

# SCHOOL OF MECHANICAL, INDUSTRIAL, AND MANUFACTURING ENGINEERING

The School of Mechanical, Industrial, and Manufacturing Engineering (MIME) at OSU offers three ABET-accredited undergraduate degrees: Mechanical Engineering, Industrial Engineering, and Manufacturing Engineering and one undergraduate degree that is currently undergoing ABET accreditation: Energy Systems Engineering (offered at OSU-Cascades campus).

The mission of the School of MIME is two-fold:

- To prepare our students as entrepreneurial, team-oriented, work-ready graduates and lifelong learners in mechanical, industrial and manufacturing engineering, and
- To engage in collaborative, cutting-edge research whose applications lead to greater prosperity and a sustainable future for Oregon and the world.

## MIME Program Objectives

ABET requires that each program establishes educational objectives defined as "broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve." While each program has specific objectives, all MIME programs' program objectives may be summarized by the following statements in three broad areas of student participation and graduate achievement:

1. **Our graduates will be systems thinkers.** MIME graduates will be able to analyze, evaluate, improve, and design engineered systems and processes using modern engineering tools (hardware and software) and approaches. They will demonstrate in-depth knowledge of mechanical, industrial and/or manufacturing systems.
2. **Our graduates will be global collaborators.** MIME graduates will be able to communicate effectively across disciplines and cultures. They will provide management and leadership skills within their organizations and work effectively in diverse environments.
3. **Our graduates will be innovative designers and problem solvers.** MIME graduates will use both structured and unstructured methodologies to innovate systems and processes. They will apply technical knowledge and creativity in solving real-world problems. They will demonstrate a sound understanding of engineering and project management fundamentals and breadth of experience with engineering design and problem-solving processes.

## Mechanical Engineering

Mechanical engineers design and develop small devices, large equipment, and processes for society. They play major roles in the design, testing and operation of mechanisms, machines, and systems, including processes for energy conversion and equipment used in households, businesses, transportation, and manufacturing.

In addition to the university baccalaureate core, the mechanical engineering curriculum has its base in mathematics, science, engineering science, and design. Mathematics and science courses occur primarily in the first two years. Engineering science is a major component, which

is treated from the sophomore year to graduation in a combination of required and technical elective sources.

OSU's Mechanical Engineering Program has all the attributes needed for the best learning environment: ABET accredited curriculum, excellent faculty, modern facilities, quality students, and strong industrial interaction.

Engineering design is an integral element of the program. The philosophy is to "plant the seed" for design at the freshman level and grow it throughout the program. Most of the skills are developed at the junior and senior levels when students have achieved proficiency in the basic technical requirements. At the junior level, the design process is extensively developed in three courses. At the senior year, design experiences occur in several areas, culminating in the two-term senior project in which students in small teams carry out the design of some product or process under the supervision of a faculty advisor. Attention to hands-on activity adds a very desirable "feel" for many aspects of the design process.

A good choice of senior electives enables students to achieve a degree of specialization and depth to match their interests. The areas include applied stress analysis; design, dynamics, and analysis of mechanical and thermal/fluid systems; concurrent engineering; control system design; mechatronics; heat transfer; and metallurgy and materials.

The faculty encourages a vibrant extracurricular program for professional and leadership experiences. Students are encouraged to obtain at least three months of work experience through an industrial or research internship or to participate in a foreign exchange program. The school's goal is to have more than 95 percent of its students graduate with such experience. In addition to students having general internships, many of the professional-level students participate in the industry-driven Multiple Engineering Cooperative Program (MECOP). This program provides two paid six-month internships at over 60 Pacific Northwest companies where interns work with a company mentor and improve their capabilities for the work environment.

Mechanical engineers can be found in a wide variety of industries including aerospace, electronics, biomedical, transportation, manufacturing, energy, automotive, and government labs. Because of the increasing complexity of mechanical engineering, graduate study for the MS and PhD degrees is advisable for students who wish to specialize in depth in any of the above areas. The undergraduate curriculum provides an excellent foundation for graduate study.

## Industrial Engineering

Industrial engineers (IEs) apply science, mathematics, and engineering methods to complex system integration and operation. Because the systems with which they work are often large and complex, IEs utilize knowledge and skills in a wide variety of disciplines, have the ability to work well with people, and take a broad, systems perspective. The Industrial Engineering degree is a very flexible degree that allows students to tailor their program of study to meet their individual career goals. A large number of restricted elective credits allows students to pursue the Business Engineering option or to customize their program to a field of interest.

IEs are key players in the integration and operation of systems in all sectors of industry and government including the following (with examples):

- aerospace (NASA space shuttle pre-launch processing systems)
- automotive (automobile final assembly plants)
- communications (telephone services)
- computers (factory information systems)
- electronics/semiconductors (silicon wafer fabrication facilities)
- food (canneries and fast food restaurant chains)
- government (department of motor vehicles service centers)
- health care (hospital central stores and operating rooms)
- manufacturing (circuit board fabrication facilities)
- retail (product distribution centers)
- transportation (airlines, overnight delivery services)

In their role as system integrators, IEs analyze and design systems. For example:

- facilities layout,
- material handling systems,
- manufacturing and other production systems,
- information systems,
- individual and group workplaces.

In the operations realm, IEs analyze, design and manage processes. For example:

- manufacturing processes-service processes,
- production system planning and control,
- resource allocation and scheduling,
- personnel assignment and scheduling,
- quality assurance,
- inventory control,
- system and personnel safety.

## Energy Systems Engineering

Energy systems engineers oversee complex energy conversion and distribution systems, work to improve energy storage systems, and manage the efficient use of energy in building, manufacturing, and processing systems. ESE professionals also study the secondary effects of energy usage from a local environmental impact, regional and national economic impact, and global climate change perspective.

Energy systems engineers pursue a variety of jobs and occupations. For example, they might be hired to do any of the following:

- Manage operations of a wind turbine farm
- Analyze efficiency of hydroelectric power systems
- Oversee production of innovative fuel-cell technologies
- Evaluate the economic viability of new solar power installations
- Assess the environmental impact of alternative energy systems

## Manufacturing Engineering

The Manufacturing Engineering degree is a more specialized degree, focusing on both high-tech manufacturing and traditional manufacturing. In particular, it is a specialization of industrial engineering that focuses on the making of physical products. The Manufacturing Engineering degree offers a hands-on education, and manufacturing engineering students are encouraged to participate in the college's MECOP program, a nationally recognized industrial cooperative education program.

Students who complete the requirements for the Manufacturing Engineering degree plus 32 additional credits (at least 16 of these credits must be from the list of industrial engineering restricted electives) can earn two separate degrees, one in manufacturing engineering and the other in industrial engineering. The additional 32 credits typically take two additional quarters to complete.

## Undergraduate Programs

### Majors

- Energy Systems Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/energy-systems-engineering-bs-hbs>)  
*[OSU-Cascades/COCC only]*  
Pre-Energy Systems Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/pre-energy-systems-engineering>)
- Industrial Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/industrial-engineering-bs-hbs>)  
Pre-Industrial Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/pre-industrial-engineering>)  
**Option**
  - *Business Engineering*
- Manufacturing Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/manufacturing-engineering-bs-hbs>)  
Pre-Manufacturing Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/pre-manufacturing-engineering>)  
**Option**
  - *Manufacturing Systems*
  - *Product Development*
- Mechanical Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/mechanical-engineering-bs-hbs>)
- Pre-Mechanical Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/pre-mechanical-engineering>)

### Minor

- Aerospace Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/aerospace-engineering-minor>)
- Materials Science (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/materials-science-minor>)

## Graduate Programs

### Majors

- Industrial Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/industrial-engineering-meng-ms-phd-mais>)  
**Graduate Options**
  - *Advanced Manufacturing*
  - *Engineering Management*

- *Human Systems Engineering*
  - *Information Systems Engineering*
  - *Manufacturing Systems Engineering*
  - Materials Science (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/materials-science-ms-phd>)
  - Mechanical Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/mechanical-engineering-meng-ms-phd>)
- Graduate Options**
- *Advanced Manufacturing*
  - *Design*
  - *Engineering Management*
  - *Materials Mechanics*
  - *Renewable Energy*
  - *Robotics*
  - *Thermal Fluids*
- Robotics (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/robotics-meng-ms-phd>)

## Minors

- Industrial Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/industrial-engineering-graduate-minor>)
- Materials Science (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/materials-science-graduate-minor>)
- Mechanical Engineering (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/mechanical-engineering-graduate-minor>)
- Robotics (<http://catalog.oregonstate.edu/college-departments/engineering/school-mechanical-industrial-manufacturing-engineering/robotics-graduate-minor>)

## EAC/ABET Accredited

**Robert B. Stone**, *Head*

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## Faculty

**Professors** Batten, Campbell, Cann, Doolen, Kim, Kruzic, Liburdy, Logendran, Narayanan, Paasch, B. Paul, Pence, Sharp, Stone, I. Tumer, K. Tumer

**Associate Professors** Albertani, Apte, Atre, Bay, Funk, Gibbons, Grimm, Hurst, Porter, Smart, Warnes

**Assistant Professors** Balasubramanian, Blunck, Calvo, DuPont, Eseonu, Feuerbacher, Fronk, Greaney, Haapala, Hagen, Hatton, Hollinger, Hoyle, Malhotra, Menguc, Ng, Niemeyer, Parmigiani, Sencer, Tucker, Vergara, Wang

**Instructors** Ettringer, Feldman, Natarajan, Shea, Squires

## Professional Faculty

Barber, Borntrager, DeAdder, Finn, Helvie, Jensen, Marx, G. Newcomb, L. Paul, Randall, J. Robinson, T.A. Robinson

## Energy Systems Engineering

### ESE 330. MODELING AND ANALYSIS OF DYNAMIC SYSTEMS. (4 Credits)

Presents basic concepts of dynamic behavior, and the analytical and computational techniques for predicting and assessing dynamic behavior. Modeling a basic system, compound system, dynamic stability, and natural behavior to continuing and abrupt inputs are presented.

**Prerequisites:** ENGR 202 with C or better and ENGR 212 [C] and MTH 256 [C] and MTH 306 [C]

### ESE 355. ENERGY REGULATION. (4 Credits)

Introductory course to the policies and laws governing energy generation and transmission in the United States with a focus on electricity. History of regulations give context to understand current regulation and potential future policies. Laws regulating the use of alternative energy resources covered in a practical setting. Offered at OSU-Cascades only.

**Prerequisites:** BA 360 (may be taken concurrently) with C or better or ENGR 390 (may be taken concurrently) with C or better

### ESE 360. ENERGY CONSUMPTION ANALYSIS. (4 Credits)

Analysis of energy use in transportation, residential and industrial sectors to understand how new technologies improve energy efficiency. Tradeoff techniques applied to decide between less efficient, less expensive systems versus more efficient, more expensive systems. International energy consumption compared, and energy losses evaluated for heating, cooling and electronic systems. Offered at OSU-Cascades only.

**Prerequisites:** (BA 360 (may be taken concurrently) with C or better or ENGR 390 (may be taken concurrently) with C or better) and ME 311 [C]

### ESE 430. FEEDBACK CONTROL SYSTEMS. (4 Credits)

Modeling and analysis of linear, continuous-time systems in the time and frequency domains. Fundamentals of single-input-single-output control system design using both time-domain and frequency-domain techniques.

**Prerequisites:** ESE 330 with C or better

### ESE 450. ENERGY GENERATION SYSTEMS. (4 Credits)

Survey of technical fundamentals and operational principles of conventional and renewable energy conversion systems to understand the environmental and sustainable issues for energy systems currently in use or may be used in the future to power our industrial society. Offered at OSU-Cascades only.

