Rose-Hulman Institute of Technology Course Catalog

Mechanical Engineering

Mechanical engineering is a broad field of endeavor with opportunities in many areas of industry: production and manufacturing; aeronautics and aerospace; robotics and automation; conventional and renewable energy; automotive and transportation; and many others. Additional opportunities for mechanical engineers include careers in government, education, and private consulting. The mechanical engineering curriculum is designed to prepare students for this wide range of options by providing them with a strong foundation in the fundamental principles of science and engineering to tackle the complex technological problems of today and adapt for the challenges of tomorrow.

The required courses of the undergraduate mechanical engineering curriculum provide the basic mathematical and scientific fundamentals underlying the practice of mechanical engineering. Technical, free, and math/science elective courses allow the student flexibility in adapting the program to their interests in pursuit of their specific career goals. Electives in the humanities, social sciences, and the arts help to foster the links between society and engineering so that the mechanical engineering graduate is aware of the roles of engineering and science in solving complex technological and social problems as well as of the impacts of social and environmental factors on engineering activities such as design. For those undergraduates who choose to continue their education at Rose-Hulman, graduate work leading to a Master of Science in Mechanical Engineering or a Master of Engineering in Mechanical Engineering is offered by the department.

Mission: To provide the curriculum, the educational environment, and the individual support necessary to graduate mechanical engineers who are technically competent, effective in practice, creative, ethical, and mindful of their responsibility to society.

Vision: To graduate the best baccalaureate mechanical engineers.

Mechanical Engineering Program Educational Objectives and Student Outcomes

Program Educational Objectives

The mechanical engineering curriculum aims to prepare students for productive careers in industry, government, education, and private consulting, as well as for graduate study. By providing a strong foundation in the fundamental principles of science and engineering and by illuminating the links between society and engineering, the curriculum enables students to apply what they have learned and to teach themselves new skills to address complex technological problems within the social and environmental context of our world. Thus, within a few years of graduation, we expect our graduates to attain the following educational objectives, which are based on the needs of our constituencies:

1. Our alumni will be successful in their careers.
2. Our alumni set and meet their own goals for career fulfillment.
3. Our alumni will continue professional development.
4. Our alumni will be cognizant of the international dimensions of their profession.

Student Outcomes

Student outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program. We expect our graduates to have the ability to:

1. Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. Communicate effectively with a range of audiences.
4. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusion.
7. Acquire and apply new knowledge as needed, using appropriate learning strategies.

The mechanical engineering program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org, under the commission's General Criteria and Program Criteria for Mechanical and Similarly Named Engineering Programs.

Summary of degree requirements

The freshman year of the mechanical engineering program includes courses in mathematics and foundational sciences, as well as introductory courses in engineering and design. Foundational sciences include physics, biology, and chemistry. The sophomore year features courses in mathematics, foundational sciences, and the engineering sciences. The final two years of the program stress the design and analysis of systems, machines and their components, and the transfer and transformation of energy. In addition to the required mathematics, science, and engineering courses, the program includes required writing and communication courses and an array of technical electives and free electives, a math/science elective, and elective courses in the humanities, social sciences, and the arts (HSSA). The requirements for an undergraduate degree in mechanical engineering are summarized in the following table:

Category	Credits
Required engineering (ME, ES, EM) courses	86
Required math courses	27
Required foundational science courses	16
Required HSSA writing and communication courses	8
Required RHIT 100 course	1
Technical electives	16

Free electives	8
Math/science elective	4
HSSA electives	28
Total	**194**

Minor in Manufacturing Engineering

The goal of this minor is to provide interested students with an opportunity to broaden their knowledge of the methods, processes and technologies related to the analysis and design of manufacturing systems.

At the completion of this minor, students will be able to:

1. Describe methods, processes and /or technologies used in manufacturing.
2. Identify, formulate, and solve problems in the area of manufacturing.
3. Analyze and design manufacturing technologies and systems within reasonable constraints such as economic, manufacturability, sustainability and environmental by applying appropriate theories and methods.
4. Communicate effectively about manufacturing engineering problem solutions, technologies, and system designs.
5. Describe interactions between humans and systems in the workplace.

Requirements

To earn the Minor in Manufacturing Engineering, a student must complete 28 credit hours according to the guidelines shown below.

Core Course (4 credits)

Select one from the following list of two courses:

- ME 317 Design for Manufacturing or
- EngD 260 Product Design Studio

Manufacturing Electives (16-20 credits)

Select 16 - 20 credit hours (4-5 courses) from the following list of manufacturing elective courses:

- EMGT 330 Introduction to Engineering Management
- EMGT 524 Production/Operations Management
- EMGT 427 Project Management
- EMGT 445 Quality Methods
- EMGT 446 Statistical Methods in Six Sigma
- EMGT 588 Quality Management
- EMGT 589 Manufacturing Systems
- EMGT 570 Lean Six Sigma
- ME 412 Lean Manufacturing
- ME 435 Robotics
- ME 517 Mechanics of Metal Forming
- ME 520 Computer Aided Design and Manufacturing

- EMGT 538 Product Realization
- EMGT 540 Human Factors
- EMGT 541 Work Analysis and Design
- EM 304 Advanced CAD – Professional Certification
- EM 305 Advanced CAD – Parametric and Equation Driven Design

HSSA Electives (4-8 credits)

Select 4 - 8 credit hours (1-2 courses) from the following HSSA courses:

- ECON S151 Introduction to Microeconomics
- ECON S152 Introduction to Macroeconomics
- PSYC S100 Introduction to Psychology
- PSYC S220 Social Psychology
- ECON S253 Managerial Economics
- ECON S352 Corporate Finance

Minor in Thermal-Fluids*

To complete the requirements of the Minor in Thermal-Fluids, a student must fulfill the following three expectations:

(1) Completion of a set of 2 courses covering basic fluid mechanics and basic thermodynamics. These are commonly required for most engineering majors. Acceptable sets include:

- ES 201 Conservation & Accounting Principles
  ES 212 Fluid Systems
  or
- CE 205 Thermodynamics
  EM 301 Fluid Mechanics
  or
- CHE 201 Conservation Principles & Balances
  CHE 301 Fluid Mechanics

(2) One of the following foundational prerequisites.

- ME 301 Applications of Thermodynamics
- CHE 303 Chemical Engineering Thermodynamics
- ME 302 Heat Transfer
- CHE 320 Fundamentals of Heat and Mass Transfer

(3) Three of the thermal-fluids electives listed below.
Thermal-Fluid Systems

- ME 408 Renewable Energy
- ME 410 Internal Combustion Engines
- ME 411 Propulsion Systems
- ME 426 Turbomachinery

Thermal-Fluid Sciences

- ME 401 Foundations of Fluid Mechanics
- ME 405 Theoretical Aerodynamics
- ME 427 Introduction to Computational Fluid Dynamics
- ME 450 Combustion
- ME 510 Gas Dynamics

Successful completion of a minor is indicated on the student's transcript. A student interested in pursuing the Minor in Thermal-Fluids should consult with the head of the Department of Mechanical Engineering.

