INDUSTRIAL & MANUFACTURING ENGINEERING

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Academic Programs

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The mission of the Industrial Engineering and Manufacturing Engineering programs at Cal Poly is to inspire and educate students for successful careers as engineering professionals using a learn-by-doing approach that develops students’ abilities to design and implement innovative, effective solutions for improving processes and systems in society, business, and industry.

The Department focuses on programs that integrate engineering with a real concern for people. Our students study topics that lead to satisfying and productive careers, and also provide strong preparation for graduate work in many fields. Programs reflect the traditional strengths of Cal Poly through close interaction between students and faculty in classroom, laboratory, and other activities. The programs use a project based learning approach where students work on multiple real life projects. Students often present results to industry representatives.

Department and university laboratories and computers are integrated into coursework to investigate, test, and apply theoretical principles learned in the classroom. The descriptions below provide details of the various programs.

Undergraduate Programs

BS Industrial Engineering

Industrial Engineering is the profession concerned with solving integrated engineering and management problems. According to the Institute of Industrial and Systems Engineers, "Industrial engineers figure out how to do things better. They engineer processes and systems that improve quality and productivity. They work to eliminate waste of time, money, materials, energy and other commodities. This is why many industrial engineers end up being promoted into management positions." Key objectives of industrial engineering are to improve the quality and productivity of creating and delivering goods and services and to act as the interface between technology and humans. Engineering methods and practical knowledge are used in formulating decision models for the optimum application of engineering and management principles.

The Bachelor of Science program in Industrial Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.ABET.org. Within three to five years of graduation, the alumni of the Industrial Engineering undergraduate program will:

1. Make immediate contributions towards the design and implementation of innovative, effective solutions for improving processes and systems in society, business, and industry.
2. Have successful careers as engineering professionals with increasing responsibility and impact in their careers.
3. Will communicate and function effectively in a collaborative and inclusive team, and will recognize the economic, societal, and ethical impacts of their decisions.
4. Effectively adapt to changes in technology and our global society over the course of their professional lives by continuously learning.

Our main focus is to prepare graduates for practice in professional engineering. Thus, our “learn by doing” philosophy is emphasized in the curriculum by the large number of design-centered laboratories, integrating design throughout the curriculum, and the senior design project experience. In the required senior design project, students demonstrate their understanding of engineering knowledge and their ability to apply that knowledge creatively to practical problems. Graduates can choose from a challenging range of career activities: operations research and analysis, production planning and scheduling, plant design, management, human factors engineering design, data processing and analytics, measurement, quality control and reliability assurance, technical economic planning, resource conservation, productivity measurement, increasing productivity using computer integrated manufacturing techniques, robotics, and, in general, systems analysis and design. The physical, engineering, and social sciences form the broad base for these endeavors.

The program is oriented to provide graduates with the capability of producing results with a minimum of additional training. Computer and hi-tech firms, health care and biomedical industries, aerospace/defense, entertainment, retail chains, agriculture, airlines, automotive, as well as government, service firms, traditional manufacturing industries, and consulting firms all employ graduates of this discipline. Graduates also are well prepared for successful graduate study.

BS Manufacturing Engineering

Manufacturing Engineering is the profession that applies engineering analysis and methods to the production of all manufactured goods and services. The manufacturing engineer plans, develops, and optimizes the processes of production including methods of manufacture, design, production tooling, and material handling, as well as the processes and systems in society, business, and industry. The emphasis is on both development and sustained operation of manufacturing systems, including computer-aided methods, automation, design for manufacture, production tooling, and material handling, as well as the processes and ancillary support systems of modern manufacturing.

The Bachelor of Science program in Manufacturing Engineering is accredited by the Engineering Accreditation Commission of ABET, http://www.ABET.org. Within three to five years of graduation, the alumni of the Manufacturing Engineering undergraduate program will:

1. Make immediate contributions towards the design and implementation of innovative, effective solutions for improving processes and systems in society, business, and industry.
2. Have successful careers as engineering professionals with increasing responsibility and impact in their careers.
3. Will communicate and function effectively in a collaborative and inclusive team, and will recognize the economic, societal, and ethical impacts of their decisions.

4. Effectively adapt to changes in technology and our global society over the course of their professional lives by continuously learning.

In the required senior design project, students demonstrate their understanding of engineering knowledge and their ability to apply that knowledge creatively to practical problems.