**Prerequisites:** ME 312 with C or better

### ESE 470. ENERGY DISTRIBUTION SYSTEMS. (4 Credits)

Detailed coverage of the electrical energy distribution system, its operation, control and design. Design considerations and impacts to meet emerging and evolving customer needs. Broader understanding of natural gas and oil pipeline distribution for these infrastructure commodities. Offered at OSU-Cascades only.

**Prerequisites:** ENGR 202 with C or better and ME 311 [C]

### ESE 471. ENERGY STORAGE SYSTEMS. (4 Credits)

Coverage of energy storage techniques involving electrochemical, mechanical and emerging options. Integration of the energy storage media, its effects on the bulk power system, and design tradeoffs to understand environmental impacts, cost, reliabilities, and efficiencies for commercialization of bulk energy storage. Offered at OSU-Cascades only.

**Prerequisites:** ENGR 202 with C or better and ME 312 [C]

**ESE 497. \*MIME CAPSTONE DESIGN. (4 Credits)**

Product design; selection and replacement of major tools, processes, and equipment; paperwork controls; subsystem revision; system or plant revision; selection and training of personnel; long-run policies and strategy. CROSSLISTED as IE 497 and ME 497. (Writing Intensive Course)

**Attributes:** CWIC – Core, Skills, WIC

**Prerequisites:** ((ENGR 390 with C or better or BA 360 with C or better) and IE 425 [C] and (ME 312 [C] or ME 312H [C]) and (ME 331 [C] or ME 331H [C]) and ESE 355 [C] and ESE 360 [C] and WR 327 [C] and (ST 314 [C] or ST 314H [C]))

**Equivalent to:** IE 497, ME 497

**ESE 498. \*MIME CAPSTONE DESIGN. (4 Credits)**

Product design; selection and replacement of major tools, processes, and equipment; paperwork controls; subsystem revision; system or plant revision; selection and training of personnel; long-run policies and strategy. CROSSLISTED as IE 498 and ME 498. (Writing Intensive Course)

**Attributes:** CWIC – Core, Skills, WIC

**Prerequisites:** ESE 497 with C or better or IE 497 with C or better or ME 497 with C or better

**Equivalent to:** IE 498, ME 498

**ESE 499. SPECIAL TOPICS. (0-16 Credits)**

*This course is repeatable for 16 credits.*

## Industrial and Manufacturing Engineering

**IE 112. SPREADSHEET SKILLS FOR INDUSTRIAL & MANUFACTURING ENGINEERS. (1 Credit)**

Basic spreadsheet functionality needed to create spreadsheet applications for common industrial and manufacturing engineering information processing tasks, including simple databases, statistical analysis, quality control, forecasting, production planning and control, and operations analysis and improvement. Topics include creating spreadsheets, formatting, data types, formulas, charts, user-defined functions, and pivot tables.

**IE 199. SPECIAL TOPICS. (1-16 Credits)**

Special topics in industrial engineering.

*This course is repeatable for 16 credits.*

**IE 212. COMPUTATIONAL METHODS FOR INDUSTRIAL ENGINEERING. (4 Credits)**

Engineering problem solving using computational methods. Data structures. Modular programming. Sorting and search algorithms. Algorithms for inventory models, production scheduling, production line analysis, and optimization.

**Prerequisites:** ENGR 112 with C or better

**Recommended:** Algebra, calculus, differentiation and integration

**IE 255. INTRODUCTORY QUANTITATIVE ANALYSIS OF INDUSTRIAL AND MANUFACTURING SYSTEMS. (3 Credits)**

An introduction to basic analysis concepts that will be utilized in subsequent industrial and manufacturing engineering courses. Emphasis will be placed on fundamental concepts such as data collection, commonly applied quantitative analysis methods, and how these are utilized to support decisions in different industrial and manufacturing system applications. Examples include resource utilization calculations, equipment fraction equations, queuing models, basic statistical inference procedures, and probability models used in discrete event simulation.

**Prerequisites:** MTH 252 with C or better

**IE 285. INTRODUCTION TO INDUSTRIAL AND MANUFACTURING ENGINEERING. (3 Credits)**

Introduction to selected topics in industrial and manufacturing engineering, including history and philosophy, product design and manufacturing cycle, integrate role of engineering and business, and multi-objective nature of organizations. Surveys of selected design problems in resource allocation, operations and quality management, and production engineering. CROSSLISTED as MFGE 285.

**Equivalent to:** MFGE 285

**IE 299. SPECIAL TOPICS. (1-16 Credits)**

Special topics in industrial engineering.

*This course is repeatable for 16 credits.*

**IE 355. STATISTICAL QUALITY CONTROL. (4 Credits)**

Control of quality through the use of statistical analysis; typical control techniques and underlying theory. Development of reliability models and procedures for product assurance. Lec/lab.

**Prerequisites:** IE 255 with C or better or ST 314 with C or better

**IE 356. EXPERIMENTAL DESIGN FOR INDUSTRIAL PROCESSES. (4 Credits)**

Systematic analysis of processes through the use of statistical analysis, methods, and procedures. Application of statistical techniques including use of classic process analysis techniques, regression and design of experiments. Lec/rec.

**Prerequisites:** IE 255 with C or better or ST 314 with C or better

**IE 366. WORK SYSTEMS ENGINEERING. (4 Credits)**

Principles and techniques of work measurement, methods engineering, workplace design, work sampling, and predetermined time systems.

Basic human factors engineering and ergonomics principles applied to workplace design. The work systems engineering process. Lec/lab/rec.

**Prerequisites:** IE 255 with C or better or ST 314 with C or better

**IE 367. PRODUCTION PLANNING AND CONTROL. (4 Credits)**

Forecasting techniques, inventory analysis, master production scheduling, material and capacity requirements, planning and scheduling methods.

**Prerequisites:** IE 255 with C or better or ST 314 with C or better

**IE 368. FACILITY DESIGN AND OPERATIONS MANAGEMENT. (4 Credits)**

Design and analysis of industrial facilities including just-in-time systems, queuing, material handling systems, material flow analysis, line balancing, systematic layout planning, design of warehouse facilities, and facilities location.

**Prerequisites:** IE 255 with C or better or ST 314 with C or better

**IE 380. \*THE RESPONSIBLE ENGINEER. (3 Credits)**

The idea of responsibility and the ethical responsibilities of the engineer.

Introduction to value, ethics, and ethical systems. Engineering as value creation and the ethical ramifications of engineering. Codes of engineering ethics. Recognizing and addressing ethical dilemmas in engineering. Examination of the individual, social, and environmental effects of engineering and technology. (Baccalaureate Core Course)

**Attributes:** CSST – Core, Synthesis, Science/Technology/Society

**IE 399. SPECIAL TOPICS. (1-16 Credits)**

Special topics in industrial engineering.

*This course is repeatable for 16 credits.*

**IE 403. THESIS. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**IE 405. READING AND CONFERENCE. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**IE 406. PROJECTS. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**IE 407. SEMINAR. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**IE 410. INTERNSHIP. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**IE 411. VISUAL PROGRAMMING FOR INDUSTRIAL APPLICATIONS. (4 Credits)**

Object-oriented modeling, Unified Modeling Language, software development concepts, file and database connectivity, and visual programming skills (Microsoft Visual Basic) for use in developing industrial applications, such as process monitoring and supply chain management.

**Prerequisites:** IE 212 with C or better

**IE 412. INFORMATION SYSTEMS ENGINEERING. (4 Credits)**

Framework for enterprise information systems. Engineering and scientific systems. Requirements definition, enhanced entity relationship modeling, logical modeling, structured query language, relational model, referential integrity. Lec/lab.

**IE 415. SIMULATION AND DECISION SUPPORT SYSTEMS. (4 Credits)**

Analysis of operations and production systems through the application of computer simulation modeling techniques. Fundamentals of computer simulation including random number generation, input/output data analysis, model validation and verification. Lec/lab.

**Prerequisites:** IE 255 with C or better or ST 314 with C or better

**IE 418. TELECOMMUNICATION CONCEPTS. (3 Credits)**

Telecommunication concepts for industrial applications. OSI reference model, local area networks, wide area networks, internet architecture. Taught fall in even years.

**Prerequisites:** IE 212 with D- or better

**Recommended:** Previous programming experience

**IE 419. WIRELESS NETWORKS. (3 Credits)**

RF fundamentals, ISO 802.11 standards, spread spectrum technology, narrow band technology, direct sequence and frequency hopping transmission schemes, electromagnetic interference, design of indoor wireless networks.

**Prerequisites:** IE 418 with C or better

**IE 425. INDUSTRIAL SYSTEMS OPTIMIZATION. (4 Credits)**

A first course in operations research. Topics include mathematical programming formulations and solutions, the simplex method, network optimization, introduction to metaheuristics, and linear programming under uncertainty.

**Prerequisites:** (IE 255 with C or better or ST 314 with C or better) and (MTH 306 [C] or MTH 341 [C])

**IE 426. STOCHASTIC MODELS OF INDUSTRIAL SYSTEMS. (4 Credits)**

The application of probabilistic and stochastic modeling methodologies to analyze the performance of production and service systems. Major topics include probability models for space planning, Poisson arrival processes, discrete and continuous time Markov chain models of machine cycle times, and queuing models applied to various industrial systems. Other applications of these tools to model inventories, process behavior, and equipment reliability is illustrated.

**Prerequisites:** (IE 255 with C or better or ST 314 with C or better) and IE 425 [C]

**IE 470. MANAGEMENT SYSTEMS ENGINEERING. (4 Credits)**

Improvement of organizational performance through the design and implementation of systems that integrate personnel, technological, environmental, and organizational variables. Topics include performance assessment and measurement as well as improvement methodologies.

**IE 471. PROJECT MANAGEMENT IN ENGINEERING. (3 Credits)**

Critical issues in the management of engineering and high-technology projects are discussed. Time, cost, and performance parameters are analyzed from the organizational, people, and resource perspectives. Network optimization and simulation concepts are introduced. Resource-constrained project scheduling case discussions and a term project are included.

**IE 475. ADVANCED MANUFACTURING COSTING TECHNIQUES. (3 Credits)**

Costing techniques applicable in advanced manufacturing enterprises: activity-based costing, economic value added, Japanese cost management techniques, life cycle costing, throughput accounting, cost of quality, and financial versus operational performance measures. Emphasis on linkages to such advanced manufacturing systems as cellular manufacturing, flexible manufacturing, JIT, Lean, and ERP.

**Prerequisites:** ENGR 390 with C or better

**IE 497. ^MIME CAPSTONE DESIGN. (4 Credits)**

Product design; selection and replacement of major tools, processes, and equipment; paperwork controls; subsystem revision; system or plant revision; selection and training of personnel; long-run policies and strategy. CROSSLISTED as ESE 497 and ME 497. (Writing Intensive Course)

**Attributes:** CWIC – Core, Skills, WIC

**Prerequisites:** ((IE 355 with C or better and IE 356 [C] and IE 366 [C] and IE 367 [C] and IE 368 [C] and WR 327 [C]) or ((ENGR 322 [C] or MATS 322 [C]) and (ENGR 391 [C] or ENGR 391H [C]) and ME 250 [C] and (ME 312 [C] or ME 312H [C]) and (ME 317 [C] or ME 317H [C]) and (ME 383 [C] or ME 383H [C]) and WR 327 [C] and (ST 314 [C] or ST 314H [C])) or ((ENGR 390 [C] or BA 360 [C]) and IE 425 [C] and (ME 312 [C] or ME 312H [C]) and (ME 331 [C] or ME 331H [C]) and ESE 355 [C] and ESE 360 [C] and WR 327 [C] and (ST 314 [C] or ST 314H [C]))

**Equivalent to:** ESE 497, ME 497

**IE 498. ^MIME CAPSTONE DESIGN. (4 Credits)**

Product design; selection and replacement of major tools, processes, and equipment; paperwork controls; subsystem revision; system or plant revision; selection and training of personnel; long-run policies and strategy. CROSSLISTED as ESE 498 and ME 498. (Writing Intensive Course)

**Attributes:** CWIC – Core, Skills, WIC

**Prerequisites:** ESE 497 with C or better or IE 497 with C or better or ME 497 with C or better

**Equivalent to:** ESE 498, ME 498

**IE 499. SPECIAL TOPICS. (1-5 Credits)**

Recent advances in industrial engineering pertaining to the theory and application of system studies. Analysis and design of natural resource systems; evaluation; detection extraction; processing and marketing systems; advanced design of production systems with reference to social, economic, and regional planning; human engineering studies of man-machine systems; applications of operations research techniques. Nonsequence course. Not offered every term.