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* ME Majors do **not** qualify for the Minor in Thermal-Fluids, but may pursue ME areas of concentration.

Areas of Concentration

Students who complete recommended courses in an area of concentration may receive, upon request, a letter from the Department Head attesting to the fact that the student has completed the requirements in the selected area of concentration in the Mechanical Engineering Department. With proper planning, students should be able to take these course offerings without overload. Students may add special topics courses or new courses not yet listed in the catalog to the list of acceptable courses for a concentration with written permission from the mechanical engineering department head.

Automotive Area of Concentration
Automotive Engineering is a very broad field covering many topics including system modeling, combustion, electrification, autonomous driving, materials, and virtual design. To help prepare for a career in this field, the Automotive Concentration is offered. One required and four elective courses are necessary, allowing students to gain either breadth or depth according to their interests.

Required Course:

- ME 359 Vehicle System Modeling

Elective Courses (choose any four):

- CSSE 461 Computer Vision
- CSSE 463 Image Recognition
- EM 402 Three Dimensional Dynamics
- EM 403 Advanced Mechanics of Materials
- MA 416 Deep Learning
- ME 401 Foundations of Fluid Mechanics
- ME 406 Control Systems
- ME 408 Renewable Energy
- ME 410 Internal Combustion Engines
- ME 422 Finite Elements for Engineering Applications
- ME 423 Fatigue
- ME 424 Mechanics of Composites

- ME 427 Introduction to Computational Fluid Dynamics
- ME 450 Combustion
- ME 506 Advanced Control Systems
- ME 522 Advanced Finite Element Analysis
- OE 450 Laser Systems & Applications
- PH 470 Automotive Lighting

Aerospace Engineering Area of Concentration

The aerospace industry provides job opportunities each year for many mechanical engineering graduates. The aerospace engineering area of concentration is intended to provide specialty courses which focus the application of basic mechanical engineering skills to aerospace systems.

The courses required to complete the concentration are as follows:

- ME 305 Introduction to Aerospace Engineering
- Plus any 4 of the following:
    - ME 401 Foundations of Fluid Mechanics
    - ME 405 Theoretical Aerodynamics
    - ME 410 Internal Combustion Engines
    - ME 411 Propulsion Systems
    - ME 422 Finite Elements for Engineering Applications
    - ME 426 Turbomachinery
    - ME 427 Introduction to Computational Fluid Dynamics
    - ME 461 Aerospace Design
    - ME 510 Gas Dynamics
    - ME 522 Advanced Finite Element Analysis
    - EM 402 Three-Dimensional Dynamics
    - EM 403 Advanced Mechanics of Materials
    - MA 336 Boundary Value Problems
    - MA 438 Advanced Engineering Mathematics
    - PH 322 Celestial Mechanics

CAD Area of Concentration

The CAD Concentration is intended to prepare students for careers with a focus in computer-aided design and analysis. The Concentration is divided into two sets of courses: Design and Analysis. The Design courses provide students with expertise in the use of modern Computer-Aided Design tools to model three-dimensional shapes and to communicate these designs graphically. The Analysis courses explore the mathematics behind modern CAD tools, giving students a solid background in computer-aided kinematics and finite element analysis.

To earn the CAD Concentration, students must complete the following three Design classes:

- EM104 Graphical Communication or ENGD100 Design and Communication Studio or BE118 Design Thinking and Communication
- EM304 Advanced CAD – Professional Certification
- EM305 Advanced CAD – Parametric and Equation Driven Design

In addition, students must choose three Analysis courses from the following list

- ME422 Finite Elements for Engineering Applications
- ME522 Advanced Finite Element Analysis
- ME304 Introduction to the Design of Mechanisms
- ME404 Advanced Design of Mechanisms
- ME480 Machine Component Design (for non-ME majors)

Dynamic Systems & Control Area of Concentration
Mechanical engineering graduates may work in industries, such as the automotive and aerospace industries, in which the understanding and control of a system's dynamic response is critical. The dynamic systems & control concentration provides students with experiences in modeling, analysis, and simulation of the dynamic behavior of systems with and without feedback control, as well as opportunities to explore data collection for vibratory systems and control algorithm implementation in a laboratory setting.

To complete the requirements of the area of concentration in Dynamics Systems & Control, students must complete five courses from this list:

- EM 402 Three-Dimensional Dynamics
- EM 406 Vibration Analysis
- EM 502 Advanced Dynamics
- EM 503 Advanced Vibration Analysis
- ME 304 Introduction to the Design of Mechanisms
- ME 404 Advanced Design of Mechanisms
- ME 406 Control Systems
- ME 441 Advanced Modeling and Simulation Techniques
- ME 445 Robot Dynamics and Control
- ME 506 Advanced Control Systems
- PH 322 Celestial Mechanics

Thermal Fluid Area of Concentration
The Thermal Fluid concentration is designed to prepare students for careers with a focus on thermodynamics, fluid dynamics, and heat transfer. The concentration comprises two balanced areas of study: thermal fluid systems (with an emphasis on applications) and thermal fluid sciences (with an emphasis on fundamentals). They equip students with astrong foundation to analyze and design thermal fluid systems. Emerging global challenges such as climate change, sustainable energy, and water resources call for creative solutions within the constraints of fundamental physical principles. The Thermal Fluid concentration plays an active and crucial role in the broad discipline of mechanical engineering.

To complete the requirements of the area of concentration in Thermal Fluid, students must complete:

- ME 401 Foundations of Fluid Mechanics

and 4 more courses from the following two areas (with at least one course from each area):

Area 1: Thermal Fluid Systems

- ME 408 Renewable Energy

- ME 410 Internal Combustion Engines
- ME 411 Propulsion Systems
- ME 426 Turbomachinery

Area 2: Thermal Fluid Sciences

- ME 405 Theoretical Aerodynamics
- ME 427 Introduction to Computational Fluid Dynamics
- ME 450 Combustion
- ME 510 Gas Dynamics

Minor in Mechanical Engineering

The goal of the minor in Mechanical Engineering is to give students a broad understanding of mechanical engineering beyond what would normally be obtained in and denoted by their major. The minor consists of required and elective courses, totaling 26 or 28 credits depending on the student's major. The distribution of required and elective courses also depends on the student's major, as detailed in the lists below. Students with more than one major should consult the ME department head to create an appropriate ME minor.

Elective courses must be selected from approved required or elective courses with an ME/ES/EM prefix taught by the ME faculty. These elective courses must be listed explicitly on the minor declaration form for approval BEFORE completing the courses. Guidance on what might constitute acceptable and unacceptable courses for the minor is available on the ME advising resources page on my.rose-hulman.edu. There is no guarantee that courses completed before formal declaration and approval will count towards the minor.

