

# MECHANICAL ENGINEERING

For the undergraduate curriculum in mechanical engineering leading to the degree bachelor of science. This curriculum is accredited under the General Criteria and Mechanical Engineering Program Criteria by the Engineering Accreditation Commission of ABET, <http://www.abet.org/>.

Mechanical engineers apply the principles of motion, energy, and force to create mechanical solutions to technological problems, thereby realizing devices and systems that make life better. About one-fifth of all engineers practicing today are mechanical engineers. Their skills are used in research, development, design, testing, production, technical sales, technical management, as well as medicine, law, and business. Mechanical engineers are characterized by personal creativity, breadth of knowledge, and versatility. For these reasons they are found to function and thrive as valuable members and leaders of multidisciplinary teams. Mechanical engineers are employed in a wide range of industries; examples include agricultural/heavy equipment, biomedical, consulting, energy and power, manufacturing, product design and transportation.

The mechanical engineering curriculum at Iowa State University is dedicated to preparing students for productive careers in the state, nation, and the world and has the following objectives:

1. Graduates will have utilized a foundation in engineering and science to improve lives and livelihoods through a successful career in mechanical engineering or other fields.
2. Graduates will have become effective collaborators and innovators, leading or participating in efforts to address social, technical and business challenges.
3. Graduates will have engaged in life-long learning and professional development through self-study, continuing education or graduate and professional studies in engineering, business, law or medicine.

The mechanical engineering curriculum is organized to provide students with a broad foundation in mathematics, science, engineering, social science and humanities. The mechanical engineering disciplinary areas emphasized are design and optimization, dynamic systems and control, materials processing and mechanics, and thermo-fluid sciences. Elective courses provide additional emphasis in terms of the student's unique educational goals, whether they include immediate entry into industry or further professional or graduate study.

A major focus throughout the mechanical engineering curriculum is a series of experiences that emphasize engineering design, culminating in a capstone design experience in the senior year. Students will develop engineering judgment through open-ended problems that require establishment of reasonable engineering assumptions and realistic constraints. Development of skills needed to be independent, creative thinkers, effective communicators, and contributing team members is emphasized throughout the curriculum. Students also develop an understanding of the societal context in which they will practice engineering, including environmental, legal, aesthetic, and human aspects.

Students are encouraged to participate in the cooperative education program or to obtain engineering internships, both domestically and abroad. Study abroad is encouraged, and the department has exchange programs with several universities around the world. These experiences help students to round out their education and to better prepare for careers in the increasingly global practice of engineering.

## Curriculum in Mechanical Engineering

Administered by the Department of Mechanical Engineering. Leading to the degree bachelor of science.

**Total credits required: 129 cr.**

**Any transfer credit courses applied to the degree program require a grade of C or better (but will not be calculated into the ISU cumulative GPA, Basic Program GPA or Core GPA). See also Basic Program and Special Programs. International Perspectives: 3 cr.<sup>1</sup>**

**U.S. Diversity: 3 cr.<sup>1</sup>**

**Communication Proficiency/Library requirement:**

ENGL 150	Critical Thinking and Communication (minimum grade of C)	3
ENGL 250	Written, Oral, Visual, and Electronic Composition (minimum grade of C)	3
LIB 160	Information Literacy	1
Choose one of the following communication courses (minimum grade of C)		3
ENGL 302	Business Communication	
ENGL 309	Proposal and Report Writing	
ENGL 314	Technical Communication	
SP CM 212	Fundamentals of Public Speaking	

**General Education Electives: 15 cr.**

Choose one course from the following:		3
ECON 101	Principles of Microeconomics	
or ECON 102	Principles of Macroeconomics	
Social Science <sup>2</sup>		3
Humanities		6
Humanities or Social Science <sup>2</sup>		3
<b>Total Credits</b>		<b>15</b>

**Basic Program: 27 cr.**

A minimum GPA of 2.00 is required for this set of courses, including any transfer courses (please note that transfer course grades will not be calculated into the Basic Program GPA). See Requirement for Entry into Professional Program in College of Engineering Overview section.

CHEM 167	General Chemistry for Engineering Students	4
or CHEM 177	General Chemistry I	
ENGL 150	Critical Thinking and Communication	3
ENGL 250	Written, Oral, Visual, and Electronic Composition	3
ENGR 101	Engineering Orientation	R
M E 160	Mechanical Engineering Problem Solving with Computer Applications <sup>3</sup>	3
LIB 160	Information Literacy	1
MATH 165	Calculus I	4
MATH 166	Calculus II	4
PHYS 221	Introduction to Classical Physics I	5
<b>Total Credits</b>		<b>27</b>

**Mechanical Engineering Foundations: 25 cr.**

A minimum GPA of 2.00 for the complete group of Foundations courses is required before students are permitted to enroll in the following Mechanical Engineering Core courses (please note that transfer course grades will not be calculated into the ME Foundations GPA): ME 324, ME 325, ME 332, ME 335, ME 370 and ME 421.

MATH 265	Calculus III	4
4 credits from the following:		4
MATH 267	Elementary Differential Equations and Laplace Transforms	
MATH 266 & MATH 268	Elementary Differential Equations and Laplace Transforms	
PHYS 222	Introduction to Classical Physics II	5
E M 274	Engineering Statics	3
E M 324	Mechanics of Materials	3
MAT E 273	Principles of Materials Science and Engineering	3
M E 231	Engineering Thermodynamics I	3
<b>Total Credits</b>		<b>25</b>

**Mechanical Engineering Core: 38 cr.**

A minimum GPA of 2.00 is required for this set of courses, including any transfer courses (please note that transfer course grades will not be calculated into the Core GPA):

E M 345	Engineering Dynamics	3
E E 442	Introduction to Circuits and Instruments	2
E E 448	Introduction to AC Circuits and Motors	2
M E 270	Introduction to Mechanical Engineering Design	3
M E 324	Manufacturing Engineering	3
M E 324L	Manufacturing Engineering Laboratory	1
M E 325	Mechanical Component Design	3
M E 332	Engineering Thermodynamics II	3
M E 335	Fluid Flow	4
M E 370	Engineering Measurements	3
M E 421	System Dynamics and Control	4
M E 436	Heat Transfer	4
One Senior Capstone Design course from the following		3
M E 415	Mechanical Systems Design	
M E 442	Heating and Air Conditioning Design	
M E 466	Multidisciplinary Engineering Design	
M E 486	Appropriate Technology Design	
<b>Total Credits</b>		<b>38</b>

**Other Remaining Courses: 24 cr.**

Complete 15 cr. Technical Electives <sup>2</sup>		15
M E 170	Engineering Graphics and Introductory Design	3
STAT 305	Engineering Statistics	3
Complete one of the following communication courses with a minimum grade of C.		3
ENGL 302	Business Communication	
ENGL 309	Proposal and Report Writing	
ENGL 314	Technical Communication	
SP CM 212	Fundamentals of Public Speaking	
<b>Total Credits</b>		<b>24</b>

**Seminar/Co-op/Internships:**

M E 202	Mechanical Engineering - Professional Planning	R
Co-op/Internship optional		

1. These university requirements will add to the minimum credits of the program unless the university-approved courses are also approved by

the department to meet other course requirements within the degree program.