*This course is repeatable for 99 credits.*

**IE 503. THESIS. (1-16 Credits)**

*This course is repeatable for 999 credits.*

**IE 505. READING AND CONFERENCE. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**IE 506. PROJECTS. (1-16 Credits)**

Graded P/N.

*This course is repeatable for 16 credits.*

**IE 507. SEMINAR. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**IE 511. VISUAL PROGRAMMING FOR INDUSTRIAL APPLICATIONS. (4 Credits)**

Object-oriented modeling, Unified Modeling Language, software development concepts, file and database connectivity, and visual programming skills (Microsoft Visual Basic) for use in developing industrial applications, such as process monitoring and supply chain management.

**Recommended:** IE 212

**IE 512. INFORMATION SYSTEMS ENGINEERING. (4 Credits)**

Framework for enterprise information systems. Engineering and scientific systems. Requirements definition, enhanced entity relationship modeling, logical modeling, structured query language, relational model, referential integrity. Lec/lab.

**IE 515. SIMULATION AND DECISION SUPPORT SYSTEMS. (4 Credits)**

Analysis of operations and production systems through the application of computer simulation modeling techniques. Fundamentals of computer simulation including random number generation, input/output data analysis, model validation and verification. Lec/lab.

**Recommended:** ST 314

**IE 518. TELECOMMUNICATION CONCEPTS. (3 Credits)**

Telecommunication concepts for industrial applications. OSI reference model, local area networks, wide area networks, internet architecture. Taught fall in even years.

**Recommended:** IE 212 and previous programming experience.

**IE 519. WIRELESS NETWORKS. (3 Credits)**

RF fundamentals, ISO 802.11 standards, spread spectrum technology, narrow band technology, direct sequence and frequency hopping transmission schemes, electromagnetic interference, design of indoor wireless networks.

**Prerequisites:** IE 518 with C or better

**IE 521. INDUSTRIAL SYSTEMS OPTIMIZATION I. (3 Credits)**

Techniques for analysis and solution of problems in industrial and management systems. Emphasis on application of linear and integer programming and extensions.

**Recommended:** MTH 341

**IE 522. INDUSTRIAL SYSTEMS OPTIMIZATION II. (3 Credits)**

Techniques for analysis and solution of problems in industrial and management systems. Emphasis on applications of dynamic programming. Markovian processes, and questions as applied to industrial problems.

**Recommended:** ST 314

**IE 545. HUMAN FACTORS ENGINEERING. (4 Credits)**

Analysis and design of work systems considering human characteristics, capabilities and limitations. Analysis and design of displays, controls, tools, and workstations. Human performance analysis. Human factors research methods.

**IE 546. HUMAN-MACHINE SYSTEMS ENGINEERING. (3 Credits)**

Development of safe, high performance human-machine systems. System/function/task analysis, function allocation, design, mockups and rapid prototyping, human factors test and evaluation. Critical examination of the human-factors and domain-specific literature to identify human factors problems, and knowledge and methods to address those problems.

**Recommended:** IE 545

**IE 548. COGNITIVE ENGINEERING. (3 Credits)**

Theories and models of human sensory, cognitive, and motor performance pertaining to the operation of complex systems. Applications to human-machine systems engineering. Research topics and methods related to cognitive engineering.

**Recommended:** IE 545

**IE 552. DESIGN OF INDUSTRIAL EXPERIMENTS. (3 Credits)**

A first course in design of experiments with an emphasis on applications and fundamental data analysis methods. Basic statistical inference, analysis of variance, blocking, general factorial designs, and two-level factorial designs are covered.

**Recommended:** ST 314

**IE 553. DESIGN OF INDUSTRIAL EXPERIMENTS II. (3 Credits)**

This second course in design of experiments is a continuation of IE 552. The same textbook is used. Topics covered include two-level fractional factorial designs, regression models, response surface methods, rules for expected sum of squares and expected mean squares, a summary of the "no-name" approach to DOE, and analysis of experiments with unbalanced data (time permitting).

**Prerequisites:** IE 552 with C or better

**IE 563. ADVANCED PRODUCTION PLANNING AND CONTROL. (3 Credits)**

Application of quantitative and heuristic methods to problems of production, material, and capacity planning. Mathematical models for inventory systems, sequencing, and scheduling. Assembly line balancing methods. Just-in-time manufacturing.

**Recommended:** IE 521 and ST 314

**IE 564. DESIGN AND SCHEDULING OF CELLULAR MANUFACTURING SYSTEMS. (3 Credits)**

Designing manufacturing cells. Impact of alternate process plan on cell design. Part-machine assignment to cells. Disaggregated manufacturing cells. Group scheduling.

**Recommended:** Computer experience

**IE 570. MANAGEMENT SYSTEMS ENGINEERING. (4 Credits)**

Improvement of organizational performance through the design and implementation of systems that integrate personnel, technological, environmental, and organizational variables. Topics include performance assessment and measurement as well as improvement methodologies.

**IE 571. PROJECT MANAGEMENT IN ENGINEERING. (3 Credits)**

Critical issues in the management of engineering and high-technology projects are discussed. Time, cost, and performance parameters are analyzed from the organizational, people, and resource perspectives. Network optimization and simulation concepts are introduced. Resource-constrained project scheduling case discussions and a term project are included.

**IE 575. SYSTEMS THINKING THEORY AND PRACTICE. (4 Credits)**

An introduction to systems science theory and practice. Systems science theory is explored through the fundamentals of systems thinking theory, and theory of knowledge. Systems science practice is explored through system dynamics modeling techniques for simulating socio-technical systems, structures, and processes.

**IE 581. OPERATIONS MANAGEMENT. (4 Credits)**

Critical and current issues on the implementation of operations management strategies for the engineering manager. Includes aspects of operations in an engineering management environment such as work systems design, forecasting, strategy, facilities location and design, management of quality and resources planning and management.

**Prerequisites:** IE 582 with B or better

**Recommended:** IE 571

**IE 582. INTRODUCTION TO MANAGEMENT FOR ENGINEERS AND SCIENTISTS. (4 Credits)**

An introduction to concepts, tools, and practices necessary for a broad understanding of the roles of engineering and technical managers. A mix of research results, case studies, and experiential learning is used to bolster theories of management, with focus on technical organizations.

**IE 583. ADVANCED ENGINEERING ECONOMICS ANALYSIS. (4 Credits)**

Examines the economics dimension of engineering management, from costing techniques to financial analysis. Topics include industrial cost analysis and estimation, economic planning, forecasting, and budgeting, and financial analysis for engineering and engineering management.

**Prerequisites:** IE 582 with B or better

**Recommended:** Basic courses in engineering economic analysis (ENGR 390)

**IE 584. SYSTEMS ENGINEERING. (4 Credits)**

An overview of systems engineering within engineering management practice. Principles of systems engineering are explored through traditional and contemporary hard and soft systems of engineering techniques and practices, and through current future developments in the field.

**Prerequisites:** IE 582 with B- or better

**Recommended:** IE 581 and IE 583 and IE 586 and IE 587

**IE 585. LEGAL ASPECT OF ENGINEERING MANAGEMENT. (3 Credits)**

A survey of legal topics relevant to engineers, including basic of legal system, labor law, intellectual property, torts, and contracts. This is an introductory course, emphasizes on legal principles that can provide engineers with the ability to recognize legal issues that are likely to arise in the engineering profession and engineering management. Note: This is an introductory class and will in no way make a student a lawyer. Students are advised to seek legal representation if he/she encounters a legal issue.

**Prerequisites:** IE 582 with B or better

**Recommended:** IE 581 and IE 583 and (IE 586 or CCE 552)

**IE 586. PROJECT RISK MANAGEMENT. (4 Credits)**

An introduction to the concept of project risk in producing constructed engineering projects. Course content includes project baselining, risk definition and identification, risk assessment and management techniques, risk control, risk response, and risk management.

CROSSLISTED as CCE 552.

**Equivalent to:** CCE 552

**IE 587. MANAGEMENT OF INFORMATION SYSTEMS. (4 Credits)**

An introduction to the management of information systems and their strategic importance in business. Topics covered include global e-business and collaboration, databases and information management, basics of telecommunications and wireless technology, security vulnerabilities of information systems, basics of business intelligence and business analytics, knowledge management and enhanced decision making.

**Prerequisites:** IE 582 with B or better

**IE 588. MANAGEMENT OF NEW PRODUCT DEVELOPMENT. (4 Credits)**

Introduces the new product development (NPD) process with the objective of understanding the underlying structure in NPD and exploring the methods to manage NPD processes by applying them to case studies and term project. The NPD process is investigated through its five key phases: (1) Opportunity identification/selection, (2) Concept generation, (3) Concept/project evaluation, (4) Development, and (5) Launch.

**Prerequisites:** IE 581 with B or better and IE 582 [B] and IE 583 [B]

**Recommended:** IE 584

**IE 589. PROFESSIONAL RESPONSIBILITY AND ETHICS. (3 Credits)**

An in-depth exploration of professional engineering ethics. Course content includes conceptual theoretical basis of ethics, ethics among professional organizations, ethical consideration of design, critical analysis of ethical situations, ethics in the workplace, and ethical considerations regarding the broader environment. CROSSLISTED as CCE 554.

**Equivalent to:** CCE 554

**IE 590. STRATEGIC PLANNING IN ENGINEERING ORGANIZATIONS. (4 Credits)**

Provides an overview the strategic planning process from a variety engineering perspective. Variety engineering is explored via key management control theory concepts and through applying students' work experience.

**Prerequisites:** IE 581 with B or better and IE 582 [B] and IE 583 [B]

**IE 594. RESEARCH METHODS IN ENGINEERING. (3 Credits)**

Introduction to research methodologies including surveys, interviews, quasi-experimentation, and case studies. Methods for research design, and collection and analysis of data.

**IE 599. SPECIAL TOPICS. (1-5 Credits)**

Recent advances in industrial engineering pertaining to the theory and application of system studies. Analysis and design of natural resource systems; evaluation; detection extraction; processing and marketing systems; advanced design of production systems with reference to social, economic, and regional planning; human engineering studies of man-machine systems; applications of operations research techniques. Nonsequence course. Not offered every term.

*This course is repeatable for 99 credits.*

**IE 603. THESIS. (1-16 Credits)**

*This course is repeatable for 999 credits.*

**IE 605. READING AND CONFERENCE. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**IE 606. PROJECTS. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**IE 607. SEMINAR. (1-16 Credits)**

*This course is repeatable for 16 credits.*

## Materials Science

**MATS 221. THE SCIENCE, ENGINEERING AND SOCIAL IMPACT OF NANOTECHNOLOGY. (3 Credits)**

Nanotechnology is an emerging engineering field that manipulates atoms and molecules to fabricate new materials and tiny devices. Properties of nanostructured materials, manufacturing methods, characterization methods, and impact on health and safety. Benefits and concerns about nanotechnology will be assessed. Lec/rec. CROSSLISTED as ENGR 221.

**Equivalent to:** ENGR 221

**Recommended:** One year of college science.

**MATS 321. INTRODUCTION TO MATERIALS SCIENCE. (4 Credits)**

Crystal structure, microstructure, and physical properties of metals, ceramics, polymers, composites, and amorphous materials. Also includes elementary mechanical behavior and phase equilibria. Lec. CROSSLISTED as ENGR 321.