ME Minor for Electrical Engineering or Computer Engineering students (26 credits total)

Required: EM104, EM121, ES201, ES212 or ES214, ME317
Electives: 8 credits
Not Allowed: ME123, EM103, ME430, ME406

ME Minor for Mathematics, Biomathematics, Biology, Computer Science, or Software Engineering students (28 credits total)

Required: EM104, EM103, EM121, ES201, ES212 or ES214, ME317
Electives: 8 credits
Not Allowed: ME123
Note that Biology students must select "math sequence 2 – modeling focus" as their math sequence

ME Minor for Chemistry students and Biochemistry and Molecular Biology students (28 credits total)

Required: EM104, EM103, EM121, ME123, ES201, ES212 or ES214, ME317
Electives: 4 credits

Not allowed: None

ME Minor for Chemical Engineering students (26 credits total)

Required: EM104, EM121, ES214, ME317
Electives: 12 credits
Not Allowed: ME123, EM103, ES201, ME406

ME Minor for Civil Engineering students (26 credits total)

Required: EM104, ME123, ME317
Electives: 16 credits
Not Allowed: EM121, EM103, ES201, ES212, ES214, EM204

ME Minor for Engineering Design and Biomedical Engineering students (28 credits total)

Required: ES212, ES214, ES205
Electives: 16 credits
Not Allowed: EM104, EM121, ME123, EM103, ES201, EM204, ME317

ME Minor for Optical Engineering and NanoEngineering students (28 credits total)

Required: EM121, ES201, ME317
Electives: 16 credits
Not Allowed: EM104, ME123, EM103

ME Minor for Physics students (26 credits total)

Required: EM103, EM121, ES201, ME317
Electives: 12 credits
Not Allowed: EM104, ME123, EM103
Physics students must choose BE100 or CSSE120 or ME123 for their computing elective

The mechanical engineering program is accredited by the Engineering Accreditation Commission of ABET,www.abet.org

Plan of Study

Freshman

Fall

Course	Credit
MA 111 Calculus I	5
Foundational Science* (PH 111)	4

RHIT 100 Foundations for Rose-Hulman Success	1
EM 104 Graphical Communications	2
HUM H190 First-Year Writing Seminar or HSSA Elective	4
	Total Credits: 16

Winter

Course	Credit
MA 112 Calculus II	5
Foundational Science* (PH 112)	4
EM 121 Statics & Mechanics of Materials I	4
HUM H190 First-Year Writing Seminar or HSSA Elective	4
	Total Credits: 17

Spring

Course	Credit
MA 113 Calculus III	5
Foundational Science* (CHEM111 or BIO101)	4
EM 103 Introduction to Design	2
ME 123 Computer Applications I	4
	Total Credits: 15

Sophomore

Fall

Course	Credit
MA 221 Matrix Algebra and Differential Equations I	4
ES 201 Conservation & Accounting Principles	4
ES 213 Electrical Systems	3
ES 213L Electrical Systems Lab	1
Foundational Science* (BIO101 or CHEM111)	4
	Total Credits: 16

Winter

Course	Credit
MA 222 Matrix Algebra and Differential Equations II	4
ES 212 Fluid Systems	4
ES 214 Mechanical Systems	4
HSSA Elective	4
	Total Credits: 16

Spring

Course	Credit
MA 223 Statistics for Engineers	4
ES 205 Analysis & Design of Engineering Systems	4
Math/Science Elective**	4
HSSA Elective	4
	Total Credits: 16

Junior

Fall

Course	Credit
ME 301 Applications of Thermodynamics	4
EM 204 Statics & Mechanics of Materials II	4
ME406 Control Systems or EM 406 Vibration Analysis	4
Free Elective**	4
	Total Credits: 16

Winter

Course	Credit
ME 317 Design for Manufacturing	4
ME 327 Numerical Methods in Engineering Analysis or ME 321 Measurement Systems	4
ME 328 Materials Engineering	4
ENGL H290 Technical Communications split winter or spring with HSSA Elective	4
	Total Credits: 16

Spring

Course	Credit
ME 302 Heat Transfer	4
ME 321 Measurement Systems or ME 327 Numerical Methods in Engineering Analysis	4
ME 480 Machine Component Design	4
HSSA Elective split winter or spring with ENGL H290 Technical Communications	4
	Total Credits: 16

Senior

Fall

Course	Credit
ME 470 Capstone Design I	4
ME 421 Lab or ME 430 Mechatronic Systems	2
HSSA Elective	4
Tech Elective**	4
Tech Elective**	4
	Total Credits: 18

Winter

Course	Credit
ME 471 Capstone Design II	4
ME 430 Mechatronic Systems or ME 421 Lab	4
HSSA Elective	4
Free Elective**	4
	Total Credits: 16

Spring

Course	Credit
ME 472 Capstone Design III	4
Tech Elective**	4
Tech Elective**	4
HSSA Elective	4
	Total Credits: 16

NOTES:

*Students must complete four foundational science classes, one in Biology (BIO101 or BIO110 or BIO120 or BIO130), two in Physics (PH111 and PH112), and one

in Chemistry (CHEM111). All foundational science classes have a laboratory component.

28 credit hours in electives composed of 16 credit hours in technical electives, 8 credit hours in free electives, and 4 credit hours of a math elective or a science elective. A **technical elective is any course (at the 200 level or above) in biomathematics, chemistry, computer science, engineering, engineering management, geology, mathematics, or physics that is not cross-listed with HSSA or similar in content to a required course. A **math elective** is at the 200-level or higher and has an MA or BMTH prefix. A **science elective** is any course in biology, chemistry, geology, or physics except those courses that are cross-listed with an engineering course.

Mechanical Engineering - Course Descriptions

ME 123 Computer Programming 4R-0L-4C F,W,S
Prerequisites: ME/PHOE major or permission of instructor
Corequisites: There are no corequisites for this course.
Software tools and engineering processes for mechanical engineers. Topics may include: structured programming (Matlab), simulation of rigid body motion, presentation software, and spreadsheets. Introduction to teaming and creativity.

ME 193 Selected Topics in Design Hours as assigned. Maximum 4 credits per term. See Department
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Selected student design projects. May include testing and/or computer aided design.

ME 199 Professional Experience 1R-0L-1C See Department
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

ME 293 Selected Topics in Design Hours as assigned. Maximum 4 credits per term. See Department
Prerequisites: Sophomore class standing
Corequisites: There are no corequisites for this course.
Selected student design projects. May include testing and/or computer aided design.