U.S. diversity and international perspectives courses may not be taken Pass/Not Pass.

2. Choose from department approved list of technical electives (<http://www.me.iastate.edu/students/degrees-and-programs/bs-degree/degree-requirements/tech-electives>) and general education electives (<http://www.me.iastate.edu/students/degrees-and-programs/bs-degree/degree-requirements/general-education>). Note: electives used to meet graduation requirements may not be taken Pass-Not Pass (P-NP).
3. See Basic Program for Professional Engineering Curricula for accepted substitutions for curriculum designated courses in the Basic Program.

**Transfer Credit Requirements**

The Mechanical Engineering Department requires a grade of a C or better for any transfer credit course that is applied to the degree program. The degree program must include a minimum of 15 credits taken from courses offered through the Mechanical Engineering Department at Iowa State University. Of these 15 credits, 3 must be from one of the senior capstone design courses. The remaining 12 credits may be from the core curriculum program (if a student is deficient in these courses) or from 400-level M E technical electives. No more than 3 credits of independent study shall be applied to meet the 12 credit requirement.

See also: A 4-year plan of study grid showing course template by semester. (<http://catalog.iastate.edu/previouscatalogs/2016-2017/collegeofengineering/mechanicalengineering/#fouryearplantext>)

**Energy Systems Minor**

<http://www.me.iastate.edu/energy-systems-minor/>

The Energy Systems minor is administered by the mechanical engineering department and is open to all undergraduates in the College of Engineering. The minor may be earned by completing 15 credits from the following courses. The complete list of approved elective courses can be found here (<http://www.me.iastate.edu/energy-systems-minor/>).

**Required courses**

ECON 380	Environmental and Resource Economics	3
E E 351	Analysis of Energy Systems	3
Electives: Choose from a list of approved courses		9
<b>Total Credits</b>		<b>15</b>

The minor must include at least 9 credits that are not used to meet any other department, college, or university requirement.

**Nuclear Engineering Minor**

<http://www.me.iastate.edu/students/degrees-and-programs/engineering-minors/>

The nuclear engineering minor is administered by the mechanical engineering department and is open to all undergraduates. The minor may be earned by completing 15 credits from the following courses. A complete list of approved courses can be found here (<http://www.me.iastate.edu/students/degrees-and-programs/engineering-minors/>).

**Required courses**

NUC E 401	Nuclear Radiation Theory and Engineering	3
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Electives: Choose from a list of approved courses.	12
<b>Total Credits</b>	<b>15</b>

The minor must include at least 9 credits that are not used to meet any other department, college, or university requirement.

Mechanical Engineering, B.S.

#### First Year

Fall	Credits Spring	Credits
CHEM 167	4 ENGL 150	3
M E 160	3 M E 170	3
MATH 165	4 MATH 166	4
ENGR 101	0 PHYS 221	5
General Education Elective	3 LIB 160	1
	<b>14</b>	<b>16</b>

#### Second Year

Fall	Credits Spring	Credits
E M 274	3 E M 324	3
MAT E 273	3 MATH 267	4
MATH 265	4 M E 231	3
PHYS 222	5 M E 270	3
ENGL 250	3 General Education Elective	3
	M E 202	0
	<b>18</b>	<b>16</b>

#### Third Year

Fall	Credits Spring	Credits
E E 442	2 M E 325	3
E E 448	2 M E 335	4
E M 345	3 M E 370	3
M E 332	3 M E 324	3
STAT 305	3 Communication Requirement	3
M E 324L	1	
General Education Elective	3	
	<b>17</b>	<b>16</b>

#### Fourth Year

Fall	Credits Spring	Credits
Gen Ed Elective (Intl Perspective)	3 Gen Ed Elective (US Diversity)	3
M E 421	4 Technical Elective	3
M E 436	4 Technical Elective	3
Technical Elective	3 Technical Elective	3
Technical Elective	3 Capstone Design	3
	<b>17</b>	<b>15</b>

**Total Credits: 129**

## Graduate Study

The department offers programs for the degrees Master of Engineering (M. Eng.), Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) with a major in mechanical engineering. The M.Eng. degree is a coursework-only degree designed to improve professional expertise in mechanical engineering. The M.S. and Ph.D. degrees are designed to improve the student's capability to conduct research as well as their professional expertise. Although co-major and formal minor programs are not offered

in mechanical engineering, courses may be used for minor work by students taking major work in other departments.

Well-qualified juniors and seniors in mechanical engineering who are interested in graduate study may apply for concurrent enrollment in the Graduate College to simultaneously pursue both the Bachelor of Science and Master of Science, the Bachelor of Science and Master of Business Administration. Under concurrent enrollment, students are eligible for assistantships and simultaneously take undergraduate and graduate courses. Details are available in the Graduate Programs Office and on the department's website (<http://www.me.iastate.edu/>).

The graduate program offers advanced study in a variety of thrust areas, including biological and nanoscale sciences, clean energy technologies, complex fluid systems, design and manufacturing innovation, and simulation and visualization.

The department offers students the opportunity to broaden their education by participating in minor programs in established departments, interdepartmental programs, or other experiences as approved by their program of study committees.

The requirements for advanced degrees are established by the student's program of study committee within established guidelines of the Graduate College. Graduate students who have not completed an undergraduate program of study substantially equivalent to that required of undergraduate students in the department can expect that additional supporting coursework will be required.

Program requirements can be found on the department webpage (<http://www.me.iastate.edu/>) and in the Mechanical Engineering Graduate Student Handbook.

#### Courses primarily for undergraduates:

##### M E 160: Mechanical Engineering Problem Solving with Computer Applications

(2-2) Cr. 3. F.S.