**Prerequisites:** (CH 202 with C or better or CH 222 with C or better or CH 232 with C or better or CH 232H with C or better or CH 224H with C or better)

**Equivalent to:** ENGR 321

**MATS 322. MECHANICAL PROPERTIES OF MATERIALS. (3 Credits)**

Mechanical behavior of materials, relating laboratory test results to material structure, and elements of mechanical analysis. Lec/lab. CROSSLISTED as ENGR 322.

**Prerequisites:** (ENGR 213 with C or better or ENGR 213H with C or better) and (ENGR 321 [C] or ENGR 321H [C] or MATS 321 [C])

**Equivalent to:** ENGR 322

**MATS 445. WELDING METALLURGY. (4 Credits)**

Theory-based course focused on the metallurgy of welds. Topics covered include welding/joining processes, heat input, diffusion, solidification, phase transformation, materials compatibility and welding defects. This is NOT a practical welding class.

**Prerequisites:** (MATS 321 with C or better or ENGR 321 with C or better or ENGR 321H with C or better) or MATS 570 with C or better

**MATS 455. EXPERIMENTAL TECHNIQUES IN MATERIAL SCIENCE. (4 Credits)**

Materials processing, characterization, computational and data analysis techniques in materials science. Focus on processing-structure-property relationships. Lec/lab.

**Prerequisites:** (ENGR 321 with C or better or ENGR 321H with C or better) *This course is repeatable for 8 credits.*

**Recommended:** ME 570

**MATS 478. THIN FILM MATERIALS CHARACTERIZATION AND PROPERTIES. (4 Credits)**

Processing of thin films and characterization of the microstructure; diffusion and solid state reactions; mechanical, magnetic and electronic properties of thin films.

**Prerequisites:** (ME 311 with C or better or ME 311H with C or better) and (ENGR 321 [C] or ENGR 321H [C] or MATS 321 [C]) and (ENGR 322 [C] or MATS 322 [C])

**MATS 499. SPECIAL TOPICS. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**MATS 509. MATERIALS SCIENCE SEMINAR. (1 Credit)**

Student participation seminar experience for one credit; students will listen to seminars concerning ongoing research activities within materials science. Students will also have the opportunity to present their own research results periodically. Graded P/N. CROSSLISTED as ME 509.

**Equivalent to:** ME 509

**MATS 545. WELDING METALLURGY. (4 Credits)**

Theory-based course focused on the metallurgy of welds. Topics covered include welding/joining processes, heat input, diffusion, solidification, phase transformation, materials compatibility and welding defects. This is NOT a practical welding class.

**Recommended:** (MATS 321 or ENGR 321 or ENGR 321H) or MATS 570

**MATS 555. EXPERIMENTAL TECHNIQUES IN MATERIAL SCIENCE. (4 Credits)**

Materials processing, characterization, computational and data analysis techniques in materials science. Focus on processing-structure-property relationships. Lec/lab.

**Prerequisites:** ME 570 with C or better

*This course is repeatable for 8 credits.*

**Recommended:** ENGR 321 or ENGR 321H

**MATS 570. STRUCTURE-PROPERTY RELATIONS IN MATERIALS. (4 Credits)**

Fundamentals of the interactions between the structure and properties of materials. Atomic bonding and atom interactions. Geometric and algebraic representations of symmetry. Introduction to phase equilibria. Phenomenological background of elasticity and plasticity in materials. Anisotropic materials and tensor representations. Influence of structure on thermal, electrical, and optical properties of materials. CROSSLISTED as ME 570.

**Equivalent to:** ME 570

**MATS 571. ELECTRONIC PROPERTIES OF MATERIALS. (4 Credits)**

Development of a quantitative description of the electronic structure of solids starting with the quantum mechanical model of the atom, atomic bonding, and band theory of solids. Quantitative description of the electronic properties of metals, semiconductors, and insulators.

**Recommended:** CH 545 or ME 570

**MATS 578. THIN FILM MATERIALS CHARACTERIZATION AND PROPERTIES. (4 Credits)**

Processing of thin films and characterization of the microstructure; diffusion and solid state reactions; mechanical, magnetic and electronic properties of thin films.

**MATS 581. THERMODYNAMICS OF SOLIDS. (4 Credits)**

Thermodynamics of solutions and phase equilibrium. Phase diagrams and invariant reactions. Order and disorder in solutions. Applications to advanced materials development. Lec/lab.

**MATS 582. RATE PROCESSES IN MATERIALS. (4 Credits)**

Diffusion in solids, including vacancy and interstitial and short-circuit diffusion. Phase transformations including classic nucleation and growth theory. Applications to materials development. Laboratory will emphasize microstructural evaluation and quantitative metallography. Lec/lab.

**MATS 584. ADVANCED FRACTURE OF MATERIALS. (4 Credits)**

Fracture mechanics will be used as a basis for predicting failure of materials, understanding failure mechanisms, and identifying causes of failure. Course will include discussion of recent journal articles, experimental demonstrations, and analysis of real fracture data.

CROSSLISTED as ME 584.

**Equivalent to:** ME 584

**Recommended:** ENGR 322

**MATS 587. DISLOCATIONS, DEFORMATION, AND CREEP. (4 Credits)**

The effects of point, line, and planar defects on plastic deformation and creep behavior in solids will be discussed with emphasis on the role of dislocations and vacancies.

**Recommended:** ENGR 322



**MATS 588. COMPUTATIONAL METHODS IN MATERIALS SCIENCE. (4 Credits)**

A broad introduction to important materials science simulation methods. These include molecular dynamics, density functional theory, and Monte Carlo methods. Learning is through a mixture of lecture and hands-on lab projects in which students use computational methods to explore and reinforce fundamental concepts in materials science. Lec/lab. CROSSLISTED as ME 588.

**Equivalent to:** ME 588

**Recommended:** Experience with Matlab or Mathematica or an equivalent

**MATS 599. SPECIAL TOPICS. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**MATS 671. ELECTRONIC PROPERTIES OF OXIDES. (4 Credits)**

Band theory of solids applied to metal oxide materials. Includes metallic oxides, non-stoichiometric semiconductors and associated defect chemistry, high temperature superconductors, electrostatics, linear dielectrics, non-linear dielectrics, piezoelectrics, and the optical properties of oxides.

**Recommended:** ME 571 or MATS 571 or PH 575

## Mechanical Engineering

**ME 206. PROJECTS. (1-16 Credits)****ME 250. INTRODUCTION TO MANUFACTURING PROCESSES. (1 Credit)**

Use of measuring and layout tools, interpretation of blueprints and drawings, identification of engineering materials. Operation of machine tools, including calculation of machining parameters. Operation of gas and MIG welding equipment. Lec/lab. Graded P/N.

**Prerequisites:** ENGR 248 with C or better

**ME 299. SPECIAL TOPICS. (1-16 Credits)**

Graded P/N.

**Equivalent to:** ME 299H

*This course is repeatable for 16 credits.*

**ME 299H. SPECIAL STUDIES. (1-16 Credits)**

Graded P/N.

**Attributes:** HNRS – Honors Course Designator

**Equivalent to:** ME 299

*This course is repeatable for 16 credits.*

**ME 306. PROJECTS. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ME 311. INTRODUCTION TO THERMAL-FLUID SCIENCES. (4 Credits)**

Basic concepts of fluid mechanics, thermodynamics and heat transfer are introduced. Conservation of mass, energy, moment and the second law of thermodynamics are included. CROSSLISTED as NSE 311.

**Prerequisites:** (ENGR 212 with C or better or ENGR 212H with C or better) and (MTH 256 [C] or MTH 256H [C])

**Equivalent to:** ME 311H, NSE 311, NSE 311H

**ME 311H. INTRODUCTION TO THERMAL-FLUID SCIENCES. (4 Credits)**

Basic concepts of fluid mechanics, thermodynamics and heat transfer are introduced. Conservation of mass, energy, moment and the second law of thermodynamics are included. CROSSLISTED as NSE 311H.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** (ENGR 212 with C or better or ENGR 212H with C or better) and (MTH 256 [C] or MTH 256H [C])

**Equivalent to:** ENGR 311, ENGR 311H, ME 311, NSE 311, NSE 311H

**ME 312. THERMODYNAMICS. (4 Credits)**

Exergy destruction, machine and cycle processes, law of corresponding states, non-reactive gas mixtures, reactive mixtures, thermodynamics of compressible fluid flow. CROSSLISTED as NSE 312.

**Prerequisites:** (MTH 256 with C or better or MTH 256H with C or better) and (ME 311 [C] or ME 311H [C] or NSE 311 [C] or NSE 311H [C] or NE 311 [C] or NE 311H [C])

**Equivalent to:** ME 312H, NSE 312, NSE 312H

**ME 312H. THERMODYNAMICS. (4 Credits)**

Energy destruction, machine and cycle processes, law of corresponding states, non-reactive gas mixtures, reactive mixtures, thermodynamics of compressible fluid flow. CROSSLISTED as NSE 312H.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** (MTH 256 with C or better or MTH 256H with C or better) and (ME 311 [C] or ME 311H [C] or NSE 311 [C] or NSE 311H [C] or NE 311 [C] or NE 311H [C])

**Equivalent to:** ME 312, NSE 312, NSE 312H

**ME 316. MECHANICS OF MATERIALS. (3 Credits)**

Determination of stresses, deflections, and stability of deformable bodies with an introduction to finite element analysis.

**Prerequisites:** (ENGR 213 with C or better or ENGR 213H with C or better) and (MTH 256 [C] or MTH 256H [C])

**ME 317. INTERMEDIATE DYNAMICS. (4 Credits)**

Continuation of the study of kinematics and kinetics of particles and rigid bodies, with applications to mechanical systems of current interest to engineers.

**Prerequisites:** (ENGR 212 with C or better or ENGR 212H with C or better) and (MTH 256 [C] or MTH 256H [C])

**Equivalent to:** ME 317H

**ME 317H. INTERMEDIATE DYNAMICS. (4 Credits)**

Continuation of the study of kinematics and kinetics of particles and rigid bodies, with applications to mechanical systems of current interest to engineers.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** ((ENGR 212 with C or better or ENGR 212H with C or better) and (MTH 256 [C] or MTH 256H [C]))

**Equivalent to:** ME 317

**ME 331. INTRODUCTORY FLUID MECHANICS. (4 Credits)**

Introduces the concepts and applications of fluid mechanics and dimensional analysis with an emphasis on fluid behavior, internal and external flows, analysis of engineering applications of incompressible pipe systems, and external aerodynamics. CROSSLISTED as NSE 331.

**Prerequisites:** ((MTH 254 with C or better or MTH 254H with C or better) and (MTH 256 [C] or MTH 256H [C]) and (ENGR 212 [C] or ENGR 212H [C]) and (ENGR 311 [C] or ME 311 [C] or ME 311H [C] or NSE 311 [C] or NSE 311H [C] or NE 311 [C] or NE 311H [C]))

**Equivalent to:** ME 331H, NSE 331, NSE 331H

**ME 331H. INTRODUCTORY FLUID MECHANICS. (4 Credits)**

Introduces the concepts and applications of fluid mechanics and dimensional analysis with an emphasis on fluid behavior, internal and external flows, analysis of engineering applications of incompressible pipe systems, and external aerodynamics. CROSSLISTED as NSE 331H.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** ((MTH 254 with C or better or MTH 254H with C or better) and (MTH 256 [C] or MTH 256H [C]) and (ENGR 212 [C] or ENGR 212H [C]) and (ENGR 311 [C] or ME 311 [C] or ME 311H [C] or NSE 311 [C] or NSE 311H [C] or NE 311 [C] or NE 311H [C]))

**Equivalent to:** ME 331, NSE 331, NSE 331H

**ME 332. HEAT TRANSFER. (4 Credits)**

A treatment of conductive, convective and radiative energy transfer using control volume and differential analysis and prediction of transport properties. CROSSLISTED as NSE 332.