ME 301 Applications of Thermodynamics 4R-0L-4C F,W
Prerequisites: ES 201 F,W* or CE 205 F *With a grade of C or better
Corequisites: There are no corequisites for this course.
Extend the conservation and accounting framework to examine energy-conversion systems. Topics include thermodynamic properties of pure substances, gas mixtures, exergy analyses, power and refrigeration cycles, psychrometric processes, combustion, and propulsion.

ME 302 Heat Transfer 4R-0L-4C S,F
Prerequisites: ES 212 W,S or CHE 301 F,S or EM 301 S, and MA 222 F,W,S

Corequisites: There are no corequisites for this course.
Introduces the basic modes of heat transfer, heat transfer properties, steady and unsteady one-dimensional heat conduction, free and forced convection, radiation and heat exchangers. Other topics may include numerical methods and boiling and condensation.

ME 304 Introduction to the Design of Mechanisms 4R-0L-4C W

Prerequisites: ME 123 F,W,S or ENGD 120 S or CSSE 120 F,W,S or BE 100 F
Corequisites: There are no corequisites for this course.
This course will cover a set of computational tools to design and analyze mechanisms to achieve specific goals. The specific focus of this course is to study kinematics (study of motion without regards to forces) of a mechanism. Students learn how to model and solve for the position, velocity, acceleration of linkages using vectors. They also study the kinematics of gear trains and specifically, planetary gear trains.

ME 305 Introduction to Aerospace Engineering 4R-0L-4C S

Prerequisites: ES 212 W,S
Corequisites: There are no corequisites for this course.
Application of fundamental engineering concepts to aerospace systems. Aircraft performance and stability. Physical properties of the standard atmosphere. Aerodynamics of the airplane including lift, drag and pitching moment estimation. Introduction to orbital mechanics.

ME 317 Design for Manufacturing 4R-0L-4C W

Prerequisites: EM 104 F
Corequisites: There are no corequisites for this course.
This is an introductory course that examines the interactions between design and manufacturing from the designer's point of view. Common manufacturing processes will be introduced and design guidelines will be developed for each process. The successful student will leave this class with an appreciation that a designer must consider the method of manufacture during the design process to ensure that a product is functional, economically viable, and safe.

ME 318 Material Processing in Manufacturing 4R-0L-4C Not Offered

Prerequisites: ME 328 W
Corequisites: There are no corequisites for this course.
An introductory course in the control of the properties of materials during manufacturing. Covers the interrelationship between material properties and the principal manufacturing processes like hot and cold working, casting, welding, heat treating and machining. Emphasizes the importance of considering manufacturability when making material selection decisions in design.

ME 321 Measurement Systems 3R-3L-4C W,S

Prerequisites: EM 103 S, and ES 205 S,F, and MA 223 F,W,S
Corequisites: There are no corequisites for this course.
Fundamentals of measurement systems in mechanical engineering including transducer operation, signal conditioning, data reduction, and presentation of results. Transducer and measurement system characteristics including resolution, sensitivity, loading, time response, and frequency response. Operating principles of basic instrumentation for measurement of mechanical quantities such as force, torque, pressure, temperature,

and flow. Topics include uncertainty analysis, data analysis, calibration, data acquisition, presentation of results, and an introduction to experiment design.

ME 323 Numerical Methods in Engineering 1R-3L-2C W,S
Prerequisites: ME 123 F,W,S or CSSE 120 F,W,S
Corequisites: There are no corequisites for this course.
Engineering problems often lead to analytically intractable equations. This course combines structured programming and applied numerical methods to obtain approximate engineering solutions. Strategies include root finding, numerical integration, finite difference, initial value and boundary value problems. Matlab is used as the programming language for solving iterative problems numerically.

ME 327 Numerical Methods of Engineering Analysis 3R-3L-4C W,S
Prerequisites: ME 123 F,W,S or BE 100 F or CSSE 120 F,W,S, and MA 222 F,W,S
Corequisites: There are no corequisites for this course.
This is an inter-disciplinary course focusing on the generation and interpretation of numerical solutions and the processing of numerical data for engineering problems. Topics include approximate solutions to nonlinear algebraic and differential equations, initial and boundary value problems, numerical integration and differentiation, optimization, data conditioning, and regression analysis. Trade-offs between accuracy and cost are emphasized. Matlab is used as the programming language.

ME 328 Materials Engineering 4R-0L-4C W
Prerequisites: CHEM 111 F,W,S
Corequisites: There are no corequisites for this course.
Introduces properties of metals, ceramics, polymers, and composites. Relates material processing to properties through underlying material structure. Overviews the materials available to engineers and discusses applications and material selection.

ME 359 Vehicle System Modeling 4R-0L-4C F
Prerequisites: ES 201 F,W
Corequisites: There are no corequisites for this course.
Excel and Simulink are used to create reactive and predictive models of vehicle powertrains, both electric and internal combustion. Drive cycles are introduced, the powertrains are iteratively refined, and insightful observations are made with respect to vehicle performance. The course concludes with modeling a vehicle of the student's choosing.

ME 380 Creative Design 4R-0L-4C See Department
Prerequisites: Permission of instructor
Corequisites: There are no corequisites for this course.
Emphasis on the creative process in engineering design. Students will develop their design capability by exploring various conceptual blocks, using creative enhancement techniques and participating in on-the-spot design.

ME 393 Selected Topics in Design As assigned. Maximum 4 credits per term. See Department
Prerequisites: Junior class standing
Corequisites: There are no corequisites for this course.
Selected student design projects. May include testing and/or computer aided design.

ME 397 Special Topics in Mechanical Engineering 4R-0L-4C See Department

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics of current interest in mechanical engineering at the 300-level.

ME 401 Foundations of Fluid Mechanics 4R-0L-4C SeeDept

Prerequisites: ES 212 W,S or EM 301 S, and MA 222 F,W,S
Corequisites: There are no corequisites for this course.
Covers the fundamental concepts of fluid dynamics with an emphasis on physical understanding. Topics include fluid kinematics, control-volume and differential analyses of fluid motion, similitude, potential flow, vorticity transport, low Reynolds number flow, boundary-layer physics, stability of laminar flow, and turbulent transport. Topics may be added or deleted as needed.

ME 402 Advanced Heat Transfer 4R-0L-4C See Department

Prerequisites: ME 302 S,F
Corequisites: There are no corequisites for this course.
This course covers additional topics in conduction, convection and radiation heat transfer as well as an introduction to mass transfer, phase change and numerical methods.

ME 404 Advanced Design of Mechanisms 4R-0L-4C F

Prerequisites: ME 304 W, and either ES 201 F,W or ENGD 215 S or BE 132 S
Corequisites: There are no corequisites for this course.
This course will cover some intermediate topics in the design of mechanisms including position analysis of three, four, five and sixbar linkages, cam analysis and design, including motion of the cam/follower system, the method of constraints in kinematics, and velocity, acceleration and force analysis using the method of constraints. The method of virtual work will be used to conduct force analysis for the inverse dynamic problem. Extensive use will be made of MATLAB (or similar software) for plotting and animating solutions to mechanism design problems.