*Prereq: M E majors only. MATH 142 or MATH 143 or MATH 145; credit or enrollment in MATH 165.*

Introduction to the field of Mechanical Engineering through problem-solving in a range of topics including statics, mechanics of materials and thermo-fluids. Techniques to professionally present and communicate solutions. Use of MATLAB computer programming to aid problem solving, including curve fitting and graphing. Only one of M E 160, ENGR 160, Aer E 160, C E 160, CPR E 185, E E 185, S E 185 and I E 148 may count towards graduation.

##### M E 170: Engineering Graphics and Introductory Design

(2-2) Cr. 3. F.S.

*Prereq: Satisfactory scores on mathematics placement assessments; credit or enrollment in MATH 142 or MATH 143 or MATH 145*

Integration of fundamental graphics, computer modeling, and engineering design. Applications of multiview drawings and dimensioning. Techniques for visualizing, analyzing, and communicating 3-D geometries. Application of the design process including written and oral reports. Freehand and computer methods.

##### M E 190: Learning Communities

(1-0) Cr. 1. Repeatable. F.S.

Enrollment in M E learning communities.

**M E 202: Mechanical Engineering - Professional Planning**

(1-0) Cr. R. F.S.

*Prereq: Sophomore classification*

Preparation for a career in mechanical engineering; discussion of opportunities for leadership, undergraduate research, experiential learning.

**M E 220: Global Sustainability**

(Cross-listed with ANTHR, ENV S, GLOBE, MAT E, SOC, T SC). (3-0) Cr. 3. F.S.

An introduction to the key global issues in sustainability. Focuses on interconnected roles of energy, materials, human resources, economics, and technology in building and maintaining sustainable systems. Applications discussed will include challenges in both the developed and developing world and will examine the role of technology in a resource-constrained world. Cannot be used for technical elective credit in any engineering department.

Meets International Perspectives Requirement.

**M E 231: Engineering Thermodynamics I**

(3-0) Cr. 3. F.S.SS.

*Prereq: MATH 166, CHEM 167, PHYS 221*

Fundamental concepts based on zeroth, first and second laws of thermodynamics. Properties and processes for ideal gases and solid-liquid-vapor phases of pure substances. Applications to vapor power cycles. Credit for either M E 231 or 330, but not both, may be applied toward graduation.

**M E 270: Introduction to Mechanical Engineering Design**

(1-6) Cr. 3. F.S.

*Prereq: M E 160 or equivalent, M E 170 or equivalent, PHYS 221*

Overview of mechanical engineering design with applications to thermal and mechanical systems. Introduction to current design practices used in industry. Semester-long team project focused on addressing societal needs. Past projects include designing human powered charging systems and products for developing nations.

**M E 298: Cooperative Education**

Cr. R. F.S.SS.

*Prereq: Permission of department*

First professional work period in the cooperative education program. Students must register for this course before commencing work.

**M E 324: Manufacturing Engineering**

(3-0) Cr. 3. F.S.SS.

*Prereq: M E 270, E M 324, MAT E 273 and M E 324L or permission of instructor*

Fundamentals of manufacturing processes including forming, machining, casting and welding with emphasis on design considerations in manufacturing. Mechanical behavior of metallic materials. Modern manufacturing practices.

**M E 324L: Manufacturing Engineering Laboratory**

(0-2) Cr. 1. F.S.SS.

*Prereq: M E 270, MAT E 273*

Laboratory exercises in metrology, mechanical testing (tensile/compression and hardness tests), computer aided design (CAD), machining operations, metal welding, metal casting, and bulk/sheet metal forming.

**M E 325: Mechanical Component Design**

(3-0) Cr. 3. F.S.SS.

*Prereq: M E 170, E M 324, and STAT 305*

Philosophy of design and design methodology. Consideration of stresses and failure models useful for static and fatigue loading. Analysis, selection and synthesis of machine elements.

**M E 332: Engineering Thermodynamics II**

(3-0) Cr. 3. F.S.SS.

*Prereq: M E 231*

Gas power cycles. Fundamentals of gas mixtures, psychrometry, and thermochemistry. Applications to one-dimensional compressible flow, refrigeration, air conditioning and combustion processes.

**M E 335: Fluid Flow**

(3-2) Cr. 4. F.S.SS.

*Prereq: E M 345, MATH 265, MATH 266 or MATH 267, credit or enrollment in M E 332.*

Incompressible and compressible fluid flow fundamentals. Dimensional analysis and similitude. Internal and external flow applications. Lab experiments emphasizing concepts in thermodynamics and fluid flow. Written reports are required.

**M E 370: Engineering Measurements**

(2-3) Cr. 3. F.S.SS.

*Prereq: E E 442, STAT 305*

Fundamentals of design, selection, and operation of components of measuring systems. Measurement processes, data acquisition systems, analysis of data, and propagation of measurement uncertainty.

**M E 396: Summer Internship**

Cr. R. Repeatable. SS.

*Prereq: Permission of department and Engineering Career Services*

Summer professional work period.

**M E 397: Engineering Internship**

Cr. R. Repeatable. F.S.

*Prereq: Permission of department and Engineering Career Services*

Professional work period, one semester maximum per academic year.

**M E 398: Cooperative Education**

Cr. R. F.S.SS.

*Prereq: M E 298, permission of department and Engineering Career Services*

Second professional work period in the cooperative education program. Students must register for this course before commencing work.

**M E 410: Mechanical Engineering Applications of Mechatronics**

(2-2) Cr. 3. Alt. S., offered irregularly.

*Prereq: E E 442, E E 448, credit or enrollment in M E 421*

Fundamentals of sensor characterization, signal conditioning and motion control, coupled with concepts of embedded computer control. Digital and analog components used for interfacing with computer controlled systems. Mechanical system analysis combined with various control approaches. Focus on automation of hydraulic actuation processes. Laboratory experiences provide hands-on development of mechanical systems.

**M E 411: Automatic Controls**

(2-2) Cr. 3. F.

*Prereq: M E 421*

Methods and principles of automatic control. Pneumatic, hydraulic, and electrical systems. Representative applications of automatic control systems. Mathematical analysis of control systems.

**M E 412: Ethical Responsibilities of a Practicing Engineer**

(3-0) Cr. 3. F.