**Prerequisites:** ((MTH 256 with C or better or MTH 256H with C or better) and (ENGR 212 [C] or ENGR 212H [C]) and (ME 311 [C] or ME 311H [C] or NE 311 [C] or NE 311H [C]) and (ME 331 [C] or ME 331H [C] or NSE 331 [C] or NSE 331H [C] or NE 331 [C] or NE 331H [C]))

**Equivalent to:** ME 332H, NSE 332, NSE 332H

**ME 332H. HEAT TRANSFER. (4 Credits)**

A treatment of conductive, convective and radiative energy transfer using control volume and differential analysis and prediction of transport properties. CROSSLISTED as NSE 332H.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** ((MTH 256 with C or better or MTH 256H with C or better) and (ENGR 212 [C] or ENGR 212H [C]) and (ME 311 [C] or ME 311H [C] or NE 311 [C] or NE 311H [C]) and (ME 331 [C] or ME 331H [C] or NSE 331 [C] or NSE 331H [C] or NE 331 [C] or NE 331H [C]))

**Equivalent to:** ME 332, NSE 332, NSE 332H

**ME 348. ADVANCED SOLID MODELING. (1 Credit)**

Practical application of graphical communication theory using advanced solid modeling software to capture design intent and generate engineering drawings. Lec/lab. Graded P/N.

**Prerequisites:** ENGR 248 with C or better

**ME 373. MECHANICAL ENGINEERING METHODS. (3 Credits)**

Analytical and numerical methods for solving representative mechanical engineering problems. Lec/rec.

**Prerequisites:** (ENGR 112 with C or better or ENGR 112H with C or better) and (MTH 256 [C] or MTH 256H [C])

**Equivalent to:** ME 373H

**ME 373H. MECHANICAL ENGINEERING METHODS. (3 Credits)**

Analytical and numerical methods for solving representative mechanical engineering problems. Lec/rec.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** (ENGR 112 with C or better or ENGR 112H with C or better) and (MTH 256 [C] or MTH 256H [C])

**Equivalent to:** ME 373

**ME 382. INTRODUCTION TO DESIGN. (4 Credits)**

Organization, planning, economics, and the use of creativity and optimization in solving mechanical design problems. Case studies and/or industrial design problems. Lec/lab.

**Prerequisites:** ENGR 248 with C or better and ME 250 (may be taken concurrently) [C]

**Equivalent to:** ME 382H

**ME 382H. INTRODUCTION TO DESIGN. (4 Credits)**

Organization, planning, economics, and the use of creativity and optimization in solving mechanical design problems. Case studies and/or industrial design problems. Lec/lab.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** ENGR 248 with C or better and ME 250 (may be taken concurrently) [C]

**Equivalent to:** ME 382

**ME 383. MECHANICAL COMPONENT DESIGN. (4 Credits)**

Failure analysis and design of machine components. Lec/lab.

**Prerequisites:** ME 316 with C or better and ME 250 (may be taken concurrently) [C]

**Equivalent to:** ME 383H

**ME 383H. MECHANICAL COMPONENT DESIGN. (4 Credits)**

Failure analysis and design of machine components. Lec/lab.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** ME 316 with C or better and ME 250 (may be taken concurrently) [C]

**Equivalent to:** ME 383

**ME 401. RESEARCH. (1-16 Credits)**

*This course is repeatable for 9 credits.*

**ME 403. THESIS. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ME 405. READING AND CONFERENCE. (1-16 Credits)**

**Equivalent to:** ME 405H

*This course is repeatable for 9 credits.*

**ME 405H. READING AND CONFERENCE. (1-16 Credits)**

**Attributes:** HNRS – Honors Course Designator

**Equivalent to:** ME 405

*This course is repeatable for 9 credits.*

**ME 406. PROJECTS. (1-16 Credits)**

*This course is repeatable for 15 credits.*

**ME 407. SEMINAR. (1-16 Credits)**

*This course is repeatable for 2 credits.*

**ME 410. INTERNSHIP. (1-16 Credits)**

Credits may not apply toward BS degree in Mechanical Engineering. Graded P/N.

*This course is repeatable for 16 credits.*

**ME 411. AEROSPACE APPLICATIONS IN MECHANICAL ENGINEERING. (4 Credits)**

Provides students with the fundamentals of mechanical engineering applications to aerospace. Topics covered include an overview of modern aircraft and spacecraft analysis, with an emphasis on performance, stability, structures, materials, FAA and FAR standards and current professional practices in the conceptual design of aerospace vehicles. Student projects will integrate course topics.

**Prerequisites:** (ME 316 with C or better and (ME 317 [C] or ME 317H [C]) and (ME 331 [C] or ME 331H [C]) and (ME 373 [C] or ME 373H [C]))

**ME 412. DESIGN OF MECHANISMS. (4 Credits)**

Analysis and study of the function, classification, position, velocity, and acceleration of multi-element mechanical linkages and mechanisms. Synthesis of mechanisms for specified multiple point paths, quick return, dwell, and straight-line motion. The lecture will instruct students in the kinematic analysis and synthesis of mechanisms through the use of theory and software packages. The laboratory will familiarize students with a modern mechanism design and animation software package. Lec/lab.

**Prerequisites:** (ME 317 with C or better or ME 317H with C or better) and ME 383 [C]

**ME 413. COMPUTER-AIDED DESIGN AND MANUFACTURING. (4 Credits)**

Introduces students to the use of computers in several extended areas of product design and manufacturing. These areas include product data management in a sustaining engineering environment; computer-aided manufacturing (CAM) and computer numerical control (CNC) operations and technology; the use of programmable logic controllers (PLCs) for industrial control systems; and the use of simulation software for virtual prototyping for Design/Manufacturing/Validation. Lec/lab.

**Prerequisites:** ME 382 with C or better or ME 382H with C or better or IE 366 with C or better

**ME 420. APPLIED STRESS ANALYSIS. (4 Credits)**

Elasticity theory, failure theories, energy methods, finite element analysis.

**Prerequisites:** ME 316 with C or better

**ME 422. MECHANICAL VIBRATIONS. (4 Credits)**

Dynamic response of single and multiple degree-of-freedom systems.

**Prerequisites:** ME 317 with C or better or ME 317H with C or better

**Equivalent to:** ME 422H

**ME 422H. MECHANICAL VIBRATIONS. (4 Credits)**

Dynamic response of single and multiple degree-of-freedom systems.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** ME 317 with C or better or ME 317H with C or better

**Equivalent to:** ME 422

**ME 424. FINITE ELEMENT MODELING OF MECHANICAL ENGINEERING SYSTEMS. (3 Credits)**

Application of modern finite element code in the analysis of complex mechanical engineering systems. Extensive use of engineering workstations. Lec/lab.

**Prerequisites:** ME 420 with C or better or ME 520 with C or better

**ME 430. SYSTEMS DYNAMICS AND CONTROL. (4 Credits)**

Modeling and analysis of linear continuous systems in time and frequency domains. Fundamentals of single-input-single-output control system design. CROSSLISTED as ECE 451.

**Prerequisites:** (ME 317 with C or better or ME 317H with C or better or (ECE 351 with C or better and ECE 352 [C] and (ENGR 212 [C] or ENGR 212H [C])) )

**Equivalent to:** ECE 451, ME 430H

**ME 430H. SYSTEMS DYNAMICS AND CONTROL. (4 Credits)**

Modeling and analysis of linear continuous systems in time and frequency domains. Fundamentals of single-input-single-output control system design. CROSSLISTED as ECE 451.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** (ME 317 with C or better or ME 317H with C or better or (ECE 351 with C or better and ECE 352 [C] and (ENGR 212 [C] or ENGR 212H [C])) )

**Equivalent to:** ECE 451, ME 430

**ME 443. RENEWABLE ENERGY: THERMAL FLUID SYSTEMS. (4 Credits)**

Evaluates several thermal/fluid power conversion strategies that deal with both thermal and fluid energy sources in terms of basic conversion technology, resource potential and developmental challenges. There are four modules, each targeting a particular renewable energy system in thermal and fluid sciences.

**Prerequisites:** (ME 311 with C or better or ME 311H with C or better or NE 311 with C or better or NE 311H with C or better) and (ME 331 [C] or ME 331H [C] or NE 331 [C] or NE 331H [C]) and (ME 332 [C] or ME 332H [C] or NE 332 [C] or NE 332H [C])

**ME 444. THERMAL SYSTEMS DESIGN AND ANALYSIS. (4 Credits)**

Integration of the concepts, laws, and methodologies from fluid mechanics, heat transfer, and thermodynamics, into a set of practical tools for thermal energy systems design and analysis.

**Prerequisites:** (ME 332 with C or better or ME 332H with C or better or NSE 332 with C or better or NSE 332H with C or better) and (ME 312 (may be taken concurrently) [C] or ME 312H (may be taken concurrently) [C] or NSE 312 (may be taken concurrently) [C] or NSE 312H (may be taken concurrently) [C])

**ME 445. INTRODUCTION TO COMBUSTION. (4 Credits)**

Study of combustion science based on the background of chemistry, thermodynamics, fluid mechanics, heat and mass transfer. Stoichiometry, energetics of chemical reactions, flame temperature, equilibrium product analyses, chemical kinetics, and chain reactions.

**Prerequisites:** (ME 312 with C or better or ME 312H with C or better) and (ME 332 [C] or ME 332H [C])

**ME 450. APPLIED HEAT TRANSFER. (4 Credits)**

An intermediate heat transfer course seeking to lay a foundation for determining the heating and cooling characteristics with a variety of modern and classical processes. Included is design of multi-component heat transfer systems. Lecture, 110 minutes twice per week.

**Prerequisites:** ME 332 with C or better or ME 332H with C or better

**ME 451. INTRODUCTION TO INSTRUMENTATION AND MEASUREMENT SYSTEMS. (4 Credits)**

Function, operation, and application of common mechanical engineering instruments, measurement principles, and statistical analysis. Major elements of measurement systems, including transduction, signal conditioning, and data recording. Function and operation of digital data acquisition systems. Lec/lab.

**Prerequisites:** (ENGR 202 with C or better or ENGR 202H with C or better) and (ME 311 [C] or ME 311H [C]) and ME 316 [C] and (ME 317 [C] or ME 317H [C]) and (ME 373 [C] or ME 373H [C]) and (ST 314 [C] or ST 314H [C])

**ME 452. THERMAL AND FLUIDS SCIENCES LABORATORY. (4 Credits)**

Course emphasis is on experiments related to thermodynamics, heat transfer, and fluid mechanics. Proper experimental methods, data and uncertainty analysis related to thermal and fluids measurements are discussed.

**Prerequisites:** (ME 311 with C or better or ME 311H with C or better) and (ME 331 [C] or ME 331H [C]) and (ME 332 [C] or ME 332H [C])

**Equivalent to:** ME 452H

**ME 452H. THERMAL AND FLUIDS SCIENCES LABORATORY. (4 Credits)**

Course emphasis is on experiments related to thermodynamics, heat transfer, and fluid mechanics. Proper experimental methods, data and uncertainty analysis related to thermal and fluids measurements are discussed.

**Attributes:** HNRS – Honors Course Designator

**Prerequisites:** (ME 311 with C or better or ME 311H with C or better) and (ME 331 [C] or ME 331H [C]) and (ME 332 [C] or ME 332H [C])

**Equivalent to:** ME 452

**ME 453. STRUCTURE AND MECHANICS LABORATORY. (4 Credits)**

Techniques for measurement of structural response and material properties. Proper use of rosette strain gauges, load cells, and displacement transducers. Full-field strain measurement using photoelasticity and digital image correlation. Proper implementation of material testing standards. Characterization of anisotropic composite materials.

