Studies  
4. Social Science Synthesis

**Area E (4 units)**

Lifelong Understanding and Self-development

**COURSE DESCRIPTIONS**

Lecture and laboratory courses listed together are to be taken concurrently.

IE 225/L Fundamentals of Human Factors Engineering/Laboratory (3/1)

Study of human physiological, biomechanical, and psychological characteristics and how they influence engineering and design of equipment, machines, products, facilities, tools, and environments. 3 lectures/problem-solving and 1 three-hour laboratory.
IE 327/L Elements of Industrial Engineering Systems/Laboratory (3/1)
Concepts and principles of system engineering theory. Introduction to the theory and methodology of systems engineering. Development of analytic techniques to establish needs, objectives, priorities and utilities, and the evaluation of system effectiveness. 3 lectures/problem-solving and 1 three-hour laboratory. Prerequisites: MAT 208, IME 224/L.

IE 392 Principles of Productivity Engineering (3)
Productivity definitions, concepts, and trends, use of various industrial engineering techniques in productivity improvement, concepts of lean manufacturing, relationship between productivity and profit, phases of a productivity improvement project, case studies. Plant visits and guest speakers. 3 lectures/problem-solving. Prerequisites: upper division standing.

IE 403 Engineering Cost Estimating (3)
Concepts and techniques of forecasting and estimating costs of engineering, manufacturing and service operations, products, equipment, projects, and systems. Preliminary and detailed procedures. Qualitative, quantitative and computer methods. 3 lectures/problem-solving. Prerequisites: junior standing in engineering.

IE 416 Operations Research I (4)
Application of optimization techniques to the problems encountered in industry and business. Transportation techniques. Linear integer and goal programming. Problem formulation and software applications. 4 lectures/problem-solving/software demonstrations. Prerequisites: MAT 208.

IE 417 Operations Research II (4)
Applications of operations research techniques to the problems encountered in industry and business. Queueing theory, Markovian analysis, and decision theory. Problem formulation and software applications. 4 lectures/problem-solving/software demonstrations. Prerequisites: IME 312.

IE 419 Reliability Concepts and Techniques (3)
Reliability concepts and techniques as used in various types of industrial applications. Analysis of the influence of reliability on such factors as complexity, cost and quality. Component reliability related to systems requirements. 3 lectures/problem-solving. Prerequisites: IME 312.

IE 426 Applied Decision Theory (3)
Introduction to decision theory and its applications. Modern utility theory and its application to decision-making under risk and uncertainty. Applications of Bayesian decision theory. Emphasis on applications covering a wide range of both profit and nonprofit-oriented institutions. 3 lectures/problem-solving. Prerequisites: IME 312 or equivalent.

IE 429/L Discrete Systems Simulation/Laboratory (3/1)
Application of discrete event simulation concepts and tools to improve or design a system in industry and business. System theory, data collection, verification and validation, and interpretation of software output. 3 lectures/problem-solving and 1 three-hour laboratory. Prerequisites: IME 312.

IE 436/L Operations Planning and Control/Laboratory (2/1)
Analysis and design of systems for planning, scheduling and controlling production, inventory and service operations/activities. Use of mathematical and computer models. Projects and open-ended problems. 2 lectures/problem-solving and 1 three-hour laboratory. Prerequisites: IE 327, IE 416, IME 326.

IE 437 Industrial Engineering Systems (3)
Concepts of systems engineering methodology. Methods of technological forecasting and future study. The design and analysis of complex systems under conditions of risk uncertainty and changing environment. 3 lectures/problem-solving. Prerequisites: IE 327.

IME 112 Industrial and Manufacturing Engineering Fundamentals (3)
Introduction to industrial and manufacturing engineering concepts, functions, and techniques. Solution of elementary industrial and manufacturing engineering problems. 3 lectures/problem-solving.

IME 113/L Industrial and Manufacturing Engineering Computations/Laboratory (2/1)

IME 224/L Work Analysis and Design/Laboratory (3/1)
Theory and application of work analysis as related to process design, facilities, workplace layout, tools and equipment, and services. Analytical techniques of measurement of work content including stopwatch time study, standard data, predetermined time systems, computerized work measurement and work sampling. 3 lectures/problem-solving and 1 three-hour laboratory.