Graduates typically work more directly with the manufacturing processes than do industrial engineers.

Emphasis is placed upon application of the basic sciences and engineering fundamentals. Knowledge of basic processes, tool design, automation, and computer-aided manufacturing are applied directly to the problems of development and sustained operation of manufacturing systems.

Graduates are prepared for job-entry at the professional level in the areas of CAD/CAM, process engineering, automation, quality assurance, and production engineering. They also are well prepared for successful graduate study.

Graduate Programs

MS Engineering Management

The mission of the MS in Engineering Management program is to inspire and educate a new generation of technical leaders with analytical knowledge, business insight, advanced communication and project management skills to design and implement data-driven, innovative, and effective solutions for improving processes and systems in industry and society.

This program emphasizes learn-by-doing and a project-based engineering education approach. Students typically work closely with industry to solve real-world problems. The MS Engineering Management program helps students sharpen both technical skills and non-technical skills required for success in their careers.

The MS Engineering Management program requires 45 quarter credits of coursework in 400 or 500 level courses, including five quarter units of senior project. At least 60% of the courses need to be at the 500-level.

MS Industrial Engineering

General Characteristics

The Master of Science in Industrial Engineering (MS IE) program is designed to prepare students for a successful career in industry as well as a further study in a Ph.D. program, building on its strength in learn-by-doing and project-based engineering education and focusing on applied research. Through the MS IE program, students will sharpen both technical skills and non-technical skills required for success in their careers.

https://ime.calpoly.edu/academics/programs

Blended BS + MS Programs

A blended program provides an accelerated route to a graduate professional degree, with simultaneous conferring of both Bachelor’s and Master’s degrees. Students in the blended program are provided with a seamless process whereby they can progress from undergraduate to graduate status. Students are required to complete all requirements for both degrees, including senior project for the Bachelor’s degree.

Blended programs are available for the following Master’s degrees offered by the Industrial and Manufacturing Engineering department:

- MS Engineering Management
- MS Industrial Engineering

Eligibility

Majors that are eligible for the blended program in MS Engineering Management are:

- BS Environmental Engineering
- BS Industrial Engineering
- BS Manufacturing Engineering
- BS Mechanical Engineering

Majors that are eligible for the blended program in MS Industrial Engineering are:

- BS Industrial Engineering
- BS Materials Engineering
- BS Mechanical Engineering

Participation in a blended program is based upon prior academic performance and other measures of professional promise. Refer to Graduate Education (http://catalog.calpoly.edu/graduateeducation/#graduateandpostbaccalaureateadmissionrequirements/) for more information and for the minimum criteria required to be eligible for a blended program at Cal Poly. Contact the Graduate Program Coordinator in the Industrial and Manufacturing Engineering department for any additional eligibility criteria.

IME Courses

IME 101. Introduction to Industrial and Manufacturing Engineering. 1 unit
Introduction of major topics in industrial and manufacturing engineering such as data analysis, process improvement, operations research, product design, and supply chain management. Professional ethics, cheating and plagiarism. Resources for academic success. Career opportunities review. 1 laboratory.

IME 140. Graphics Communication and Modeling. 2 units
Introduction to computer-aided drafting and modeling of solid objects. Visualization and sketching for engineers. Communication of design information to manufacturing using pictorials, orthographic projection, section views, and auxiliary views. Manufacturing tolerances. 1 lecture, 1 laboratory.

IME 141. Manufacturing Processes: Net Shape. 1 unit
Metal casting as a net shape process in manufacturing. Properties of molding materials and methods of casting. Introduction to rapid prototyping. Pattern and casting design principles. 1 laboratory.

IME 142. Manufacturing Processes: Materials Joining. 2 units
Theory and application of metal cutting and welding processes. Includes shielded metal arc, flux cored arc, submerged arc, gas metal arc, gas tungsten arc, brazing, resistance, and oxy-acetylene processes. Bonding theory, joint design, codes and testing. Introduction to adhesive bonding. Open to all majors. 1 lecture, 1 laboratory.
IME 143. Manufacturing Processes: Material Removal. 2 units
Uses, capabilities, and theoretical and operational characteristics of lathe and milling machine tools, including conventional, automatic and numerical control. Cutting tool characteristics, machining parameters, quality control, and production methods. Design considerations for manufacturing. Introduction to robotics and automation. Open to all majors. 1 lecture, 1 laboratory.