*Prereq: Credit or enrollment in M E 325*

The study of ethics in engineering design and the engineering profession. A comprehensive look at when ethical decisions must be made and an approach to make them. The approach takes into account moral, legal, technical, experiential, and standards to aid in ethical decision making. Each area will be studied through lectures, debates, guest speakers, class discussion, and case studies.

**M E 413: Fluid Power Engineering**

(Cross-listed with A B E). (2-2) Cr. 3. F.

*Prereq: Credit or enrollment in E M 378 or M E 335, A B E 216 or M E 270*

Properties of hydraulic fluids. Performance parameters of fixed and variable displacement pumps and motors. Hydraulic circuits and systems. Hydrostatic transmissions. Characteristics of control valves. Analysis and design of hydraulic systems for power and control functions.

**M E 415: Mechanical Systems Design**

(0-6) Cr. 3. F.S.

*Prereq: M E 324, M E 325*

Mechanical Engineering Capstone Design course. Team approach to solving design problems involving mechanical systems. Teams will use current design practices they will encounter in industry. Document decisions concerning form and function, material specification, manufacturing methods, safety, cost, and conformance with codes and standards. Solution description includes oral and written reports. Projects often worked with industry sponsors.

**M E 417: Advanced Machine Design**

(Dual-listed with M E 517). (3-0) Cr. 3. S.

*Prereq: M E 325, M A T E 273*

Stress life, strain life, and fracture mechanics approaches to fatigue life and design with metals, polymers and ceramics. Introduction to material selection in design of machine components. Thermal and structural considerations in design of machine components and hybrid materials. Course project and relevant literature review required for graduate credit.

**M E 418: Mechanical Considerations in Robotics**

(Dual-listed with M E 518). (3-0) Cr. 3. S.

*Prereq: Credit or enrollment in M E 421*

Three dimensional kinematics, dynamics, and control of robot manipulators, hardware elements and sensors. Laboratory experiments using industrial robots.

**M E 419: Computer-Aided Design**

(3-0) Cr. 3. F.

*Prereq: M E 325*

Theory and applications of computer-aided design. Computer graphics programming, solid modeling, assembly modeling, and finite element modeling. Mechanical simulation, process engineering, rapid prototyping and manufacturing integration.

**M E 421: System Dynamics and Control**

(3-2) Cr. 4. F.S.SS.

*Prereq: E E 442, E E 448, E M 345, M A T H 267*

Modeling and simulation of mechanical, electrical, fluid, and/or thermal systems. Development of equations of motion and dynamic response characteristics in time and frequency domains. Fundamentals of classical control applications, including mathematical analysis and design for closed loop control systems. Introduction to computer interfacing for simulation, data acquisition, and control. Laboratory exercises for hands-on system investigation and control implementation.

**M E 423: Creativity and Imagination for Engineering and Design**

(Dual-listed with M E 523). (3-0) Cr. 3.

Broad exposure to the study of creativity, both in scientific research and in engineering design practice. Exploration of the subject includes readings from a variety of fields; in-class discussion and activities; and individual and team projects that enable students to develop their creativity. Graduate students also will do independent research on creativity and develop a related teaching module.

**M E 425: Optimization Methods for Complex Designs**

(Dual-listed with M E 525). (3-0) Cr. 3. F.

*Prereq: M E 160, M A T H 265*

Optimization involves finding the 'best' according to specified criteria. Review of a range of optimization methods from traditional nonlinear to modern evolutionary methods such as Genetic algorithms. Examination of how these methods can be used to solve a wide variety of design problems across disciplines, including mechanical systems design, biomedical device design, biomedical imaging, and interaction with digital medical data. Students will gain knowledge of numerical optimization algorithms and sufficient understanding of the strengths and weaknesses of these algorithms to apply them appropriately in engineering design. Experience includes code writing and off-the-shelf routines. Numerous case-studies of real-world situations in which problems were modeled and solved using advanced optimization techniques.

**M E 433: Alternative Energy**

(3-0) Cr. 3. F.

*Prereq: P H Y S 221/P H Y S 222 and C H E M 167*

Basic principles, performance, and cost analysis of alternative energy systems including biofuels, bioenergy, wind, solar, fuel cells, storage and other alternative energy systems. Performance analysis and operating principles of systems and components, and economic analysis for system design and operation will be taught. Emphasis is on alternative energy technologies needed to meet our future energy needs at various scales ranging from household to city to national levels.

**M E 436: Heat Transfer**

(3-2) Cr. 4. F.S.SS.

*Prereq: M E 335*

Heat transfer by conduction, convection, and radiation. Similarity concepts in heat, mass, and momentum transfer. Methods for determination of heat transfer coefficients. Combined modes of heat transfer. Heat exchangers. Lab experiments emphasizing concepts in thermodynamics and heat transfer. Written reports are required.



**M E 437: Introduction to Combustion Engineering**

(3-0) Cr. 3. S.

*Prereq: Credit in M E 332 or equivalent and credit or enrollment in M E 335 or equivalent.*

Introduction to the fundamentals of combustion and the analysis of combustion systems for gaseous, liquid, and solid fuels-including biomass fuels. Combustion fundamentals are applied to the analysis of engines; turbines, biomass cookstoves; suspension, fixed-bed, and fluidized-bed furnaces; and other combustion devices.

**M E 441: Fundamentals of Heating, Ventilating, and Air Conditioning**

(3-0) Cr. 3. F.

*Prereq: Credit or enrollment in M E 436*

Space conditioning and moist air processes. Application of thermodynamics, heat transfer, and fluid flow principles to the analysis of heating, ventilating, and air conditioning components and systems. Performance and specification of components and systems.

**M E 442: Heating and Air Conditioning Design**

(1-5) Cr. 3. S.

*Prereq: M E 441*

Design criteria and assessment of building environment and energy requirements. Design of heating, ventilating, and air conditioning systems. System control and economic analysis. Oral and written reports required.

**M E 444: Elements and Performance of Power Plants**

(3-0) Cr. 3. S.

*Prereq: M E 332, credit or enrollment in M E 335*

Basic principles, thermodynamics, engineering analysis of power plant systems. Topics include existing power plant technologies, the advanced energyplex systems of the future, societal impacts of power production, and environmental and regulatory concerns.

**M E 448: Fluid Dynamics of Turbomachinery**

(Cross-listed with AER E). (3-0) Cr. 3. S.

*Prereq: AER E 311 or M E 335*

Applications of principles of fluid mechanics and thermodynamics in performance analysis and design of turbomachines. Conceptual and preliminary design of axial and radial flow compressors and turbines using velocity triangles and through-flow approaches.