IME 239 Industrial Costs and Controls (3)

IME 299/299A/299L Special Topics for Lower Division Students (1–4)
Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture, laboratory, or a combination.

IME 301 Application of Statistics in Engineering (3)
Statistical conclusions for problems observed in industry and business. Descriptive statistics, discrete and continuous distributions, hypothesis testing, control charts, factorial experiments and regression analysis. 3 lectures/problem-solving/software demonstrations. Prerequisites: MAT 116.

IME 312 Engineering Probability and Statistics (3)
Engineering applications of the concepts of probability, statistical distributions, statistical analysis, regression and correlation analysis, analysis of variance and covariance, design of experiments, and probabilistic and statistical models. 3 lectures/problem-solving. Prerequisites: IME 301 or equivalent.
IME 326 Production Planning and Control (3)
Principles of production planning and control systems. Methods of forecasting, planning, scheduling, and controlling production operations and inventory activities. Quantitative models and computer systems. 3 lectures/problem-solving. Prerequisites: IME 112, IME 224, IME 312.

IME 328/L Electronic Process Design/Laboratory (1/1)
Design of manufacturing processes with particular emphasis on processes used in the electronics industry. Evaluation of alternative methods of processing depending upon delivery, volume, and quality specifications. Types of processes included are finishing, plating, printed circuit board production, component preparation and installation, chassis construction, electroforming, and packaging. 1 lecture/problem-solving and 1 three-hour laboratory. Prerequisites: basic electronic and drafting course.

IME 331/L Facilities Planning, Layout and Design/ Laboratory (3/1)
Planning and designing facilities, layouts, and material handling systems. Systems engineering approach; quantitative analysis methods; computerized techniques. Projects. 3 lectures/problem-solving and 1 three-hour laboratory. Prerequisite: IME 326. MFE 126/L recommended.

IME 400 Special Study for Upper Division Students (1–2)
Individual or group investigation, research, studies or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

IME 415/L Quality Control by Statistical Methods (3/1)
Systems of inspection, analysis and action taken to control the quality of manufacturing processes. Process control techniques, acceptance sampling methods, statistical analysis and other techniques used by management to control costs and improve quality. 3 lectures/problem-solving and 1 three-hour lab. Prerequisites: IME 312.

IME 435/L Design of Experiments (3/1)
Introduction to design and analysis of experiments. Applications in product and process design and development; process correction and quality improvement. Taguchi’s loss-function approach to quality; signal-to-noise ratio analysis. 3 lectures/problem-solving and 1 three-hour laboratory. Prerequisites: IME 312.

IME 460 Undergraduate Seminar (1)
Preparation, oral presentation, and discussion by students of technical papers on recent engineering developments. 1 seminar. Prerequisites: senior standing.

IME 461, 462 Senior Project (2) (3)
Selection and completion of a project under faculty supervision. Projects typical of problems which graduates must solve in their fields of employment. Project results are presented in a written and oral formal report. Minimum 120 hours total time. Prerequisites: IME 460.

IME 471, 472 Team Senior Project (2) (3)
Selection and completion of a team project under the supervision of a faculty member. The project will be of sufficient magnitude to require the efforts of a team of students to complete within the allotted time. Project results are presented orally and in a formal written report. Prerequisites: IME 460, senior standing.

IME 499/499A/499L Special Topics for Upper Division Students (1–4)
Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture, laboratory, or a combination.

MFE 126/L Engineering Graphics I/Laboratory (2/1)
Engineering graphics for product design, manufacturing and construction. Emphasis on graphic communication used for processing parts and layouts. Orthographic projection, pictorial views, section and auxiliary views, dimensioning for production-processing, and the four fundamental views of descriptive geometry. Use of instruments and CAD for engineering drawings. 2 lectures/problem-solving and 1 three-hour laboratory.