**Prerequisites:** ME 451 with C or better

**ME 460. INTERMEDIATE FLUID MECHANICS. (4 Credits)**

Ideal fluid flow including potential flow theory. Introduction to compressible flow. Viscous flow and boundary layer theory. Introduction to turbulence.

**Prerequisites:** ME 331 with C or better or ME 331H with C or better

**ME 461. GAS DYNAMICS. (4 Credits)**

Studies one-dimensional isentropic flow, nozzles, diffusers, normal and oblique shocks, compressible flow with friction and heating, and an introduction to propulsion systems.

**Prerequisites:** (ME 312 with C or better or ME 312H with C or better) and (ME 331 [C] or ME 331H [C])

**ME 480. MATERIALS SELECTION. (3 Credits)**

Selecting materials for engineering applications. The major families of materials, their properties, and how their properties are controlled; case studies and design projects emphasizing materials selection.

**Prerequisites:** MATS 322 with C or better or ENGR 322 with C or better

**ME 484. FRACTURE OF MATERIALS. (3 Credits)**

Fracture mechanics and fatigue mechanisms: mechanisms of ductile and brittle fracture. Environmentally induced fracture and fatigue. Considerations in design of engineering materials and structures will be discussed.

**Prerequisites:** MATS 322 with C or better or ENGR 322 with C or better

**ME 497. ^MIME CAPSTONE DESIGN. (4 Credits)**

Product design; selection and replacement of major tools, processes, and equipment; paperwork controls; subsystem revision; system or plant revision; selection and training of personnel; long-run policies and strategy. CROSSLISTED as ESE 497 and IE 497. (Writing Intensive Course)

**Attributes:** CWIC – Core, Skills, WIC

**Prerequisites:** ((IE 355 with C or better and IE 356 [C] and IE 366 [C] and IE 367 [C] and IE 368 [C] and WR 327 [C])) or ((ENGR 322 [C] or MATS 322 [C] and (ENGR 391 [C] or ENGR 391H [C]) and ME 250 [C] and (ME 312 [C] or ME 312H [C]) and (ME 317 [C] or ME 317H [C]) and (ME 383 [C] or ME 383H [C]) and WR 327 [C] and (ST 314 [C] or ST 314H [C])) or ((ENGR 390 [C] or BA 360 [C]) and IE 425 [C] and (ME 312 [C] or ME 312H [C]) and (ME 331 [C] or ME 331H [C]) and ESE 355 [C] and ESE 360 [C] and WR 327 [C] and (ST 314 [C] or ST 314H [C]))

**Equivalent to:** ESE 497, IE 497

**ME 498. ^MIME CAPSTONE DESIGN. (4 Credits)**

Product design; selection and replacement of major tools, processes, and equipment; paperwork controls; subsystem revision; system or plant revision; selection and training of personnel; long-run policies and strategy. CROSSLISTED as ESE 498 and IE 498. (Writing Intensive Course)

**Attributes:** CWIC – Core, Skills, WIC

**Prerequisites:** ESE 497 with C or better or IE 497 with C or better or ME 497 with C or better

**Equivalent to:** ESE 498, IE 498

**ME 499. SPECIAL TOPICS. (0-16 Credits)**

**Equivalent to:** ME 499H

*This course is repeatable for 16 credits.*

**ME 499H. SPECIAL TOPICS. (0-16 Credits)**

**Attributes:** HNRS – Honors Course Designator

**Equivalent to:** ME 499

*This course is repeatable for 16 credits.*

**ME 501. RESEARCH. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ME 502. INDEPENDENT STUDIES. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ME 503. THESIS. (1-16 Credits)**

*This course is repeatable for 999 credits.*

**ME 505. READING AND CONFERENCE. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ME 506. PROJECTS. (1-16 Credits)**

Graded P/N.

*This course is repeatable for 16 credits.*

**ME 507. SEMINAR. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ME 508. THERMAL FLUID SCIENCE SEMINAR. (1 Credit)**

Student participation seminar experience for 1 course credit. Students will present and listen to seminars concerning ongoing research within the thermal fluid sciences.

**ME 509. MATERIALS SCIENCE SEMINAR. (1 Credit)**

Student participation seminar experience for one credit; students will listen to seminars concerning ongoing research activities within materials science. Students will also have the opportunity to present their own research results periodically. Graded P/N. CROSSLISTED as MATS 509.

**Equivalent to:** MATS 509

**ME 511. PRECISION MACHINE DESIGN. (3 Credits)**

Tolerance analysis and application in design/manufacturing practice, principles of machine design and computational analysis of errors in machine design, sensor mounting and sensor calibration, machine level error budget with geometric and thermal errors, structural design of joints and supports, deterministic damping, exact constraint design for flexures and couplings, bearing systems design, motion and power system design for machine tools. CROSSLISTED as MFGE 511.

**Equivalent to:** MFGE 511

**Recommended:** An understanding of mechanical component design and solid

**ME 512. DESIGN OF MECHANISMS. (4 Credits)**

Analysis and study of the function, classification, position, velocity, and acceleration of multi-element mechanical linkages and mechanisms. Synthesis of mechanisms for specified multiple point paths, quick return, dwell, and straight-line motion. The lecture will instruct students in the kinematic analysis and synthesis of mechanisms through the use of theory and software packages. The laboratory will familiarize students with a modern mechanism design and animation software package. Lec/lab.

**Recommended:** (ME 317 or ME 317H) and ME 383

**ME 513. BIO-INSPIRED DESIGN. (4 Credits)**

Intersection of design and biology that seeks to systematically mine biological knowledge to solve design problems. Investigates inspiration from nature from three different types: visual, conceptual, and computational. Includes design rules, heuristics, principles or patterns to solve engineering problems. Algorithmic bio-inspiration emulates natural algorithms for control or optimization problems.

**ME 515. RISK AND RELIABILITY ANALYSIS IN ENGINEERING DESIGN. (4 Credits)**

Fundamentals of risk, uncertainty, and reliability. Methods to analyze and quantify the risk of failures, and the reliability of complex systems, including fault tree analysis, reliability block diagrams, probabilistic risk assessment. Introduction to research methods for risk and reliability analysis during the early design stages.

**ME 516. MODELING AND ANALYSIS OF COMPLEX SYSTEMS. (4 Credits)**

Introduction to challenges and considerations when designing complex systems. Fundamentals of systems engineering and methods used in practice. Models and tools used to enable the use of models for trade studies during the design of complex systems. Model-based design environments and methodologies. Introduction to decision support tools in design.

**ME 517. OPTIMIZATION IN DESIGN. (4 Credits)**

Optimization methods as applied to engineering design, theory and application of nonlinear optimization techniques for multivariate unconstrained and constrained problems. Model boundedness and sensitivity.

**ME 519. SELECTED TOPICS IN DESIGN. (3-4 Credits)**

Topics in mechanical design selected from the following: design processes, quality engineering, design for assembly, statistical machine design, the Taguchi method, and parametric design.

*This course is repeatable for 32 credits.*

**ME 520. APPLIED STRESS ANALYSIS. (4 Credits)**

Elasticity theory, failure theories, energy methods, finite element analysis.

**Recommended:** ME 316

**ME 521. LINEAR ELASTICITY. (4 Credits)**

A general introduction to the theory of elasticity. The solution of 2-D problems using the Airy stress function in rectangular and polar coordinates. The solution of 3-D problems using the Galerkin vector, the Papkovitch-Neuber solution, and complex variable methods. Applications to asymptotic fields at discontinuities, contact and crack problems, and thermoelasticity.

**Recommended:** ME 316

**ME 522. MECHANICAL VIBRATIONS. (4 Credits)**

Dynamic response of single and multiple degree-of-freedom systems.

**Recommended:** ME 317

**ME 523. ADVANCED STRESS ANALYSIS. (4 Credits)**

An introduction to the mechanics of nonlinear elastic, plastic, and viscoelastic material behavior including large deformations.

**Recommended:** ME 316

**ME 524. FINITE ELEMENT MODELING OF MECHANICAL ENGINEERING SYSTEMS. (3 Credits)**

Application of modern finite element code in the analysis of complex mechanical engineering systems. Extensive use of engineering workstations. Lec/lab.

**Prerequisites:** ME 520 with C or better

**ME 526. NUMERICAL METHODS FOR ENGINEERING ANALYSIS. (3 Credits)**

Numerical solutions of linear equations, difference equations, ordinary and partial differential equations. CROSSLISTED as NSE 526.

**Equivalent to:** NSE 526

**Recommended:** Programming experience and previous exposure to numerical

**ME 529. SELECTED TOPICS IN SOLID MECHANICS. (3-4 Credits)**

Advanced topics in solid mechanics emphasizing research applications of current interest.

*This course is repeatable for 32 credits.*

**ME 531. LINEAR MULTIVARIABLE CONTROL SYSTEMS I. (4 Credits)**

Theoretical design of control systems for systems modeled by linear multivariable differential equations. Topics covered include controllability, observability, state feedback control, pole placement, output feedback, estimator design, and control designs that include both estimators and regulators.

**ME 532. LINEAR MULTIVARIABLE CONTROL SYSTEMS II. (4 Credits)**

Focuses on designing control systems where the device to be controlled is an uncertain system, yet can be described by a set of linear differential equations. Lec.

**Prerequisites:** ME 531 with C or better

**ME 533. NONLINEAR DYNAMIC ANALYSIS. (4 Credits)**

Course focuses on understanding the behavior of nonlinear dynamic systems of interest to mechanical engineers. Lec.

**Recommended:** ME 317

**ME 534. NONLINEAR MULTIVARIABLE CONTROL SYSTEMS. (4 Credits)**

Focuses on designing control systems when the device to be controlled is mathematically described by a nonlinear set of differential equations. Lec.

**Prerequisites:** ME 533 with C or better

**ME 539. SELECTED TOPICS IN DYNAMICS. (1-16 Credits)**

Advanced topics in dynamics emphasizing research applications of current interest.

*This course is repeatable for 30 credits.*

**ME 540. INTERMEDIATE THERMODYNAMICS. (4 Credits)**

Students are expected to master classical thermodynamics by way of solving extended problems using software tools. Statistical thermodynamics concepts are also introduced and exercised.

**Recommended:** ME 312

**ME 541. LIQUID-VAPOR PHASE CHANGE AND HEAT TRANSFER. (4 Credits)**

Advanced treatment of underlying physics and engineering modeling approaches for heat transfer associated with vapor/liquid phase change processes. Topics include thermodynamics and mechanical aspects of phase change processes, pool boiling, filmwise and dropwise condensation, internal convective boiling and condensation, and other emerging areas in phase change heat transfer.

**ME 543. RENEWABLE ENERGY: THERMAL FLUID SYSTEMS. (4 Credits)**

Evaluates several thermal/fluid power conversion strategies that deal with both thermal and fluid energy sources in terms of basic conversion technology, resource potential and developmental challenges. There are four modules, each targeting a particular renewable energy system in thermal and fluid sciences.

**Recommended:** (ME 311 or ME 311H or NE 311 or NE 311H) and (ME 331 or ME)

**ME 544. ADVANCED POWER GENERATION SYSTEMS. (4 Credits)**

Thermal mechanical evaluation of modern power generation technologies, including fossil and nuclear Rankine cycle power plants, gas turbines, cogeneration power plants, distributed power generation and fuel cells. Lec/rec.

**Recommended:** ME 312 and (ME 332 or ME 332H)

**ME 545. INTRODUCTION TO COMBUSTION. (4 Credits)**

Study of combustion science based on the background of chemistry, thermodynamics, fluid mechanics, heat and mass transfer. Stoichiometry, energetics of chemical reactions, flame temperature, equilibrium product analyses, chemical kinetics, and chain reactions.