**M E 449: Internal Combustion Engines**

(3-1) Cr. 3. F.

*Prereq: M E 335*

Basic principles, thermodynamics, combustion, and exhaust emissions of spark-ignition and compression-ignition engines. Laboratory determination of fuel properties and engine performance. Effects of engine components and operating conditions on performance. Written reports required.

**M E 451: Engineering Acoustics**

(Cross-listed with E E, E M). (2-2) Cr. 3. Alt. S., offered even-numbered years.

*Prereq: PHYS 221 and MATH 266 or MATH 267*

Properties of sound waves and noise metrics (pressure, power levels, etc). Sound sources and propagation. Principles of wave propagation in one-, two-, and three-dimensions. Wave reflection and transmission. Wave propagation in rectangular, cylindrical, and annular ducts. Acoustics fields for model noise sources. Introduction to aerodynamic noise sources in aircraft, aircraft engines, and wind turbines. Selected laboratory experiments.

**M E 456: Machine Vision**

(Dual-listed with M E 556). Cr. 3. Repeatable. Alt. S., offered irregularly.

*Prereq: MATH 317, M E 421 or permission of instructor*

Broad exposure to the study of creativity, both in scientific research and in engineering design practice. Exploration of the subject includes readings from a variety of fields; in-class discussion and activities; and individual and team projects that enable students to develop their creativity. Graduate students also will do independent research on creativity and develop a related teaching module.

**M E 466: Multidisciplinary Engineering Design**

(Cross-listed with A B E, AER E, B M E, CPR E, E E, ENGR, I E, MAT E). (1-4)

Cr. 3. Repeatable. F.S.

*Prereq: Student must be within two semesters of graduation and permission of instructor.*

Application of team design concepts to projects of a multidisciplinary nature. Concurrent treatment of design, manufacturing and life cycle considerations. Application of design tools such as CAD, CAM and FEM. Design methodologies, project scheduling, cost estimating, quality control, manufacturing processes. Development of a prototype and appropriate documentation in the form of written reports, oral presentations, computer models and engineering drawings.

**M E 467: Multidisciplinary Engineering Design II**

(Cross-listed with AER E, CPR E, E E, ENGR, I E, MAT E). (1-4) Cr. 3.

Repeatable, maximum of 2 times. Alt. F., offered irregularly. Alt. S., offered irregularly.

*Prereq: Student must be within two semesters of graduation or receive permission of instructor.*

Build and test of a conceptual design. Detail design, manufacturability, test criteria and procedures. Application of design tools such as CAD and CAM and manufacturing techniques such as rapid prototyping. Development and testing of a full-scale prototype with appropriate documentation in the form of design journals, written reports, oral presentations and computer models and engineering drawings.

**M E 475: Modeling and Simulation**

(3-0) Cr. 3. S.

*Prereq: M E 421, credit or enrollment in M E 436*

Introduction to computer solution techniques required to simulate flow, thermal, and mechanical systems. Methods of solving ordinary and partial differential equations and systems of algebraic equations; interpolation, numerical integration; finite difference and finite element methods.

**M E 479: Sustainability Science for Engineering Design**

(3-0) Cr. 3. Alt. S., offered irregularly.

*Prereq: Any engineering design course*

Scientific principles and quantitative methods concerning sustainability. Analysis of environmental issues associated with engineering design and product manufacturing in an economic and social context. Heuristic and analytical methods for assessing the sustainability of existing or potential product/service designs. Application to a design problem in teams.

**M E 484: Technology, Globalization and Culture**

(Dual-listed with M E 584). (Cross-listed with WLC). (3-0) Cr. 3. F.

*Prereq:* junior or senior classification for M E 484; graduate classification for M E 584

Cross-disciplinary examination of the present and future impact of globalization with a focus on preparing students for leadership roles in diverse professional, social, and cultural contexts. Facilitate an understanding of the threats and opportunities inherent in the globalization process as they are perceived by practicing professionals and articulated in debates on globalization. Use of a digital forum for presenting and analyzing globalization issues by on-campus and off-campus specialists.

Meets International Perspectives Requirement.

**M E 486: Appropriate Technology Design**

(3-0) Cr. 3. Alt. F., offered irregularly.

*Prereq:* M E 231, M E 270, enrollment in M E 335; or permission of instructor.

Hands-on design experience utilizing knowledge acquired in core mechanical engineering courses. Emphasis with engineering problem formulation and solution, oral and written communication, team decision-making and ethical conduct. Design projects include engineering considerations in appropriate technology which have multidisciplinary components in economics and sociology.

**M E 490: Independent Study**

Cr. 1-6. Repeatable.

*Prereq:* Senior classification

Investigation of topics holding special interest of students and faculty. Election of course and topic must be approved in advance by supervising faculty.

**M E 490H: Independent Study: Honors**

Cr. 1-6. Repeatable.

*Prereq:* Senior classification

Investigation of topics holding special interest of students and faculty. Election of course and topic must be approved in advance by supervising faculty.

**M E 490J: Independent Study: Thermodynamics and Energy Utilization**

Cr. 1-6. Repeatable.

*Prereq:* Senior classification

Investigation of topics holding special interest of students and faculty. Election of course and topic must be approved in advance by supervising faculty.

**M E 490M: Independent Study: Nuclear Engineering**

Cr. 1-6. Repeatable.

*Prereq:* Senior classification

Investigation of topics holding special interest of students and faculty. Election of course and topic must be approved in advance by supervising faculty.

**M E 490O: Independent Study: Design and Optimization**

Cr. 1-6. Repeatable.

*Prereq:* Senior classification

Investigation of topics holding special interest of student and faculty. Election of course and topic must be approved in advance by supervising faculty.

**M E 490P: Dynamic Systems and Controls**

Cr. 1. Repeatable.

*Prereq:* Senior classification

Investigation of topics holding special interest of student and faculty. Election of course and topic must be approved in advance by supervising faculty.

**M E 490Q: Independent Study: Materials Processing and Mechanics**

Cr. 1-6. Repeatable.

*Prereq:* Senior classification

Investigation of topics holding special interest of student and faculty. Election of course and topic must be approved in advance by supervising faculty.

**M E 490R: Independent Study: Thermo-fluids**

Cr. 1-6. Repeatable.

*Prereq:* Senior classification

Investigation of topics holding special interest of student and faculty. Election of course and topic must be approved in advance by supervising faculty.