MFE 201/L Manufacturing Processes Systems/Laboratory (3/1)
Study of basic manufacturing processes with emphasis on terminology, technology, process principles and capabilities, material selection and comparative advantages and disadvantages. Processes discussed include material removal, joining, assembly and casting. Other topics include NC, measurement and gaging, and statistical methods. 3 lectures/problem-solving and 1 three-hour laboratory.

MFE 217/L Manufacturing Processes—Materials, Metrology and Treatments/Laboratory (2/1)
First in a three-course sequence. Provides basic knowledge of engineering materials and the enhancement of their mechanical properties; measurement methods and process controls. Statistical process control; heat treatment of materials; electronic manufacturing and surface technology. 2 lectures/problem-solving and 1 three-hour laboratory. Prerequisite: CHM 121/L.

MFE 221/L Manufacturing Processes I—Material Removal/Laboratory (2/1)
An introduction to science of metal removal and the physics of metal cutting as related to cutting tool geometry, material being cut and machine tools being used. Consideration of machine speeds, feeds, tolerances and surface finish determines as related to both manually and numerically controlled machines; dynamics of metal cutting, tool life analysis, economics of machining, the concept of group technology in cellular and flexible modes. 2 lectures/problem-solving and 1 three-hour laboratory. Prerequisite: MFE 217 or equivalent.

MFE 226/L Engineering Graphics II/Laboratory (2/1)
Engineering graphics for manufacturing. Emphasis on preparation and use of detail drawings and assembly drawings and application of geometric and positional tolerancing (ANSI Y14.5). Interpretation of engineering drawings, representation of threads and fasteners, and assembly drawings using CAD. 2 lectures/problem-solving and 1 three-hour laboratory. Prerequisite: MFE 126/L or equivalent.

MFE 230/L Manufacturing Processes II—Forming, Casting and Joining/Laboratory (2/1)
Theory and practice related to processes dealing with the deformation, consolidation and casting of engineering materials. Modern manufacturing methods are explored with emphasis placed on the application of engineering principles to the production of marketable products. Topics include: molding, casting, powder metallurgy, hot and cold working, welding and introductory exposure to manufacturing systems. 2 lectures/problem-solving and 1 three-hour laboratory. Prerequisite: MFE 217 or equivalent.
MFE 250/L Principles of Numerical Control/Laboratory (2/1)
Principles and applications of numerical control in manufacturing, manual and computer-assisted programming, NC systems including advanced CNC systems for full contouring, macro- and variable programming, programmable controllers for CNC and DNC applications in industry. 2 lectures/problem-solving and 1 three-hour laboratory. Prerequisites: MFE 126/L, and either MFE 201/L or MFE 221/L.

MFE 305/L Material Fabrication Processes/Laboratory (2/1)
Joining metals with an emphasis on their weldability, design and fabrication considerations, inspection and testing of weldments, and the design of the equipment for the most common welding and cutting processes. Included are the selection of the welding processes relative to the product, material type, and production requirements. Students will prepare weld joints that are properly designed, evaluate and test the quality of their weldments. 2 lecture/problem-solving, 1 three-hour laboratory. Prerequisites: MFE 201 or MFE 230.

MFE 310/L Advanced Computer-Aided Drafting/Laboratory (2/1)
Advanced commands and the development of skills in 3-D visualization, application of advanced drawing techniques for assembly modeling; wireframe and solid modeling. 2 lectures/problem-solving and 1 three-hour laboratory. Prerequisites: MFE 126/L or equivalent.

MFE 320/L Measurement and Methods/Laboratory (3/1)
Commonly used units of measurement, measurement devices and measurement techniques found in industrial and environmental systems including dimensional measurement, force, electricity, time and work, noise, light, temperature, humidity, atmospheric constituents and radiation. Emphasis on metrology, work measurement and methods improvement. Introduction to process capability, measurement assurance and the continuous improvement process. 3 lectures/problem-solving and 1 three-hour laboratory.

MFE 326/L Production Engineering/Laboratory (3/1)
The utilization of engineering concepts in the planning and design of processes and products. Selection of appropriate manufacturing processes and systems; sequences of operations, equipment and facilities; methods and tooling to assure optimum producibility. 3 lectures/problem-solving and 1 three-hour laboratory. Prerequisites: MFE 226, MFE 230/L, and MFE 250/L.