IME 144. Introduction to Design and Manufacturing. 4 units
Recommended: IME 140 or ME 129.
Supplemental review of visualization, sketching, and drafting fundamentals. Computer-aided solid modeling of parts and assemblies. Introduction to conventional machining processes on lathes and mills, computer numerical control, quality control, production methods, and design for manufacturing. Open to all majors. 2 lectures, 2 laboratories.

IME 145. Subtractive Manufacturing Processes for Mechanical Designs I. 1 unit
Concurrent: ME 129.
Material removal manufacturing processes as related to mechanical design. Manual and computer-controlled (CNC) machining processes and equipment. Interpretation of engineering drawings, operation setup, process parameters, inspection of parts. Manufacturing of standard machine design features. Design for manufacturing and assembly (DFMA). Not open to students with credit in IME 143. 1 laboratory.

IME 146. Subtractive Manufacturing Processes for Mechanical Designs II. 1 unit
Prerequisite: IME 145. Concurrent: ME 130.
Material removal manufacturing processes for mechanical design. Fits and assignment of part tolerances. Machining and inspection of geometric dimensioning and tolerancing (GD&T). Teamwork for batch part production. Design for manufacturing and assembly (DFMA) concepts. Not open to students with credit in IME 143. 1 laboratory.

IME 156. Basic Electronics Manufacturing. 2 units
Practical electronics manufacturing knowledge expanded through concepts such as CAD/CAM design, Design for Manufacture (DFM), documentation requirements, prototyping and production planning. Hands-on techniques learned for project planning, soldering, automation, hand tool usage and production methods. 1 lecture, 1 laboratory.

IME 200. Special Problems for Undergraduates. 1-2 units
Prerequisite: Consent of department chair.
Individual investigation, research, studies, or surveys of selected problems. Total credit limited to 4 units, with a maximum of 2 units per quarter.

IME 212. Introduction to Enterprise Analytics. 4 units
Prerequisite: CSC 232.

IME 223. Process Improvement Fundamentals. 4 units
Prerequisite: MATH 141. Recommended: IME 101.
Principles of work simplification and motion analysis. Recording of work flow and methods. Process improvement through work measurement and standards, time study, synthetic data, predetermined time systems and work sampling. Allowances and performance rating, productivity measures. Introduction to lean manufacturing principles. Client based project. 3 lectures, 1 laboratory.

IME 239. Industrial Costs and Controls. 3 units
Prerequisite: IME 223.
Estimation of manufacturing costs for production planning, cost analysis, and control. Planning, budgeting, and control processes. Costs, accounting data and analysis of variances for managerial control, inventory valuation, and decision making. Techniques of pricing, cost estimating and cost reduction, and activity-based costing. 3 lectures.

IME 240. Additional Engineering Laboratory. 1-2 units
Total credit limited to 4 units, with a maximum of 2 units per quarter. 1 or 2 laboratories.

IME 270. Selected Topics. 1-4 units
Prerequisite: Open to undergraduate students and consent of instructor.
Directed group study of selected topics. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 lectures.

IME 301. Operations Research I. 4 units
Prerequisite: MATH 244.
Systems modeling methodology, mathematical model formulations, linear programming, graphical and simplex methods. Sensitivity analysis. Integer and binary programming. Transportation, transshipment, assignment, and other network optimization models. Computer applications. 3 lectures, 1 activity.

IME 303. Project Organization and Management. 4 units
Prerequisite: Junior standing; IME 314 or IME 315.
Design and implementation of a major industrial/business systems project. Project planning considerations. Motivational and influence techniques used in project management. Scheduling techniques with risk assessment. Resource leveling and management under constraints. Reducing project duration. Monitoring progress with earned value analysis. Project audit and closure. Planning and implementation of a project. Application of project management software. 3 lectures, 1 laboratory.

IME 305. Operations Research II. 4 units
Corequisite: IME 301 or STAT 321.
**IME 312. Data Management and System Design. 4 units**  
Prerequisite: CSC 232.

Design and management of industrial databases and reporting systems. Relationships of financial accounting databases and production systems. Efficient data entry and reports, queries, macro function, and Internet based database applications. 3 lectures, 1 laboratory.