**M E 490S: Independent Study: Emerging Areas**

Cr. 1-6. Repeatable.

*Prereq:* Senior classification

Investigation of topics holding special interest of student and faculty. Election of course and topic must be approved in advance by supervising faculty.

**M E 498: Cooperative Education**

Cr. R. Repeatable. F.S.SS.

*Prereq:* M E 298, permission of department and Engineering Career Services

Third and subsequent professional work periods in the cooperative education program. Students must register for this course before commencing work.

**Courses primarily for graduate students, open to qualified undergraduates:**

**M E 510: Economics and Policy of Engineered Energy Systems**

Cr. 3. S.

*Prereq:* Graduate standing.

Economics and policy for U.S. energy systems, with an emphasis on connections to engineering. Topics include: economic analysis of conventional energy commodity markets and technologies, deregulated electricity markets, and emerging energy technologies; demand forecasting; economic and environmental policy in energy; integrated assessment; and semester-specific contemporary issues. Economics majors may not apply this course towards graduation.

**M E 511: Advanced Control Design**

(3-0) Cr. 3. S.

*Prereq:* M E 411

Application of control design methods using continuous, discrete, and frequency-based models. Approaches include classical, pole assignment, model reference, internal model, and adaptive control methods. Mechanical design projects.

**M E 517: Advanced Machine Design**

(Dual-listed with M E 417). (3-0) Cr. 3. S.

*Prereq: M E 325, MAT E 273*

Stress life, strain life, and fracture mechanics approaches to fatigue life and design with metals, polymers and ceramics. Introduction to material selection in design of machine components. Thermal and structural considerations in design of machine components and hybrid materials. Course project and relevant literature review required for graduate credit.

**M E 518: Mechanical Considerations in Robotics**

(Dual-listed with M E 418). (3-0) Cr. 3. S.

*Prereq: Credit or enrollment in M E 421*

Three dimensional kinematics, dynamics, and control of robot manipulators, hardware elements and sensors. Laboratory experiments using industrial robots.

**M E 520: Material and Manufacturing Considerations in Design**

(3-0) Cr. 3. Alt. F., offered irregularly.

*Prereq: M E 324, M E 325*

Integration of materials, design and manufacturing. Materials selection. Design for assembly and manufacturing (DFMA). Design and redesign to facilitate cost-effective manufacturing using material selection and DFMA software.

**M E 521: Mechanical Behavior and Manufacturing of Polymers and Composites**

(Cross-listed with M S E). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: M E 324 or MAT E 272 and E M 324*

Effect of chemical structure and morphology on properties. Linear viscoelasticity, damping and stress relaxation phenomena. Structure and mechanics of filler and fiber reinforced composites. Mechanical properties and failure mechanisms. Material selection and designing with polymers. Processing of polymer and composite parts.

**M E 523: Creativity and Imagination for Engineering and Design**

(Dual-listed with M E 423). (3-0) Cr. 3.

Broad exposure to the study of creativity, both in scientific research and in engineering design practice. Exploration of the subject includes readings from a variety of fields; in-class discussion and activities; and individual and team projects that enable students to develop their creativity. Graduate students also will do independent research on creativity and develop a related teaching module.

**M E 525: Optimization Methods for Complex Designs**

(Dual-listed with M E 425). (Cross-listed with HCI). (3-0) Cr. 3. F.

*Prereq: M E 160, MATH 265*

Optimization involves finding the 'best' according to specified criteria. Review of a range of optimization methods from traditional nonlinear to modern evolutionary methods such as Genetic algorithms. Examination of how these methods can be used to solve a wide variety of design problems across disciplines, including mechanical systems design, biomedical device design, biomedical imaging, and interaction with digital medical data. Students will gain knowledge of numerical optimization algorithms and sufficient understanding of the strengths and weaknesses of these algorithms to apply them appropriately in engineering design. Experience includes code writing and off-the-shelf routines. Numerous case-studies of real-world situations in which problems were modeled and solved using advanced optimization techniques.

**M E 527: Mechanics of Machining and Finishing Processes**

(3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: M E 324*

Mechanics of material removal for ductile materials. Shear zone theory. Oblique cutting. Heat transfer in machining. Milling and grinding. Mechanics of material removal for brittle materials. Optimal selection and design of cutting parameters. Control of machining processes. Principles of precision finishing. Design considerations for machining and finishing processes.

**M E 528: Micro/Nanomanufacturing**

(3-0) Cr. 3. Alt. S., offered irregularly.

*Prereq: M E 324*

Concepts and applications of micro/nanotechnology appropriate to the manufacturing field. An overview of micro/nano-fabrication techniques including mechanical, EDM, laser and lithography. MEMS device fabrication. Scaling laws. Top down and bottom up approaches of nanomanufacturing. Experimental or theoretical project leading to potential submission of a manuscript for journal or conference.

**M E 530: Advanced Thermodynamics**

(3-0) Cr. 3. F.

*Prereq: M E 332*

Fundamentals of thermodynamics from the classical viewpoint with emphasis on the use of the first and second laws for analysis of thermal systems. Generalized thermodynamic relationships. Computer applications of thermodynamic properties and system analysis. Selected topics.

**M E 531: Advanced Energy Systems and Analysis**

Cr. 3. F.

*Prereq: any undergraduate thermodynamics course; mathematics through differential equations*

Introduction to energy systems including economic and thermodynamic principles. Various production systems will be analyzed. Application to transportation and building systems will be emphasized. Sustainability, climate change and other current energy system topics.

**M E 532: Compressible Fluid Flow**

(Cross-listed with AER E). (3-0) Cr. 3. S.

*Prereq: AER E 310, 311 or equivalent*

Thermodynamics of compressible flow. Viscous and inviscid compressible flow equations. One dimensional steady flow; isentropic flow, shocks, expansions. Multidimensional compressible flow aspects. Linear and nonlinear wave analysis and method of characteristics. Subsonic, transonic, supersonic and hypersonic flows.

**M E 535: Thermochemical Processing of Biomass**

(Cross-listed with BRT). (3-0) Cr. 3. S.

*Prereq: Undergraduate course work in thermodynamics and transport phenomena*

Introduction to thermal and catalytic processes for the conversion of biomass to biofuels and other biobased products. Topics include gasification, fast pyrolysis, hydrothermal processing, syngas to synfuels, and bio-oil upgrading. Application of thermodynamics, heat transfer, and fluid dynamics to bioenergy and biofuels.