ME 405 Theoretical Aerodynamics 4R-0L-4C W

Prerequisites: ES 212 W,S
Corequisites: There are no corequisites for this course.
Introduction to aerodynamics theory. Development of equations of conservation of mass and momentum. Vorticity, induced velocity and irrotational flow. Stream function, velocity potential, Laplace's equation and the principle of superposition. Flow about a body, the Kutta-Joukowski Theorem. Concepts of thin airfoil and finite wing theory. Exact solutions to elementary viscous flow problems.

ME 406 Control Systems 3R-3L-4C F

Prerequisites: ES 205 S,F
Corequisites: There are no corequisites for this course.
Basic principles of feedback control theory. Mathematical modeling and performance analysis of dynamical systems. Includes stability analysis, root locus compensation and design, frequency response analysis. Implementation of control system analysis and design is gained with several laboratory experiences.

ME 407 Power Plants 4R-0L-4C See Department

Prerequisites: ME 301 F,W
Corequisites: There are no corequisites for this course.

Steam, cogeneration and combined cycles are studied with the aid of property software. Various components of the cycles are studied in detail. A survey of alternative power sources is presented. Tours of power plants are taken when available.

ME 408 Renewable Energy 4R-0L-4C W
Prerequisites: ES 212 W,S or equivalent
Corequisites: There are no corequisites for this course.
Covers renewable energy sources such as solar heating and cooling, wind energy, biomass, and photovoltaic energy. Surveys the energy availability of these sources and life cycle cost and present value used to evaluate the system. Students will design a system which utilizes a renewable energy source and economically evaluate the system.

ME 409 Air Conditioning 4R-0L-4C See Department
Prerequisites: ES 212 W,S, and ME 302 S,F
Corequisites: There are no corequisites for this course.
Human comfort and the properties of air. Air conditioning in residences, public and industrial buildings using vapor compression and absorption units. Cooling loads, psychrometry, fans, duct sizing and layout, automatic control, and acoustic design considerations.

ME 410 Internal Combustion Engines 4R-0L-4C F
Prerequisites: ES 212 W,S or CHE 301 F,S
Corequisites: There are no corequisites for this course.
Study of spark ignition and compression ignition engines. Influences of engine design features on performance, economy, and air pollution. Influence of the combustion process, carburetion, fuel injection and ignition characteristics on engine operation.

ME 411 Propulsion Systems 4R-0L-4C S
Prerequisites: ME 301 F,W
Corequisites: There are no corequisites for this course.
Application of basic principles in the study of the performance characteristics of air and space vehicles. Aerodynamics of steady one dimensional isentropic compressible flow. Shock waves, gas turbines, turbojet, turbofan, turboprop, turboshaft, ram jet, rocket, nuclear propulsion and space propulsion systems are discussed and compared.

ME 412 Lean Manufacturing 4R-0L-4C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course introduces students to lean manufacturing - the identification of value and elimination of waste in a manufacturing process. The course will feature frequent assigned reading and discussion as well as factory simulations, factory tours, and projects. Students will develop a fundamental understanding of lean principles and will be able to apply their knowledge in any profession.

ME 414 Materials Selection in Mechanical Design 4R-0L-4C See Department
Prerequisites: EM 204 F, S
Corequisites: There are no corequisites for this course.
Introduces the Ashby approach to materials selection, a systematic method for choosing materials for applications based on design constraints, design objectives, and combinations of relevant materials properties. All classes of materials are considered,

including metals, ceramics, polymers, and composites. The CES EduPack software is used extensively throughout the course. Project work is emphasized.

ME 415 Corrosion & Engineering Materials 4R-0L-4C Not Offered
Prerequisites: ME 328 W or CHE 315 F,S
Corequisites: There are no corequisites for this course.
Presents fundamentals of metallurgy and corrosion mechanisms in engineering metals. Discusses various classes of corrosion and methods of mitigating corrosion with emphasis on practical situations.

ME 416 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with EP 410, ECE 416, and CHE 405.

ME 417 Advanced Materials Engineering 4R-0L-4C See Department
Prerequisites: ME 328 W, and EM 203 W or EM 204 F, S
Corequisites: There are no corequisites for this course.
Fundamentals of deformation and fracture in metals, polymers, and ceramics with application to design. Emphasis on time-temperature dependence of polymers, brittle behavior of advanced ceramics, and the fracture mechanics approach to design of high strength and critical application materials.

ME 419 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Prerequisites: EP 410 S or equivalent
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics.

ME 421 Mechanical Engineering Laboratory 0R-6L-2C F,W
Prerequisites: ME 321 W,S, and ENGL H290 F, W, S
Corequisites: There are no corequisites for this course.
Introduction to engineering experimentation, centered on an experimental project planned and executed by students. Uncertainty analysis, instrumentation systems, and statistical design of experiments. Emphasis on project on project planning and execution, developing a scope of work, interim deliverables, and reporting engineering results.

ME 422 Finite Elements for Engineering Applications 4R-0L-4C W
Prerequisites: EM 204 F, S
Corequisites: There are no corequisites for this course.
Introduces finite element methodology from a strongly theoretical perspective. Emphasizes solving various 1D and 2D static, transient, and modal problem statements including trusses, beams, plane stress, plane strain, and axisymmetric models. Problems of interest similar to those found in Statics I and II, as well as Machine Component Design. Also assesses higher order bases, time stepping procedures, and

iterative solvers. Utilizes Matlab and ANSYS for computational work. Upon completion of this class you should be “useful” to a Computer Aided Engineering group from both a theory and implementation standpoint.

ME 423 Fatigue 4R-0L-4C See Department
Prerequisites: EM 204 F, S
Corequisites: There are no corequisites for this course.
Introduces modern methods in fatigue analysis and testing, with a focus on metal fatigue. Covers the stress-life approach, the strain-life approach, and crack growth analysis based on fracture mechanics.

ME 424 Mechanics of Composites 4R-0L-4C F
Prerequisites: EM 204 F, S, and ME 328 W
Corequisites: There are no corequisites for this course.
Introduction to the basic mechanical aspects of composite materials such as: types / classification of composites, micro and macro-mechanical models for material properties, stress/strain analysis, and the manufacturing or composites. Specific focus is given to fiber-reinforced composite materials. Project work is emphasized.

ME 425 Aerospace Engineering Laboratory 1R-3L-2C See Department
Prerequisites: ES 212 W,S
Corequisites: There are no corequisites for this course.
Introduction to experiment planning and execution. Projects involve wind tunnel testing including measurement of forces and moments and flow visualization. Student organized and executed with direct faculty consultation. Emphasis on written presentation.