**IME 314. Engineering Economics. 3 units**  
Prerequisite: MATH 241.


**IME 315. Financial Decision Making for Engineers. 3 units**  
Prerequisite: MATH 142.

Develop business case for engineering projects. Investment evaluation using after-tax Net Present Value and Internal rate of return. Sensitivity analysis. Financial Statements. Fully allocate costs. Categorization and calculation of costs: fixed, variable, recurring, capital, overhead. Use of spreadsheet programs. Course may be offered in classroom-based or online format. 3 lectures.

**IME 319. Human Factors Engineering. 3 units**  
Prerequisite: PSY 201 or PSY 202, and junior standing.

Analysis of factors influencing the efficiency of human work. Data on the physical and mental capacities of persons, the physical environment, work organization, and the problem of aging. Design of machines, operations, human computer interface and work environment to match human capacities and limitations, including the handicapped. Multidisciplinary team project. 3 lectures.

**IME 320. Human Factors and Technology. 4 units**  
2020-21 or later: Upper-Div GE Area B  
2019-20 catalog: GE Area B7  
2017-19 or earlier catalog: GE Area F  
Prerequisite: Junior standing; completion of GE Area A with grades of C- or better; and completion of GE Areas B1 through B4, with a grade of C- or better in one course in GE Area B4 (GE Area B1 for students on the 2019-20 or earlier catalogs).

Analysis of cognitive, sensory and physical limitations and capabilities of operators and users of technology, both hardware and software, in working and living environments. Analysis of pertinent databases for a proactive approach to designing user-centered industrial products / systems, consumer products, and work environment. 4 lectures. Fulfills GE Upper-Division B (GE Area B7 for students on the 2019-20 catalog; GE Area F for students on earlier catalogs).

**IME 322. Leadership and Project Management. 2 units**  
Prerequisite: Junior standing in an engineering program.

Theory and practice in leadership and project management skills for engineering design teams. Basic issues related to, and tools used for, managing projects and concepts comprising project management. Emphasis on situations requiring resolutions and management decisions by groups representing various elements of an enterprise. 2 lectures. Crosslisted as HNRS/IME 322.

**IME 326. Engineering Test Design and Analysis. 4 units**  
Prerequisite: STAT 321 with a grade of C- or better.

Data gathering and statistical testing applied to industrial engineering and manufacturing fields. Experimental methods for product and process evaluation and comparisons; interpretation of engineering data. Engineering experimental design, linear and nonlinear regression, ANOVA, and multifactor ANOVA. Utilization of existing computer software. 4 lectures.

**IME 327. Test Design and Analysis in Manufacturing Engineering. 4 units**  
Prerequisite: STAT 321 with a grade of C- or better or consent of instructor; or ME 236.

Sampling and descriptive statistics. Central limit theorem. Hypothesis testing for means and variances. Analysis of variance (ANOVA) and factorial design. Applications in engineering design, reliability manufacturing, and inspection. Design projects. 3 lectures, 1 laboratory.

**IME 330. Fundamentals of Manufacturing Engineering. 4 units**  
Prerequisites: IME 141 or ITP 341; IME 142; CE 204 or CE 208; MATE 210; MATE 215; IME 144, or IME 143 and ME 251.

Engineering analysis of manufacturing processes for casting, molding, forming, joining, and machining. Design for manufacturability and estimation of production costs. Process design strategies. Setup and operation of processing equipment; inspection methods. Field trip to manufacturing center. 3 lectures, 1 laboratory.

**IME 335. Computer-Aided Manufacturing I. 4 units**  
Prerequisite: MATH 244, IME 144 or IME 143 and ME 251; and CSC 101, CSC 231, CSC 232 or CSC 234.

Use of the computer to communicate design information to manufacturing. Computer Numerical Control (CNC) programming. Use of CAD/CAM software. Overview of manufacturing systems in an automated environment, including cellular manufacturing and computer-aided process planning. 3 lectures, 1 laboratory.

**IME 336. Computer-Aided Manufacturing II. 4 units**  
Prerequisite: IME 335, ME 212, MATH 244, or consent of instructor.


**IME 342. Manufacturing Systems Integration. 4 units**  
Prerequisite: MATH 241 and IME 223. Recommended: STAT 321.

Analysis and design tools for production planning, control, and simulation of manufacturing systems. Use of systems modeling software. Overview of ergonomics and facilities design. 3 lectures, 1 laboratory.