**Recommended:** ME 312 and (ME 332 or ME 332H)

**ME 546. CONVECTION HEAT TRANSFER. (3 Credits)**

An advanced treatment of forced and natural convection heat transfer processes emphasizing underlying physical phenomena. Current topical literature will be considered; analytical and numerical problem solving is included.

**Recommended:** (ME 332 or ME 332H) and ME 373

**ME 547. CONDUCTIVE HEAT TRANSFER. (3 Credits)**

Analytical and numerical solutions to steady state and transient conduction problems.

**Recommended:** (ME 332 or ME 332H) and ME 373

**ME 548. RADIATION HEAT TRANSFER. (3 Credits)**

Analytical and numerical methods of solution of thermal radiation problems.

**Recommended:** (ME 332 or ME 332H) and ME 373

**ME 549. SELECTED TOPICS IN HEAT TRANSFER. (3 Credits)**

Topics in heat transfer including advanced problems in conduction, radiation, and convection. Additional examination of heat transfer in multiphase systems, inverse problems, combined modes, equipment design, solution techniques and other topics of current interest considered, including extensive use of current literature. Not all topics covered each year.

*This course is repeatable for 9 credits.*

**ME 550. APPLIED HEAT TRANSFER. (4 Credits)**

An intermediate heat transfer course seeking to lay a foundation for determining the heating and cooling characteristics with a variety of modern and classical processes. Included is design of multi-component heat transfer systems. Lecture, 110 minutes twice per week.

**Recommended:** ME 332 or ME 332H

**ME 552. MEASUREMENTS IN FLUID MECHANICS AND HEAT TRANSFER. (4 Credits)**

Course emphasis is on measurement techniques and data analysis methods related to fluid mechanics and heat transfer. Proper experimental methods, data and uncertainty analyses related to thermal and fluids measurements are discussed. Local and spatial mapping of fluid and thermal fields are highlighted.

**Recommended:** (ME 331 or ME 331H) and (ME 332 or ME 332H) and ME 451.

**ME 553. STRUCTURE AND MECHANICS LABORATORY. (4 Credits)**

Techniques for measurement of structural response and material properties. Proper use of rosette strain gauges, load cells, and displacement transducers. Full-field strain measurement using photoelasticity and digital image correlation. Proper implementation of material testing standards. Characterization of anisotropic composite materials.

**Recommended:** ME 451

**ME 560. INTERMEDIATE FLUID MECHANICS. (4 Credits)**

Ideal fluid flow including potential flow theory. Introduction to compressible flow. Viscous flow and boundary layer theory. Introduction to turbulence.

**Recommended:** ME 331

**ME 561. GAS DYNAMICS. (4 Credits)**

Studies one-dimensional isentropic flow, nozzles, diffusers, normal and oblique shocks, compressible flow with friction and heating, and an introduction to propulsion systems.

**Recommended:** ME 312 and (ME 331 or ME 331H)

**ME 564. TURBULENCE MODELING. (3 Credits)**

An introductory course on theory of different turbulence modeling techniques such as Reynolds Averaged Navier Stokes (RANS), Large Eddy Simulation (LES), and Direct Numerical Simulation (DNS) applied to a range of turbulent flows including free shear flows, boundary layers, and internal flows.

**Prerequisites:** ME 560 with C or better and (ME 565 [C] or ME 566 [C])

**ME 565. INCOMPRESSIBLE FLUID MECHANICS. (3 Credits)**

Generalized fluid mechanics; kinematics; methods of description, geometry of the vector field, dynamics of nonviscous fluids, potential motion, two-dimensional potential flow with vorticity.

**ME 566. VISCOUS FLOW. (3 Credits)**

Boundary layer, stability, transition prediction methods, computational methods in fluid mechanics, recent developments.

**ME 567. ENGINEERING APPLICATIONS OF COMPUTATIONAL FLUID DYNAMICS. (4 Credits)**

Basic concepts of computational fluid dynamics, a technique used for solving fully three-dimensional fluid flow problems with no exact solution, will be discussed and applied to general engineering applications using commercially available software. Lec.

**Recommended:** ME 312 and (ME 331 or ME 331H)

**ME 568. TURBULENT FLOW DYNAMICS. (4 Credits)**

An introductory course of the basic physics of turbulent flows, coverage will include statistical methods and physical interpretation of a range of flows including boundary layer flows, internal flows, and environmental flows.

**Prerequisites:** ME 560 with C or better

**Recommended:** A first course in fluid mechanics such as ME 331

**ME 569. SELECTED TOPICS IN FLUID MECHANICS. (2-4 Credits)**

Topics in fluid mechanics emphasizing research applications of current interest.

*This course is repeatable for 32 credits.*

**ME 570. STRUCTURE-PROPERTY RELATIONS IN MATERIALS. (4 Credits)**

Fundamentals of the interactions between the structure and properties of materials. Atomic bonding and atom interactions. Geometric and algebraic representations of symmetry. Introduction to phase equilibria. Phenomenological background of elasticity and plasticity in materials. Anisotropic materials and tensor representations. Influence of structure on thermal, electrical, and optical properties of materials. **CROSSLISTED** as MATS 570.

**Equivalent to:** MATS 570

**ME 580. MATERIALS SELECTION. (3 Credits)**

Selecting materials for engineering applications. The major families of materials, their properties, and how their properties are controlled; case studies and design projects emphasizing materials selection. Lec/lab.

**Recommended:** MATS 322 or ENGR 322

**ME 583. COMPOSITE MATERIALS. (3 Credits)**

Fibers and matrices, mechanics of composites, reinforcement and failure mechanisms, properties and applications. Lec/lab.

**Recommended:** MATS 322 or ENGR 322

**ME 584. ADVANCED FRACTURE OF MATERIALS. (4 Credits)**

Fracture mechanics will be used as a basis for predicting failure of materials, understanding failure mechanisms, and identifying causes of failure. Course will include discussion of recent journal articles, experimental demonstrations, and analysis of real fracture data. **CROSSLISTED** as MATS 584.

**Equivalent to:** MATS 584

**Recommended:** MATS 322 or ENGR 322 or equivalent is recommended.

**ME 585. FATIGUE OF MATERIALS. (4 Credits)**

Analyzes the failure of materials by fatigue including how fatigue behavior is characterized, how fatigue failure is predicted, the physical mechanisms responsible for fatigue failure of various materials, and how such behavior is related to the atomic structure and microstructure of the material.

**Prerequisites:** ME 570 with C or better or MATS 570 with C or better

**ME 588. COMPUTATIONAL METHODS IN MATERIALS SCIENCE. (4 Credits)**

A broad introduction to important materials science simulation methods. These include molecular dynamics, density functional theory, and Monte Carlo methods. Learning is through a mixture of lecture and hands-on lab projects in which students use computational methods to explore and reinforce fundamental concepts in materials science. Lec/lab. CROSSLISTED as MATS 588.

**Equivalent to:** MATS 588

**Recommended:** Experience with Matlab or Mathematica or an equivalent

**ME 589. SELECTED TOPICS IN MATERIALS. (3 Credits)**

Topics in materials science to correspond to areas of graduate research. Topics will be chosen from the following list: optical materials, dielectrics, oxidation and corrosion, ceramics, thermophysical properties, polymers and viscoelasticity, coatings and thin films. Lec/rec.

*This course is repeatable for 32 credits.*

**ME 596. SELECTED TOPICS IN THERMODYNAMICS. (3 Credits)**

Topics in thermodynamics including advanced problems in classical thermodynamics and statistical thermodynamics of current interest. Topics will likely be considered, including extensive use of literature. Not all topics covered each year.

*This course is repeatable for 32 credits.*

**ME 597. PRECISION MOTION GENERATION. (4 Credits)**

Introduces fundamental knowledge in mechatronic systems used in manufacturing equipment such as CNC machine tools, and their computer numerical controls. Students will be exposed to sensors and actuators utilized in machine tools, industrial robots and for process automation. Fundamental knowledge to model and identify dynamics of motion delivery systems, design and analysis of accurate position control algorithms for precision motion generation will be covered. Digital motion control design will be introduced. Motion planning and real-time path interpolation algorithms will be covered. Students will be able to design NC systems for 2D motion platforms.

**Recommended:** ME 430

**ME 599. SPECIAL TOPICS. (0-16 Credits)**

*This course is repeatable for 32 credits.*

**ME 601. RESEARCH. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ME 603. THESIS. (1-16 Credits)**

*This course is repeatable for 999 credits.*

**ME 605. READING AND CONFERENCE. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ME 606. PROJECTS. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ME 607. SEMINAR. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ME 611. MODERN PRODUCT DESIGN. (4 Credits)**

Modern product development, design and prototyping are covered. Product development and prototyping is examined from a research standpoint in this course. Customer outcomes gathering, functional modeling, product architecture, modern techniques for concept generation and selection are explored. Also covered are recently developed theories and techniques for prototyping. The topics' place in the overall design process is shown through a product development and prototyping project.

**ME 613. SUSTAINABLE PRODUCT DESIGN. (4 Credits)**

Graduate students will work in multidisciplinary design teams to develop innovative and environmentally friendly products. Combining the principles of integrated product development and sustainable design thinking, students will (a) advance their knowledge of the design process by creating a patent-quality new product, (b) learn and employ environmentally-minded design theory and methods, including various software packages and online tools, and (c) further enhance team-working skills by working collaboratively in a professional design team. Sustainable Product Development is conducted as a collaborative design experience, in that lectures, discussion, and team working time will be integrated into class sessions.

**ME 615. DESIGN UNDER UNCERTAINTY. (4 Credits)**

Tackles the problem of decision making in engineering design. The fundamental challenge faced in making decisions in engineering designs is that they are almost exclusively decisions made under uncertainty. Sources of uncertainty could result from engineering models, experiments conducted, or lack of knowledge of future events. The course will cover three basic topics 1) how do we quantify uncertainty, 2) how do we account for the uncertainty in decision making, and 3) how do we make design selection decisions about products or systems we design.

**Prerequisites:** ME 517 with C or better

**ME 617. DESIGN AUTOMATION. (4 Credits)**

Design automation is the field of study whereby advanced numerical methods are used to automate difficult or tedious design decisions. Typically, such methods are based on numerical optimization and artificial intelligence. They work in tandem with other engineering digital tools like computer-aided design, computer-aided manufacturing, and finite-element analysis. This course builds upon a fundamental understanding of optimization to introduce students to a range of different techniques that may be used to support engineering decision-making. This includes heuristic methods, AI tree-search, discrete and stochastic algorithms. The course concludes with discussion of recent innovations in multi-objective, multi-disciplinary and robust optimization.

**Prerequisites:** ME 517 with C or better

**ME 667. COMPUTATIONAL FLUID DYNAMICS. (3 Credits)**

Application of modern computational techniques to solve a wide variety of fluid dynamics problems including both potential and viscous flow with requirements for computer code development.

**Prerequisites:** (ME 560 with C or better or ME 565 with C or better or ME 566 with C or better) and (ME 526 [C] or ME 575 [C])

## Manufacturing Engineering

**MFGE 285. INTRODUCTION TO INDUSTRIAL AND MANUFACTURING ENGINEERING. (3 Credits)**

Introduction to selected topics in industrial and manufacturing engineering, including history and philosophy, product design and manufacturing cycle, integrated role of engineering and business, and multi-objective nature of organizations. Surveys of selected design problems in resource allocation, operations and quality management, and production engineering. CROSSLISTED as IE 285.

**Equivalent to:** IE 285

**MFGE 336. PRODUCTION ENGINEERING. (4 Credits)**

Provides a general understanding of the production engineering function within industry and the means by which to achieve tight tolerances through machining. Geometric dimensioning and tolerancing, fixture and gage design, and fundamentals of metal cutting mechanics are introduced, and their interactions are explored. Lec/lab.