ME 426 Turbomachinery 4R-0L-4C See Department
Prerequisites: ES 205 S,F
Corequisites: There are no corequisites for this course.
Introduces the theory and issues related to the design of axial and radial flow turbines, compressors and pumps. Euler's equation and vector diagrams are used to evaluate energy transfer and efficiency.

ME 427 Introduction to Computational Fluid Dynamics 3R-3L-4C S
Prerequisites: ES 212 W,S, and ME 323 W,S or ME 327 W,S
Corequisites: There are no corequisites for this course.
Covers the key components of a CFD calculation: mesh generation, numerical algorithm and turbulence modeling. Survey of solution strategy includes both the finite volume and the finite difference methods. Issues on formal order of accuracy, dissipation, dispersion, stability and space-time coupling are discussed in detail. Both structured programs and commercial software will be used as vehicles in obtaining a CFD solution.

ME 428 Materials Research and Instrumentation 4R-0L-4C See Department
Prerequisites: CHEM 111 F,W,S junior standing.
Corequisites: There are no corequisites for this course.
Introduces students to small scale manufacturing methods (deposition, lithography, and etching techniques) and instrumentation for probing these materials (scanning electron microscopy, x-ray diffraction, Raman spectroscopy, and profilometry). Electronic, magnetic, and optical properties are also discussed including (semi-conductivity, dielectric behavior, ferroelectricity, piezoelectricity, types of magnetism, and quantum

dots). Students are expected to read journal articles throughout the course related to these topics and to conduct research in an area of interest in a small team.

ME 429 Experimental Fluid Mechanics 2R-6L-4C W
Prerequisites: ES 212 W,S
Corequisites: There are no corequisites for this course.
An introduction to experimental methods used to study thermal/fluid phenomena. Techniques studied include pressure and force measurement, particle image velocimetry (PIV), laser-induced fluorescence (LIF), laser Doppler velocimetry (LDV), constant temperature/constant current hot-wire anemometry (CTA/CCA), and schlieren/ shadowgraph imaging. Focus is placed on understanding the comparative strengths and weaknesses of techniques in a variety of situations.

ME 430 Mechatronic Systems 3R-3L-4C F,W
Prerequisites: ME 123 F,W,S or CSSE 120 F,W,S or BE 100 F or ENGD 120 S, and ES 213 S, and ES 213L S or ECE 203 S, F or ENGD 120 S or BE 131 S
Corequisites: There are no corequisites for this course.
Applications of microprocessors and microcontrollers and digital electronics to the design and utilizations of embedded control systems in smart systems and products. Topics include Boolean logic and algebra, system hardware and software development, and interfacing for mechanical applications.

ME 435 Robotics Engineering 3R-3L-4C S
Prerequisites: ME 430 F,W or ECE 230 W,S
Corequisites: There are no corequisites for this course.
Interdisciplinary course in robotics focusing on communication, software development, kinematics, robot GUI design, sensing, control, and system integration. Labs in the course cover MATLAB GUI development with GUIDE, Denavit-Hartenberg parameters, Arduino programming, Arduino to Android communication, Android app development, and OpenCV4Android image recognition. Students in the course will program an Android + Arduino, 6-wheeled mobile robot with 5 DOF servo arm to participate in an outdoor GPS robotics challenge. Cross-listed with CSSE 435.

ME 441 Advanced Modeling and Simulation Techniques 4R-0L-4C S
Prerequisites: ES 205 S,F
Corequisites: There are no corequisites for this course.
Covers cross-disciplinary system analysis, modeling, simulation, and control using specialized techniques. Systems to be investigated include linear mechanical, rotational mechanical, electrical, thermal, pneumatic, electro-magnetic, and combinations thereof. Bond graph method for modeling. System simulation and controller design using MATLAB and Simulink. Discussion of modeling, simulation, and control of nonlinear systems. Special topics may be added if time permits.

ME 445 Robot Dynamics and Control 4R-0L-4C W
Prerequisites: ME 406 F or ECE 320 W,S or BE 350 W,S
Corequisites: There are no corequisites for this course.
This course introduces students to the basics of kinematic and dynamic modeling of serial manipulators. Students will also learn joint-space position control and gain familiarity with Cartesian-space control.

ME 447 Visualizing Data 4R-0L-4C Not Offered
Prerequisites: Junior class standing

Corequisites: There are no corequisites for this course.
The course is about creating truthful and compelling data visuals. We study elements of statistical analysis, programming in R, human perception, graphic design, and visual rhetoric and ethics. After successfully completing this course, students should be able to design effective and truthful data displays, credibly explain their design rationale, produce publication-quality visuals, and credibly critique a data display. Prior experience with R is not required.

ME 450 Combustion 4R-0L-4C S
Prerequisites: ME 301 F,W or CHE 303 F,S
Corequisites: There are no corequisites for this course.
Study of the thermodynamics and kinetics of combustion processes and the underlying chemical processes. Topics covered include deflagration and detonation waves, combustion of solid, liquid, and gaseous fuels, and environmental impacts of combustion. Laboratory experience via in-class, hands-on exercises.

ME 461 Aircraft Design 4R-0L-4C F
Prerequisites: ME 305 S
Corequisites: There are no corequisites for this course.
Fundamentals of conceptual aircraft design. Aerodynamic analysis, design constraints based on customer requirements, mission profiles, aircraft sizing, optimization, and presentation of performance capabilities. Oral and written communication emphasized. Design teams.

ME 462 Thermal Design 4R-0L-4C See Department
Prerequisites: ES 212 W,S, and ME 302 S,F
Corequisites: There are no corequisites for this course.
Applications of the thermodynamic, heat transfer, and fluid flow principles to the modeling and design of thermal systems. These systems include pumps, fans, and heat and mass exchangers. A team project which includes the design, construction and testing of a fluid or thermal device or system provides the focus for the course.

ME 470 Capstone Design I 2R-3L-4C F,S
Prerequisites: ES 205 S,F, and EM 204 F, S, and ME 301 F,W, and ME 480 S,F (or concurrent registration), and Junior standing.
Corequisites: There are no corequisites for this course.
Students work in teams with three to five members on design projects furnished from clients. The emphasis is on creating design solutions, with appropriate analyses, to meet stakeholders' needs. In addition to regular meetings with their faculty advisors, the teams are expected to maintain close and continuous communications with their clients during the quarter. The ten week projects culminate in interim reports which are submitted to the clients.

ME 471 Capstone Design II 1R-4L-4C F,W
Prerequisites: ME 470 F,S, and ME 480 S,F
Corequisites: There are no corequisites for this course.
This course is a continuation of ME470. Students continue work in teams with three to five members developing the project started in ME470. The emphasis is on detailing design solutions identified in the first quarter. In addition to regular meetings with their faculty advisors, the teams are expected to maintain close and continuous communications with their clients during the quarter. The ten week projects culminate in

interim reports which are submitted to the clients. This course is intended to be taken in the quarter immediately following ME470.