**IME 356. Manufacturing Automation. 4 units**  
Prerequisite: EE 321.

Computers in the factory automation environment. Basic control theory including feedback. Programming and use of programmable logic controllers (PLC), human-machine interface (HMI), and industrial control systems. Interfacing of electro-mechanical systems; analog and digital inputs, output; programmable controllers. Computer process control. 3 lectures, 1 laboratory.
IME 372. Applications of Enterprise Analytics. 4 units
Prerequisite: IME 212, IME 312, IME 326, MATH 244.
Applications of Big Data Analytics to solve enterprise problems with the emphasis on manufacturing organizations. Data clustering and classification algorithms. Applications of multiple, stepwise, and logistic regression methods. Over-fitting and regularization. Machine learning, neural networks, and Bayesian analysis. Healthcare analytics. 3 lectures, 1 laboratory.

IME 400. Special Problems for Advanced Undergraduates. 1-4 units
Prerequisite: Consent of instructor.
Individual investigation, research, studies, or surveys of selected problems. Total credit limit to 4 units.

IME 401. Sales Engineering. 2 units
Prerequisite: Senior standing in engineering.
Concepts and principles of engineering in sales. Role of the professional engineer in the analysis, design, development, production, and final application of a product or system required by the buyer. 2 seminars.

IME 408. Systems Engineering. 3 units
Prerequisite: CSC 232.

IME 409. Economic Decision Systems. 3 units
Prerequisite: IME 239; IME 314 or IME 315; and IME 305.
Economic evaluation of information for complex decisions. Analysis of risks and uncertainties. Bayes theory and models. Decision theory, sequential decisions, and value of information applied to financial evaluation and control. Major project justification procedures. 3 lectures.

IME 410. Production Planning and Control Systems. 4 units
Prerequisite: IME 342 or IME 305.
Building blocks of manufacturing resource planning (MRP II). Demand forecasting, production planning, master scheduling development. BOM and inventory files. MRP computations and operational challenges. Capacity analysis and production control in push and pull systems. Enterprise Resource Planning (ERP). Principles of JIT and lean manufacturing. Not open to students with credit in IME 580. 3 lectures, 1 laboratory.

IME 416. Automation of Industrial Systems. 3 units
Prerequisite: IME 356, ME 305 or equivalent.
Automation in manufacturing and warehousing. Economic selection of automation systems. Projects in automation. 2 lectures, 1 laboratory.

IME 417. Supply Chain and Logistics Management. 4 units
Prerequisite: IME 342 or IME 410.
Overview of key logistics and supply chain management concepts. Models and solution methods for the design, control, operation, and management of supply chains. Techniques that are used to analyze supply chains. Team projects in partnership with industry sponsors. 4 lectures.

IME 418. Product-Process Design. 4 units
Prerequisite: Senior standing in engineering or graduate standing. Recommended: IME 450.
Innovative new product design and creative development process. Design for manufacturability. Study of constraints for prototyping, designing, testing, processing, quality, and customer satisfaction. Lifecycle analysis. Examination of relevant environmental and ethical issues. Design projects using real world problems. 3 lectures, 1 laboratory.

IME 420. Simulation. 4 units
Prerequisite: IME 305; IME 326 or IME 327; or graduate standing.
Queueing systems. Design and analysis of production and service systems using the simulation technique. System modeling. Random number and function generators, programming, and characteristics of simulation languages. Design projects using real world problems. 3 lectures, 1 laboratory.

IME 421. Manufacturing Organizations. 3 units
Prerequisite: KINE 250, PSY 201, or PSY 202; junior standing. Recommended: IME 314.

IME 424. Industrial Engineering in Healthcare. 4 units
Prerequisite: IME 223.
Industrial engineering applications in healthcare industry. Background on healthcare reform. Simulation, operations research, supply chain, facility engineering, process improvement case studies. Emerging topics in industrial engineers in healthcare, change management, patient flow, Lean Six Sigma, nursing, patient safety, and decision-making. 4 lectures.

IME 428. Engineering Metrology. 4 units
Prerequisite: IME 143 or IME 144; and IME 326, IME 327, IME 503 or STAT 312.
Measurement of attributes and variables; standards, accuracy and precision; mechanical, electronic and optical/laser measurement systems. Contact and non-contact measurement; straightness, flatness and squareness; GDT (Geometric Dimensioning and Tolerancing); CMM (Coordinate Measurement Machines); surface roughness; metrology for electronic products. 3 lectures, 1 laboratory.