**Prerequisites:** (ENGR 213 with C or better or ENGR 213H with C or better) and ENGR 248 [C] and (ENGR 321 [C] or ENGR 321H [C] or MATS 321 [C] or MATS 321H [C]) and ME 250 [C]

**MFGE 337. MATERIALS AND MANUFACTURING PROCESSES. (4 Credits)**

Introduces mechanical manufacturing methods by which materials are economically shaped into valuable products. The overall goal is to develop an understanding of how the functionality, shape, materials, cost and sustainability of a product influence manufacturing process selection and design. Lec/lab.

**Prerequisites:** ((ENGR 321 with C or better or ENGR 321H with C or better or MATS 321 with C or better or MATS 321H with C or better) and ME 250 [C] and MFGE 336 [C])

**MFGE 436. LEAN MANUFACTURING SYSTEMS ENGINEERING. (4 Credits)**

The planning, evaluation, deployment, and integration of lean manufacturing theory and methods. Examines manufacturing processes/equipment and systems, e.g., planning/control, product design, supply chain resource management. Lec/lab.

**MFGE 437. COMPUTER CONTROL OF MANUFACTURING PROCESSES. (4 Credits)**

Introduces fundamental knowledge in the automation of manufacturing systems and processes. Automated manufacturing system design and operations—computer numerical control (CNC) technology; NC part programming; sensors and actuators, their modeling and dynamic simulation; feedback motion delivery systems design and tuning; programmable logic controls (PLC) for industrial control systems, and path planning for numerical controlled (NC) machinery. Lec/lab.

**Prerequisites:** (ME 317 with C or better or ME 317H with C or better or MFGE 336 with C or better) and (ENGR 212 [C] or ENGR 212H [C])

**MFGE 438. COMPOSITES MANUFACTURING. (4 Credits)**

Introduction to fiber-reinforced composite materials and their applications. Topics include matrices and reinforcement; open and closed molding processes; filament winding, quality, testing, damage assessment; basics of factory operations and sustainability of composites. Students will complete laboratory projects using fiber-reinforced laminates. Lec/lab.

**Prerequisites:** ENGR 213 with C or better or ENGR 213H with C or better

**MFGE 499. SPECIAL TOPICS. (0-5 Credits)**

*This course is repeatable for 99 credits.*

**MFGE 507. SEMINAR. (1-16 Credits)**

Graded P/N.

*This course is repeatable for 16 credits.*

**MFGE 511. PRECISION MACHINE DESIGN. (3 Credits)**

Tolerance analysis and application in design/manufacturing practice, principles of machine design and computational analysis of errors in machine design, sensor mounting and sensor calibration, machine level error budget with geometric and thermal errors, structural design of joints and supports, deterministic damping, exact constraint design for flexures and couplings, bearing systems design, motion and power system design for machine tools. CROSSLISTED as ME 511.

**Equivalent to:** ME 511

**Recommended:** An understanding of mechanical component design and solid

**MFGE 531. MICROMANUFACTURING. (4 Credits)**

Introduction to microsystem platforms, scaling laws and size effects in micromanufacturing techniques with an emphasis on microchannel arrays, microchannel lamination and micro-scale characterization. Lec/lab.

**MFGE 535. INDUSTRIAL SUSTAINABILITY ANALYSIS. (3 Credits)**

Students are exposed to the role of business and engineering in the design and implementation of sustainable industrial systems. Drivers, metrics, and analysis concepts, methods, and tools are introduced. Students incorporate business and engineering considerations in making product, manufacturing process, and supply chain design considerations.

**MFGE 536. LEAN MANUFACTURING SYSTEMS ENGINEERING. (4 Credits)**

The planning, evaluation, deployment, and integration of lean manufacturing theory and methods. Examines manufacturing processes/equipment and systems, e.g., planning/control, product design, supply chain resource management. Lec/lab.

**MFGE 538. COMPOSITES MANUFACTURING. (4 Credits)**

Introduction to fiber-reinforced composite materials and their applications. Topics include matrices and reinforcement; open and closed molding processes; filament winding, quality, testing, damage assessment; basics of factory operations and sustainability of composites. Students will complete laboratory projects using fiber-reinforced laminates. Lec/lab.

**Recommended:** (ENGR 213 or ENGR 213H)

**MFGE 599. SPECIAL TOPICS. (0-5 Credits)**

*This course is repeatable for 99 credits.*

## Mechanical/Industrial/Manufacturing Engineering

**MIME 101. INTRODUCTION TO MIME. (3 Credits)**

Provides students with an overview of mechanical, industrial, manufacturing, and energy systems engineering careers and an introduction to technical areas of study. Skills necessary for success in both the academic curriculum and in the engineering profession will also be emphasized, including communication and ethics. Lec/rec.

**Equivalent to:** ME 101, MIME 101H

**MIME 101H. INTRODUCTION TO MIME. (3 Credits)**

Provides students with an overview of mechanical, industrial, manufacturing, and energy systems engineering careers and an introduction to technical areas of study. Skills necessary for success in both the academic curriculum and in the engineering profession will also be emphasized, including communication and ethics. Lec/rec.

**Attributes:** HNRS – Honors Course Designator

**Equivalent to:** MIME 101

**MIME 199. SPECIAL TOPICS. (0-4 Credits)****MIME 299. SPECIAL TOPICS. (0-4 Credits)**

*This course is repeatable for 4 credits.*

**MIME 399. SPECIAL TOPICS. (0-4 Credits)**

Special topics in mechanical, industrial, and manufacturing engineering. *This course is repeatable for 16 credits.*

**MIME 504. WRITING AND CONFERENCE/EXPLORATION. (1-9 Credits)**

Students will be allowed to register for a variable number of MIME 504 credits to bring their registration up to full-time status (9 credits). Graded P/N.

*This course is repeatable for 15 credits.*



**MIME 507. SEMINAR/NEW STUDENT ORIENTATION. (1 Credit)****Robotics****ROB 421. APPLIED ROBOTICS. (4 Credits)**

Multidisciplinary teams of students design, build, and demonstrate a robotic system, including all sensing, computation, and actuation. The specific task, such as checkers-playing robots, changes each year, and is designed to be challenging for ambitious students. Robots will compete in a friendly competition at the end of the term. Lec/lab.

**ROB 456. INTELLIGENT ROBOTS. (4 Credits)**

Foundations of probabilistic reasoning for robotics. Topics include state estimation, robot motion, perception, localization and decision making under uncertainty.

**Recommended:** ME 373 or ME 373H or ECE 353 or CS 331

**ROB 501. RESEARCH. (1-16 Credits)**

Graded P/N.

*This course is repeatable for 99 credits.*

**ROB 503. THESIS. (1-16 Credits)**

*This course is repeatable for 999 credits.*

**ROB 505. READING AND CONFERENCE. (1-16 Credits)**

*This course is repeatable for 16 credits.*

**ROB 506. PROJECTS. (1-16 Credits)**

Graded P/N.

*This course is repeatable for 16 credits.*

**ROB 507. SEMINAR. (1-16 Credits)**

Graded P/N.

*This course is repeatable for 16 credits.*

**ROB 514. INTRODUCTION TO ROBOTICS. (4 Credits)**

A broad introduction to the field of robotics, and to the graduate Robotics program. The goal of the class is to take students with different backgrounds (mechanical engineering, computer science, electrical engineering, physics, etc.) and give them a common base in the fundamentals of robotics. A secondary goal is to introduce students to the Robotics program, and to give them some of the skills that will make them successful, both in the program and as a professional roboticist.

**ROB 521. RESEARCH ROBOTICS. (4 Credits)**

Multidisciplinary teams of students will use the backdrop of a robotics competition to generate a research question, then design, build, and demonstrate a robotic system that is used to answer this research question. An example may be a Jenga-playing robot, where students try a new computer vision algorithm, or test a theory on force control. This directly parallels graduate research in robotics, where systems-building is necessary, and toy problems can illustrate research results, but the important focus is a core research question. The specific competition task changes each year, and robots will compete at the end of the term. Lec/lab.

**ROB 534. SEQUENTIAL DECISION MAKING IN ROBOTICS. (4 Credits)**

Examines sequential decision making in robotics with a focus on motion planning and related optimization problems applied to fielded systems in marine, aerial, and ground domains. Discussions regarding both fundamental background material as well as cutting edge research in the following areas: discrete planning, sampling-based planning, planning under uncertainty, multi-robot systems, optimization, and performance guarantees.

**ROB 537. LEARNING-BASED CONTROL. (4 Credits)**

Provides an introduction to learning systems and their application to the control of nonlinear systems. Covered topics include neural networks, reinforcement learning, and evolutionary algorithms. Includes project component in which students write a technical paper and give a conference style presentation based on their project.

**ROB 538. AUTONOMOUS AGENTS AND MULTI-AGENT SYSTEMS. (4 Credits)**

Provides an introduction to autonomous agents and multi-agent systems. In particular, it focuses on how to use agents as building blocks for different autonomous systems. Covered topics include reinforcement learning, game theory, swarms, auctions, and collectives. Because this course covers a constantly evolving field, there will be a significant paper reading component in addition to the regular lectures. Students are expected to spend at least three hours a week reading, discussing and critiquing assigned papers.

**ROB 541. GEOMETRIC MECHANICS. (4 Credits)**

An introduction to geometric methods in the analysis of dynamic systems. Using the kinematics of simple robotic systems as a motivating example, we explore topics such as manifolds and Lie groups, representations of velocity, holonomic and nonholonomic constraints, constraint curvature and response to cyclic inputs, distance metrics.

**Recommended:** Prior exposure to linear algebra and differential equations

**ROB 542. ACTUATOR DYNAMICS. (4 Credits)**

Focuses on how inertia, spring compliance, and other passive dynamics affect highly dynamic, software-controlled systems. Examples include robotic manipulation tasks, robot-human interaction, CNC machines, or legged locomotion. Lec/lab.

**Recommended:** Prior courses on dynamics and control

**ROB 562. HUMAN CONTROL SYSTEMS. (4 Credits)**

Covers mechanisms of human motor systems and control of the neuromusculoskeletal anatomy followed by functional analysis of these system components. Then all the components are integrated to study feedback control dynamics. Covers classic to modern theories of motor control, adaptation, cognitive involvement, and rehabilitation techniques.

**Equivalent to:** ME 539

**Recommended:** Basic feedback control systems, linear algebra,

**ROB 564. SOFT ROBOTICS. (4 Credits)**

Soft robotics researchers propose building intelligent machines purely out of stretchable compressible soft materials. The course is centered on term-long projects that will result in real soft robots with the goal of presenting to the international community. The topics covered include rapid digital manufacturing, soft actuators, soft sensors, soft logic, soft energy, applications of soft robotics, and modeling soft mechanics.

**ROB 567. HUMAN ROBOT INTERACTION. (4 Credits)**

The field of human-robot interaction brings together research and application of methodology from robotics, human factors, human-computer interaction, interaction design, cognitive psychology, education and other fields to enable robots to have more natural and more rewarding interactions with humans throughout their spheres of functioning.

**Recommended:** Background in one of human factors,

**ROB 568. SOCIAL ROBOTICS. (4 Credits)**

In-depth exploration of the leading research, design principles, and challenges in Human-Robot Interaction (HRI), with an emphasis on socially interactive robots. Topics include social embodiment, multi-modal communication, human-robot teamwork, social learning, aspects of social psychology and cognition, as well as applications and evaluation with human subjects. Requires participation, lightning talks, student-led lectures, written critiques of class readings, and a group project involving a hypothetical social robotics project.

**ROB 599. SPECIAL TOPICS. (0-16 Credits)**

*This course is repeatable for 32 credits.*

**ROB 601. RESEARCH. (1-16 Credits)**

Graded P/N.

*This course is repeatable for 99 credits.*

**ROB 603. THESIS. (1-16 Credits)**

*This course is repeatable for 999 credits.*

**ROB 605. READING AND CONFERENCE. (1-16 Credits)**

*This course is repeatable for 16 credits.*