ME 472 Capstone Design III 1R-4L-4C W,S
Prerequisites: ME 471 F,W
Corequisites: There are no corequisites for this course.
This course is a continuation of ME 471. The student teams test their prototype solutions and transfer the project results to their client. Continuous and regular communication with the outside clients, as well as with the faculty advisors, is expected. The course culminates with a final report that documents the design process. This course is intended to be taken in the quarter immediately following ME471.

ME 480 Machine Component Design 4R-0L-4C S,F
Prerequisites: EM 204 F, S or BE 222 W or EM 203 W
Corequisites: There are no corequisites for this course.
Applications of fundamentals of engineering mechanics in analysis and synthesis of machine components and systems. Special emphases placed on stress/strength analyses and fatigue failures. Design of mechanical components and systems including threaded fasteners, springs, bearings, gears, shafts, clutches, brakes, belts, chains, and couplings.

ME 490 Directed Research As assigned. Maximum 4 credits per term. See Department
Prerequisites: Completion of freshman and sophomore course requirements and approval of adviser and course instructor
Corequisites: There are no corequisites for this course.
Selected projects for student research.

ME 491 Directed Research As assigned. Maximum 4 credits per term. See Department
Prerequisites: Completion of freshman and sophomore course requirements and approval of adviser and course instructor
Corequisites: There are no corequisites for this course.
Selected projects for student research.

ME 493 Selected Topics in Design Hours as assigned. Maximum 4 credits per term. See Department
Prerequisites: Senior class standing
Corequisites: There are no corequisites for this course.
Selected student design projects. May include testing and/or computer aided design.

ME 497 Special Topics in Mechanical Engineering 4R-0L-4C Arranged See Department
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics of current interests in mechanical engineering.

ME 501 Advanced Thermodynamics 4R-0L-4C See Department
Prerequisites: ME 301 F,W or equivalent
Corequisites: There are no corequisites for this course.

Study of advanced thermodynamic topics: modeling of transient systems, exergy (availability) analysis, equations of state and thermodynamics relationships for simple, compressible substances.

ME 502 Topics in Heat Transfer 4R-0L-4C See Department
Prerequisites: ME 302 S,F
Corequisites: There are no corequisites for this course.
Course may be repeated for different heat transfer topics.

ME 503 Viscous Fluid Flow 4R-0L-4C See Department
Prerequisites: ME 401 SeeDept
Corequisites: There are no corequisites for this course.
Material and spatial descriptions of fluid motion. The Reynolds transport equation. The stress tensor and governing equations for the motion of viscous fluids. Newtonian fluids, the Navier-Stokes equations. Asymptotic solutions including fully developed channel flow, oscillating flat plate, wakes and jets. Introduction to boundary layers and turbulent flow including Reynolds averaging.

ME 505 Modeling & Simulation of Dynamic Systems 4R-0L-4C Not Offered
Prerequisites: ES 205 S,F, and MA 222 F,W,S
Corequisites: There are no corequisites for this course.
Modeling and simulation of engineering components and systems. Emphasis on a unified work-energy approach to modeling physical systems, model formulation using a differential-algebraic form of Lagrange's equation, and the numerical solution of the resulting initial-value problem. Applications are explored using modeling and simulation projects.

ME 506 Advanced Control Systems 4R-0L-4C See Department
Prerequisites: ME 406 F or equivalent or consent of instructor
Corequisites: There are no corequisites for this course.
Physical models for control; system response, analysis and design. Time domain; system response, analysis and design. Frequency domain; state variable representation/description; stability, controllability, observability; linear quadratic regulator, pole-placement, state estimation/observers.

ME 507 Applied Nonlinear Control Systems 4R-0L-4C Not Offered
Prerequisites: ME 406 F or equivalent or consent of instructor
Corequisites: There are no corequisites for this course.
Analysis and design of controls for inherently nonlinear systems and the use of nonlinear elements in design. Techniques for analysis and design include, stability by Liaqunov, describing functions, phase plane analysis, sliding control, adaptive control and control of multi-input systems.

ME 510 Gas Dynamics 4R-0L-4C F
Prerequisites: ES 212 W,S
Corequisites: There are no corequisites for this course.
Introduction to the dynamics of a compressible flow. Equations of motion for subsonic and supersonic flow. Nozzle flow. Normal and oblique shock waves, Prandtl-Meyer flow. Steady and unsteady, one dimensional gas flow with friction and heat transfer.

ME 511 Numerical Methods for Dynamic Systems Analysis 4R-0L-4C Not Offered
Prerequisites: ES 205 S,F, and ME 323 W,S or ME 327 W,S

Corequisites: There are no corequisites for this course.
Applications of approximate numerical solution techniques, including the finite element method, to the analysis of dynamic, continuous systems. Introduction to variational principles in mechanics for purposes of formulating governing equations of motion.

ME 512 Light Weight Structures 4R-0L-4C See Department
Prerequisites: MA 222 F,W,S, and EM 203 W or EM 204 F, S
Corequisites: There are no corequisites for this course.
Applies the principles of mechanics to the structural analysis of mechanical and aerospace components. Covers stress tensors, shear flow in open and closed sections, beam columns, unsym-metrical bending. Castigliano's theorem, statically indeterminate structures , thin walled pressure vessels, introduction to elasticity.

ME 513 Environmental Noise 4R-0L-4C See Department
Prerequisites: Senior class standing
Corequisites: There are no corequisites for this course.
Introduces noise and its sources as a potential public health hazard. Covers the basics of sound propagation relating to noise measurement and analysis. Emphasizes effects on humans and the environment. Covers methods of noise and vibration control and abatement including absorption, enclosures, vibration isolation, damping, and mufflers. Team projects involving noise measurement and reduction are required.

ME 514 Materials Selection in Mechanical Design 4R-0L-4C See Department
Prerequisites: Graduate standing or permission of instructor.
Corequisites: There are no corequisites for this course.
Same as ME414, with the requirement that ME514 is only open to graduate students having a graduate project or thesis that the instructor agrees would benefit from the materials selection approach taught in ME414. Students enrolled in ME 514 must complete an experimental, computational, and/or theoretical project related to their graduate work that includes complexities not covered in ME414. Students may not receive credit for both ME414 and ME514.

ME 516 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior class standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with EP 510, ECE 516, CHE 505, and BE 516.

ME 517 Mechanics of Metal Forming 4R-0L-4C See Department
Prerequisites: EM 204 F, S
Corequisites: There are no corequisites for this course.
Fundamentals of plasticity, 2D and 3D stress and strain tensors, characteristics of yield surfaces, flow rules and constitutive relations for elasto-plastic materials. Modelling of metal forming processes using work balance, slab and upper bound analysis techniques. Friction in metal forming. The mechanics of bulk metal forming processes such as extrusion, sheet metal forming, stamping, rolling, drawing, and stretching. Design forming tool dies.