MFE 334/L Foundry Process Engineering/Laboratory (2/1)
Investigation of the various casting techniques characteristic of modern foundry practice. Green sand, sodium silicate, shell core, shell mold, investment, die casting and lost foam considered in relation to required molds, patterns, melting processes and materials. Computer applications include simulation software for mold system design. 2 lectures/problem-solving. Prerequisites: MFE 126, MFE 217, MFE 230 or MFE 201 or equivalents.

MFE 373/L Tool and Die Engineering/Laboratory (2/1)
Introduction to the fundamentals of tool and die design. Functions, components and appropriate manufacturing techniques, die life, maintenance, storage and safety. 2 lectures/problem-solving and 1 three-hour laboratory. Prerequisites: MFE 221/L and MFE 230/L.

MFE 375/L Computer-Aided Design/Computer-Aided Manufacturing/Laboratory (3/1)
Integration of computer-aided design principles, part design specifications and producibility concepts in computer-aided manufacturing applications. Emphasis on machine tools for flexible automation, CNC machining data generation, CAD/CAM interface and communication of automated systems. 3 lectures/problem-solving and 1 three-hour laboratory. Prerequisites: MFE 250/L and MFE 126/L or equivalent.

MFE 380/L Manufacturing Metrology/Laboratory (1/1)
The science of engineering measurement as used in inspection and quality control. Emphasis is placed on the general use of scientific measuring devices and how these devices can be used to secure optimal conditions of manufacture. 1 lecture/problem-solving and 1 three-hour laboratory.

MFE 406 Safety Engineering (3)
Principles of safety engineering applied to manufacturing systems. Control of noise, heat, electrical hazards, vibration, radiation, lighting, and air contaminant’s in the workplace. Accident prevention. Material handling safety, machine guards and personal protection equipment. 3 lectures/problem-solving.

MFE 438/L Plastics Engineering I/Laboratory (3/1)
Plastic materials and their processing. Review of the pertinent organic chemistry of polymer materials. Classification, properties, characteristics and applications of plastics; polyethylene, PVC, ABS, polyesters, phenolics and urethanes. Study of processes including injection molding, extrusion, thermoforming and blowmolding; applications, process parameters, quality, economics and tooling considerations. 3 lectures/problem-solving and 1 three-hour laboratory.

MFE 439 Composites Manufacturing (2)
Current topics in plastics processing. Basics of composite properties; strength with respect to fiber loading-type and orientation. Processing methods for composite production; manual lay-up, vacuum, filament winding. 2 lectures/problem-solving.

MFE 450/L Introduction to Computer Integrated Manufacturing/Laboratory (3/1)

MFE 465 Metal Working Theory and Applications (3)
Three-dimensional stress and strain analysis, yield criteria for ductile metals. Stress-strain relations. Phenomenological nature of engineering metals. Plane strain plastic deformation. Plastic strain with axial symmetry and pseudo plane stress. Extremum principles for plastic material. 3 lectures/problem-solving. Prerequisites: MFE 221/L, MFE 230/L or MFE 201, ME 218.
MFE 476/476L Advanced Computer-Aided Manufacturing Systems/Laboratory (3/1)
Principles of group technology, cellular manufacturing, computer-aided process planning, flexible manufacturing systems and computer networks in manufacturing, Information Technology in Manufacturing. 3 lectures/problem-solving, 1 three-hour laboratory. Prerequisite: MFE 450.

MFE 484 Producibility Engineering (3)
Engineering methodologies and design practices which have proven in industry to improve product producibility, reliability, and quality are presented. Concepts include concurrent engineering, just-in-time manufacturing and cellular arrangements for flexible manufacturing. 3 lectures/problem-solving. Prerequisites: MFE 326.

MFE 499/499A/499L Special Topics for Upper Division Students (1-4)
Group study of a selected topic, the title to be specified in advance. Total credit limited to 8 units, with a maximum of 4 units per quarter. Instruction is by lecture, laboratory, or a combination.