**M E 536: Advanced Heat Transfer**

(3-0) Cr. 3. S.

*Prereq: M E 436*

Advanced treatment of heat transmission by conduction, convection, and radiation.



**M E 538: Advanced Fluid Flow**

(3-0) Cr. 3. F.

*Prereq: Credit or enrollment in M E 436*

Detailed analysis of incompressible/compressible, viscous/inviscid, laminar/turbulent, and developing fluid flows on a particle/point control volume basis.

**M E 539: Nanoscale Heat Transfer**

Cr. 3. S.

*Prereq: Any undergraduate course on thermodynamics or heat transfer or transport phenomena or solid state physics*

Fundamentals of heat transfer in nanoscale systems, ballistic and diffusive transport, heat conduction due to photons and electrons. Wave and particle nature of energy transfer. Basics of nanoscale thermal radiation. Size effects and transport characteristics for solids, liquids and gases. Computational methodologies and measurement techniques for thermal properties.

**M E 542: Advanced Combustion**

(3-0) Cr. 3. S.

*Prereq: M E 332 or CH E 381*

Thermochemistry and transport theory applied to combustion. Gas phase equilibrium. Energy balances. Reaction kinetics. Flame temperatures, speed, ignition, and extinction. Premixed and diffusion flames. Combustion aerodynamics. Mechanisms of air pollution.

**M E 543: Introduction to Random Vibrations and Nonlinear Dynamics**

(Cross-listed with E M). (3-0) Cr. 3. Alt. S., offered odd-numbered years.

Vibrations of continuous systems. Nonlinear vibration phenomena, perturbation expansions; methods of multiple time scales and slowly-varying amplitude and phase. Characteristics of random vibrations; random processes, probability distributions, spectral density and its significance, the normal or Gaussian random process. Transmission of random vibration, response of simple single and two-degree-of-freedom systems to stationary random excitation. Fatigue failure due to random excitation.

**M E 545: Thermal Systems Design**

(3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: M E 436*

Integrating thermodynamics, fluid mechanics, and heat transfer to model thermal equipment and to simulate thermal systems. Second law and parametric analysis; cost estimation, life cycle analysis and optimization. Some computer programming required.

**M E 546: Computational Fluid Mechanics and Heat Transfer I**

(Cross-listed with AER E). (3-0) Cr. 3. F.

*Prereq: AER E 310 or M E 335, and programming experience*

Basic concepts of discretization, consistency, and stability. Explicit and implicit methods for ordinary differential equations. Methods for each type of partial differential equation. Iterative solution methods; curvilinear grids. Students will program basic algorithms.

**M E 547: Computational Fluid Mechanics and Heat Transfer II**

(Cross-listed with AER E). (3-0) Cr. 3. S.

*Prereq: AER E 546 or equivalent*

Application of computational methods to current problems in fluid mechanics and heat transfer. Methods for solving the Navier-Stokes and reduced equation sets such as the Euler, boundary layer, and parabolized forms of the conservation equations. Introduction to relevant aspects of grid generation and turbulence modeling.

**M E 552: Advanced Acoustics**

(Cross-listed with E M). (3-0) Cr. 3. Alt. F., offered irregularly.

*Prereq: E M 451*

Theoretical acoustics: wave propagation in fluids; acoustic radiation, diffraction and scattering; nonlinear acoustics; radiation force; cavitation; and ray acoustics.

**M E 556: Machine Vision**

(Dual-listed with M E 456). Cr. 3. Repeatable. Alt. S., offered irregularly.

*Prereq: MATH 317, M E 421 or permission of instructor*

Broad exposure to the study of creativity, both in scientific research and in engineering design practice. Exploration of the subject includes readings from a variety of fields; in-class discussion and activities; and individual and team projects that enable students to develop their creativity. Graduate students also will do independent research on creativity and develop a related teaching module.

**M E 557: Computer Graphics and Geometric Modeling**

(Cross-listed with COM S, CPR E). (3-0) Cr. 3. F.

*Prereq: M E 421, programming experience in C*

Fundamentals of computer graphics technology. Data structures. Parametric curve and surface modeling. Solid model representations. Applications in engineering design, analysis, and manufacturing.

**M E 561: Scanning Probe Microscopy**

(2-2) Cr. 3. Alt. F., offered irregularly.

*Prereq: First year physics, chemistry*

Introduction to the scanning probe microscope (SPM, also known as atomic force microscope or AFM) and associated measurement techniques. Overview of instrumentation system, basic principles of operation, probe-sample interaction and various operational modes to obtain micro/nanoscale structure and force spectroscopy of material surfaces. Examples of SPM significance and applications in science and engineering research, nanotechnology and other industries. Laboratory work involving use of a scanning probe microscope system is an integral part of the course.

**M E 563: Micro and Nanoscale Mechanics**

(3-0) Cr. 3. Alt. S., offered odd-numbered years.

*Prereq: E M 324 and M E 325*

Review of Fundamentals: (Elasticity, Electromagnetism, Mechanical response), Mechanics of thermally, electrostatically and magnetically actuated microsystems, Mechanics and design of nanostructured materials, mechanics of surface stress engineering and its implications to sensors and thin film structures.

**M E 564: Fracture and Fatigue**

(Cross-listed with AER E, E M, M S E). (3-0) Cr. 3. Alt. F., offered even-numbered years.

*Prereq: E M 324 and either MAT E 216 or MAT E 273 or MAT E 392.**Undergraduates: Permission of instructor*

Materials and mechanics approach to fracture and fatigue. Fracture mechanics, brittle and ductile fracture, fracture and fatigue characteristics, fracture of thin films and layered structures. Fracture and fatigue tests, mechanics and materials designed to avoid fracture or fatigue.

**M E 566: Phase Transformation in Elastic Materials**

(Cross-listed with E M). (3-0) Cr. 3. S.

*Prereq: EM 510 or EM 516 or EM 514*

Continuum thermodynamics and kinetics approaches to phase transformations. Phase field approach to stress- and temperature-induced martensitic transformations and twinning at the nanoscale. Nucleation and growth. Nanostructural evaluation. Analytical and numerical solutions. Surface stresses and energy. Surface-induced phase transformations. Large Strain formulation.

**M E 573: Random Signal Analysis and Kalman Filtering**

(Cross-listed with AER E, E E). (3-0) Cr. 3. F.