IME 429. Ergonomics Laboratory. 1 unit
Prerequisite: IME 319; and IME 326 or IME 327.
Investigation of various physiological, sensory, and cognitive capabilities and limitations of people in work and living environments through laboratory data collection, design of experiments and statistical analysis. 1 laboratory.
IME 430. Quality Engineering. 4 units
Prerequisite: IME 326, IME 327, IME 503, STAT 302 or STAT 312.


IME 432. Additive Manufacturing. 4 units
Prerequisite: IME 144 or ME 251; and MATE 210. Recommended: IME 330.

Engineering principles, materials, equipment, design for manufacturing, process flow, post processing, and applications of additive manufacturing processes, including: photopolymerization, powder bed fusion, extrusion, direct energy deposition, printing, binder jetting, and sheet lamination. Process selection, environment considerations, safety, and cost analysis for manufacturing. 3 lectures, 1 laboratory.

IME 435. Reliability for Design and Testing. 3 units
Prerequisite: IME 326, IME 327, IME 503 or STAT 312.

Reliability concepts and mathematical models, mechanical device reliability, electrical device reliability, systems reliability and maintainability, reliability data, assurance program elements. Not open to students with credit in IME 542. Course may be offered in classroom-based or online format. 3 lectures.

IME 441. Engineering Supervision I. 1 unit
Prerequisite: Consent of instructor.

Theory and principles of supervision. Application of fundamental concepts and techniques of supervision provided by assignment in engineering laboratories. 1 laboratory each.

IME 442. Engineering Supervision II. 1 unit
Prerequisite: Consent of instructor.

Theory and principles of supervision. Application of fundamental concepts and techniques of supervision provided by assignment in engineering laboratories. 1 laboratory each.

IME 443. Facilities Planning and Design. 4 units
Prerequisite: IME 144; IME 223; IME 314; and either IME 305 or IME 342. Recommended: IME 319 and IME 420.

Design concepts and input requirements in planning and design of new or renovation of existing manufacturing systems. Product, process, and flow and activity analysis techniques. Flow lines and buffering techniques. Computer-aided layout design and evaluation. Design of handling systems. Math models of location problems. Multidisciplinary team project. 3 lectures, 1 laboratory.

IME 450. Manufacturing Process and Tool Engineering. 4 units
Prerequisite: MATH 244, IME 330. Recommended: IME 335.

Engineering design of fixtures and tools for manufacturing processes. Interpretation of engineering design specifications. Analysis of cost, quality, productivity, and safety in tool design. Mechanical analysis of tool design. Detailed process design for net shape production and component design for manufacture. Process and tool design projects. 3 lectures, 1 laboratory.

IME 451. Radio Frequency Identification and Sensing System Design. 4 units
Prerequisite: EE 201 or IME 156 or ITP 150.

Radio frequency identification (RFID) and its role in asset and inventory management, facility access, payment transaction systems, and other applications. RFID and the Internet of Things (IIOT). Physics and types of RFID and other sensing devices. Economic analysis. Multidisciplinary project teams design RFID systems for real-world applications. 2 lectures, 2 laboratories.

IME 457. Advanced Electronic Manufacturing. 4 units
Prerequisite: IME 156 or EE 143 or EE 201.

Design and fabrication of commercial electronic products; PCB layout design, bill of material analysis and component purchasing, production planning and scheduling, programming automated surface-mount assembly line, marketing of products. Multidisciplinary project teams exposed to real-world challenges of electronics manufacturers. 2 lectures, 2 laboratories.

IME 458. Microelectronics and Electronics Packaging. 4 units
Prerequisite: EE 112 or EE 113 or EE 201. Recommended: MATE 210.


IME 460. Introduction to Value Chain Analysis. 3 units
Prerequisite: IME 223 or ITP 303; and senior standing.

Introduction to value chain concepts and their application to the analysis and improvement of business operations. Application of lean principles to optimize the value chain. 3 lectures.

IME 470. Selected Advanced Topics. 1-4 units
Prerequisite: Consent of instructor.

Directed group study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 lectures.

IME 471. Selected Advanced Laboratory. 1-4 units
Prerequisite: Consent of instructor.

Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

IME 481. Senior Design Project I. 2 units
Prerequisite: Senior standing in major and consent of instructor.

Culminating design project typical of problems faced in professional practice. Individual or group projects typically involve system design, modeling, analysis and testing. Project focus is on problem definition, planning, scheduling, literature review, conceptual design and generation of alternative designs, and development of business case for project communication and formal reports to document project methodology. Professional ethics. 1 lecture, 1 laboratory.
IME 482. Senior Design Project II. 2 units
Prerequisite: IME 481.
Continuation of IME 481. Involves research methodology, project design, analysis, implementation, and/or testing. Project results documented in thesis-like formal reports suitable for reference library and formal oral presentations. Professional ethics. 1 lecture, 1 laboratory.

IME 483. Senior Design Project III. 2 units
Prerequisite: IME 482.
Continuation and completion of project from IME 482. Focus on testing and experimentation of implemented design project. Evaluation of project sustainability and impacts of societal, organizational, economic, and environmental nature. Project results and recommendations summarized and presented in formal reports suitable for reference library and formal oral presentations. 1 lecture, 1 laboratory.

IME 495. Cooperative Education Experience. 4-12 units
CR/NC
Prerequisite: Sophomore standing and consent of instructor.
Full-time work experience in business, industry, government, and other areas of student career interest. Positions are paid and usually require relocation and registration in course for two consecutive quarters. A formal report and evaluation by work supervisor required. Credit/No Credit grading only. No major credit allowed; total credit limited to 24 units.

IME 500. Individual Study. 1-4 units
Prerequisite: Consent of department chair and supervising faculty member.
Advanced study planned and completed under the direction of a member of the department faculty. Open only to students who have demonstrated ability to do independent work.

IME 503. Applied Statistical Methods in Engineering. 4 units
Prerequisite: Graduate standing.
Application of important statistical distributions in engineering and management. Coverage of sampling distributions and their roles in design of experiments. Applications of hypothesis testing, ANOVA, analysis of covariance, multiple and nonlinear regressions in industry and service systems. Introduction to nonparametric analysis. 3 lectures, 1 laboratory.

IME 507. Graduate Seminar. 2 units
Prerequisite: Graduate standing.
Seminars in industrial engineering, integrated technology management, and engineering management by researchers and practitioners from academia and industry. Preparation for conducting research. Presentation of student research projects. Overview of graduate education requirements. Ethics issues in research. 1 seminar, 1 laboratory.

IME 510. Systems Engineering I. 4 units
Prerequisite: Graduate standing or consent of instructor.

IME 511. Systems Engineering II. 4 units
Prerequisite: IME 510, graduate standing or consent of instructor.
Risk management. Design strategies to meet system/mission requirements. Design for supportability, manufacturability, reliability, etc. Quality function development and quality control concepts. 4 lectures.

IME 520. Advanced Information Systems for Operations. 4 units
Prerequisite: Graduate standing or consent of instructor. Recommended: IME 410.
Advanced information systems (IS) applications in manufacturing and service operations. Introduction of common IS applications, such as manufacturing execution systems; reporting systems; capacity planning systems; scheduling systems; and customer inquiry systems. Industry-specific analysis of IS requirements and availability. 4 seminars.

IME 527. Design of Experiments. 4 units
Prerequisite: IME 326 or IME 327 or IME 503 or STAT 312.
Experimental design principles. Comparative experiments for population parameters. ANOVA and randomized block design. Factorial designs, the 2^k factorial designs, and factorial designs with blocks. Fractional factorial designs. Response surface methodology. Fitting regression models. Design projects using real world problems. Substantial use of statistical software. 3 lectures, 1 laboratory.

IME 541. Advanced Operations Research. 4 units
Prerequisite: Graduate standing and consent of instructor.

IME 542. Applied Reliability Engineering. 4 units
Prerequisite: Graduate standing. Recommended: IME 326 or IME 327 or IME 503 or STAT 312.
Reliability terminology and bathtub curve. Failure distributions: Exponential, Lognormal, and Weibull. Probability plotting. Reliability of systems. Maintainability and availability. Reliability in design; Load-strength analysis; Failure modes and effects analysis; Fault tree analysis. Reliability testing; Reliability management. Not open to students with credit in IME 435. 3 lectures, 1 laboratory.