ME 518 Advanced Kinematics 4R-0L-4C Not Offered

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Considers the analysis, design, and simulation of planar and spatial mechanisms. The mechanisms examined are parallel manipulators, serial manipulators, and compliant mechanisms. These mechanisms are analyzed for position, velocity, acceleration, and workspace. The techniques used for the analysis include vector approaches, homogeneous transformations, and dual number techniques.

ME 519 Advanced MEMS: Modeling & Packaging 3R-3L-4C F

Prerequisites: EP 410 S or equivalent
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with ECE 519, EP 511, and CHE 519.

ME 520 Computer-Aided Design & Manufacturing (CAD/CAM) 4R-0L-4C S

Prerequisites: EM 104 F and Senior class standing
Corequisites: There are no corequisites for this course.
Use and management of computer in engineering for drafting, design management, documentation, and manufacturing. Covers drafting methods and standards, design data management, CNC operations and implementation.

ME 522 Advanced Finite Element Analysis 4R-1L-4C S

Prerequisites: ME 422 W
Corequisites: There are no corequisites for this course.
A continuation of ME 422. Includes multi-dimensional extensions of 2-D theory for transient, nonlinear problem statements in engineering. Utilizes Matlab and Ansys for developing and assessing FEA solutions to real world problems via theory developed in ME 422.

ME 523 Fatigue 4R-0L-4C See Department

Prerequisites: Permission of instructor.
Corequisites: There are no corequisites for this course.
Same as ME 423, with the additional requirement that students enrolled in ME 523 must complete an experimental, computational, and/or theoretical project including complexities not covered in ME 423. Students may not receive credit for both ME 423 and ME 523.

ME 524 Mechanics of Composites 4R-0L-4C F

Prerequisites: EM 204 F, S, and ME 328 W and graduate standing, or permission of instructor.
Corequisites: There are no corequisites for this course.
Same as ME 424 with the requirement that ME 524 is only open to graduate students. Students enrolled in ME 524 must complete an additional laboratory project in the course extending the principles developed in the course beyond what is directly covered during the course itself. Students may not receive credit for both ME 424 and ME 524.

ME 526 Turbomachinery 4R-0L-4C See Department

Prerequisites: ES 205 S,F or equivalent, or permission of instructor
Corequisites: There are no corequisites for this course.

Introduces the theory and issues related to the design of axial and radial flow turbines, compressors and pumps. Euler's equation and vector diagrams are used to evaluate energy transfer and efficiency. Students enrolled in ME 526 must complete a design project including complexities not covered in ME 426. Students may not receive credit for both ME 426 and ME 526

ME 527 Computational Fluid Dynamics 3R-3L-4C S
Prerequisites: ES 212 W,S, and ME 323 W,S or ME 327 W,S
Corequisites: There are no corequisites for this course.
Covers the key components of a CFD calculation: mesh generation, numerical algorithm and turbulence modeling. Survey of solution strategy includes both the finite volume and the finite difference methods. Issues on formal order of accuracy, dissipation, dispersion, stability and space-time coupling are discussed in detail. Both structured programs and commercial software will be used as vehicles in obtaining a CFD solution. Students enrolled in ME527 must complete a design project not covered in ME 427. Students may not receive credit for both ME 427 and ME 527.

ME 528 Materials Research and Instrumentation 4R-0L-4C See Department
Prerequisites: CHEM 111 F,W,S graduate standing, or permission of instructor.
Corequisites: There are no corequisites for this course.
Same as ME 428 with the additional requirement that students enrolled in ME 528 must work individually on their research topic. The research topic must also be multifaceted requiring use of several of the instruments discussed during class. Students may not receive credit for both ME 428 and ME 528.

ME 536 Computational Intelligence in Control Engineering 4R-0L-4C See Department
Prerequisites: ME 406 F or equivalent, or consent of instructor
Corequisites: There are no corequisites for this course.
Machine learning and adaptation applied to feedback control, guidance and navigation. Neural Networks for pattern recognition, modeling and control. Radial basis function model identification by recursive least squares. Fuzzy logic controllers. Genetic algorithm for optimization and turning of controllers including fuzzy logic control.

ME 541 Advanced Modeling and Simulation Techniques 4R-0L-4C S
Prerequisites: ES 205 S,F
Corequisites: There are no corequisites for this course.
This course is the same as ME 441 with the addition of greater depth on modeling, simulation, and control of nonlinear systems. ME 541 students will also complete a course project not part of ME 441. Students may not receive credit for both ME 441 and ME 541.

ME 545 Robot Dynamics and Control 4R-0L-4C W
Prerequisites: ME 406 F or ECE 320 W,S or BE 350 W,S graduate standing, or permission of instructor.
Corequisites: There are no corequisites for this course.
This course is the same as ME445 with the additional topic of orientation representation and greater depth on dynamic modeling. ME545 students will also complete a course project. Students may not receive credit for both ME445 and ME545.

ME 547 Visualizing Data 4R-0L-4C Not Offered
Prerequisites: Graduate standing and instructor consent.

Corequisites: There are no corequisites for this course.
Same as ME 447 with the added requirement that the course is open only to graduate students having a graduate project or thesis generating quantitative data that the course instructor has agreed meets the 500-level course objectives.

ME 550 Combustion 4R-0L-4C S
Prerequisites: ME 301 F,W or CHE 303 F,S
Corequisites: There are no corequisites for this course.
Study of the thermodynamics and kinetics of combustion processes and the underlying chemical processes. Topics covered include deflagration and detonation waves, combustion of solid, liquid, and gaseous fuels, and environmental impacts of combustion. Laboratory experience via in-class, hands-on exercises. Students enrolled in ME 550 must complete a design project not covered in ME 450. Students may not receive credit for both ME 450 and ME 550.

ME 590 Thesis Research As assigned See Department
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Credits as assigned; however, not more than 12 credits will be applied toward the requirements of an M.S. degree.

ME 597 Selected Topics for Graduate Students As assigned. Maximum 4 credits per term. See Department
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics arranged by instructor.

ME 699 Professional Experience 1R-0L-1C See Department
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The professional experiences course captures the practical work experiences related to the student's academic discipline. Students are required to submit a formal document of their reflections, which communicates how their employment opportunity reinforced and enhanced their academic studies. The work experiences should be informative or integral to the advancement or completion of the student's program requirements. The course will be graded as "S" satisfactory, or "U" unsatisfactory based on the written report of the professional experience.

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Rose-Hulman
Institute of Technology
5500 Wabash Avenue
Terre Haute, IN 47803
812-877-1511