IME 543. Applied Human Factors. 4 units
Prerequisite: Graduate standing or consent of instructor. Recommended: IME 326 or IME 327 or IME 503.
Human factors/ergonomics analysis and evaluation of automation, mobile communication technology, and interface design for Internet websites. Usability analysis of current hardware/software products with an emphasis on a user-centric design approach. Team-based projects. 3 seminars, 1 laboratory.
IME 544. Advanced Topics in Engineering Economy. 4 units
Prerequisite: Graduate standing. Recommended: Undergraduate course in engineering economy.

IME 545. Advanced Topics in Simulation. 4 units
Prerequisite: Graduate standing. Recommended: IME 420.
Validation of simulation models. Statistical techniques for variance reduction. Experimental design and optimization. Comparison of attributes of simulation languages. Review of current manufacturing and service industry applications. Case studies. 3 lectures, 1 laboratory.

IME 556. Technological Project Management. 4 units
Prerequisite: Graduate standing or consent of instructor.
Projects in industrial organizations and enterprises. Emerging technologies and project management. Relationship to strategic plans and managing change in organizations. Formulating, selecting, structuring, and planning projects. Project organization and control. Overcoming barriers. Application of project management software. 3 seminars, 1 laboratory.

IME 570. Selected Advanced Topics. 1-4 units
Prerequisite: Graduate standing.
Directed group study of selected topics for advanced students. Open to graduate students and selected seniors. Topic lists will be provided with class schedule outlines. 1 to 4 seminars.

IME 571. Selected Advanced Laboratory. 1-4 units
Prerequisite: Graduate standing or consent of instructor.
Directed group laboratory study of selected topics for advanced students. Open to undergraduate and graduate students. The Class Schedule will list topic selected. Total credit limited to 8 units. 1 to 4 laboratories.

IME 577. Engineering Entrepreneurship. 4 units
Prerequisite: Graduate standing or consent of instructor.
The special requirements of entrepreneurship in a high-tech environment. Guest lectures, focused seminar topics, a business plan project, and case studies provide the tools to evaluate and pursue technology-based business opportunities. 4 lectures.

IME 580. Manufacturing Systems. 4 units
Prerequisite: Graduate standing.
Modern approaches in production and inventory planning and control to support large-scale manufacturing systems, material requirements planning (MRP I), manufacturing resource planning (MRP II), and just-in-time (JIT) manufacturing systems. Enterprise resource planning (ERP) and integration with financials. Information requirements, operational issues, and policy matters. Not open if credit in IME 410. 4 seminars.

IME 596. Graduate Project/Internship. 1-5 units
Prerequisite: Graduate standing and consent of instructor.
Integrative learning experience through internship and project. Focus on a significant industrial or research problem in an engineering field. Project involves student(s), faculty, and sponsoring representative(s) in a collaborative learning environment, and culminates in a comprehensive written report. Total credit limited to 5 units.

IME 599. Thesis. 1-9 units
Prerequisite: Graduate standing and consent of instructor.
Systematic study of a significant problem under faculty supervision. Both a written thesis and an oral defense are required. Total credit limited to 9 units.

SIE Courses
SIE 509. Systems Integration Overview. 1 unit
Prerequisite: Admission to the graduate certificate program in Systems Integration Engineering.
Orientation and overview of the Systems Integration Engineering graduate certificate program, including introduction to systems integration, learning technologies, teamwork, personality types, leadership, desired attributes of an engineer, and presentations by visiting system experts. 1 lecture.

SIE 510. Introduction to Systems. 4 units
Prerequisite: SIE 509.
Introduction to man-made and socio-technical systems, including life cycle concepts, needs analysis, requirements discovery, models, complexity, project management, life cycle costing, risk management, and decision making. Verification, validation, and virtual collaboration of teams. Course offered online only. 4 lectures.

SIE 511. Systems Analysis. 4 units
Prerequisite: SIE 510.
Analysis topics and techniques within the systems context, including functional analysis, systems simulation, design analysis, financial analysis, schedule analysis, manufacturability, reliability, maintainability, and usability. Course offered online only. 4 lectures.

SIE 512. Systems Synthesis. 4 units
Prerequisite: SIE 511.
Systems synthesis and integration through systems thinking, interface management, configuration management, lean systems, A3 Thinking, commercial versus government systems, system verification and validation, and internal versus external subsystem development. Course offered online only. 4 lectures.