*Prereq: E E 324 or AER E 331 or M E 370 or M E 411 or MATH 341*

Elementary notions of probability. Random processes. Autocorrelation and spectral functions. Estimation of spectrum from finite data. Response of linear systems to random inputs. Discrete and continuous Kalman filter theory and applications. Smoothing and prediction. Linearization of nonlinear dynamics.

**M E 574: Optimal Control**

(Cross-listed with AER E, E E). (3-0) Cr. 3. S.

*Prereq: E E 577*

The optimal control problem. Variational approach. Pontryagin's principle, Hamilton-Jacobi equation. Dynamic programming. Time-optimal, minimum fuel, minimum energy control systems. The regulator problem. Structures and properties of optimal controls.

**M E 575: Introduction to Robust Control**

(Cross-listed with AER E, E E). (3-0) Cr. 3.

*Prereq: E E 577*

Introduction to modern robust control. Model and signal uncertainty in control systems. Uncertainty description. Stability and performance robustness to uncertainty. Solutions to the H<sub>2</sub>, H<sub>∞</sub>, and l<sub>1</sub> control problems. Tools for robustness analysis and synthesis.

**M E 576: Digital Feedback Control Systems**

(Cross-listed with AER E, E E). (3-0) Cr. 3. F.

*Prereq: E E 475 or AER E 432 or M E 411 or MATH 415; and MATH 267*

Sampled data, discrete data, and the z-transform. Design of digital control systems using transform methods: root locus, frequency response and direct design methods. Design using state-space methods. Controllability, observability, pole placement, state estimators. Digital filters in control systems. Microcomputer implementation of digital filters. Finite wordlength effects. Linear quadratic optimal control in digital control systems. Simulation of digital control systems.

**M E 577: Linear Systems**

(Cross-listed with AER E, E E, MATH). (3-0) Cr. 3. F.

*Prereq: E E 324 or AER E 331 or MATH 415; and MATH 207*

Linear algebra review. Least square method and singular value decomposition. State space modeling of linear continuous-time systems. Solution of linear systems. Controllability and observability. Canonical description of linear equations. Stability of linear systems. State feedback and pole placements. Observer design for linear systems.

**M E 578: Nonlinear Systems**

(Cross-listed with AER E, E E, MATH). (3-0) Cr. 3. S.

*Prereq: E E 577*

Linear vs nonlinear systems. Phase plane analysis. Bifurcation and center manifold theory. Lyapunov stability. Absolute stability of feedback systems. Input-output stability. Passivity theory and feedback linearization. Nonlinear control design techniques.

**M E 580: Virtual Environments, Virtual Worlds, and Application**

(Cross-listed with HCI). (3-0) Cr. 3. F.

*Prereq: Senior or Graduate status.*

A systematic introduction to the underpinnings of Virtual Environments (VE), Virtual Worlds, advanced displays and immersive technologies; and an overview of some of the applications areas particularly virtual engineering.

**M E 584: Technology, Globalization and Culture**

(Dual-listed with M E 484). (Cross-listed with WLC). (3-0) Cr. 3. F.

*Prereq: junior or senior classification for M E 484; graduate classification for M E 584*

Cross-disciplinary examination of the present and future impact of globalization with a focus on preparing students for leadership roles in diverse professional, social, and cultural contexts. Facilitate an understanding of the threats and opportunities inherent in the globalization process as they are perceived by practicing professionals and articulated in debates on globalization. Use of a digital forum for presenting and analyzing globalization issues by on-campus and off-campus specialists.

Meets International Perspectives Requirement.

**M E 590: Special Topics**

Cr. 1-8. Repeatable.

**M E 590Q: Special Topics: Independent Literature Investigation**

Cr. 1-8. Repeatable.

**M E 590T: Special Topics: Biological and Nanoscale Sciences**

Cr. 1-8. Repeatable.

**M E 590U: Special Topics: Complex Fluid Systems**

Cr. 1-8. Repeatable.

**M E 590V: Special Topics: Clean Energy Technologies**

Cr. 1-8. Repeatable.

**M E 590W: Special Topics: Design and Manufacturing Innovation**

Cr. 1-8. Repeatable.

**M E 590Z: Special Topics: Simulation and Visualization**

Cr. 1-8. Repeatable.

**M E 599: Creative Component**

Cr. arr. Repeatable.

**Courses for graduate students:****M E 600: Seminar**Cr. R. Repeatable.  
(1-0).**M E 625: Surface Modeling**

(3-0) Cr. 3. Alt. F., offered irregularly. Alt. S., offered irregularly.

*Prereq: M E 557, programming experience in C*

Theory and implementation of contemporary parametric sculptured surface modeling technology. Non-uniform rational B-spline (NURBS) curves and surfaces. Fundamental computational algorithms. Construction techniques. Advanced modeling topics. Computer projects.

**M E 632: Multiphase Flow**

(Cross-listed with CH E). (3-0) Cr. 3. Alt. S., offered odd-numbered years.  
*Prereq: M E 538*

Single particle, multiparticle and two-phase fluid flow phenomena (gas-solid, liquid-solid and gas-liquid mixtures); particle interactions, transport phenomena, wall effects; bubbles, equations of multiphase flow. Dense phase (fluidized and packed beds) and ducted flows; momentum, heat and mass transfer. Computer solutions.

**M E 637: Convection Heat Transfer**

(3-0) Cr. 3. Alt. F., offered irregularly. Alt. S., offered irregularly.  
*Prereq: M E 436*

Convection heat transfer to internal or external flows under laminar or turbulent conditions. Dimensionless parameters. Classical solutions of Newtonian viscous flows. Forced and free convection. Special topics.

**M E 638: Radiation Heat Transfer**

(3-0) Cr. 3. Alt. F., offered irregularly.  
*Prereq: M E 436*

Techniques for analysis of radiation in enclosures. Radiative properties of surfaces. Radiative transfer in participating media. Combined modes of transfer. Approximate methods of analysis.

**M E 647: Advanced Computational Fluid Dynamics**

(Cross-listed with AER E). (3-0) Cr. 3. S.  
*Prereq: AER E 547*

An examination of current methods in computational fluid dynamics. Differencing strategies. Advanced solution algorithms for unstructured meshes. Grid generation. Construction of higher-order CFD algorithms. Parallel computing. Current applications. Use of state of the art CFD codes.

**M E 690: Advanced Topics**

Cr. arr. Repeatable.  
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

**M E 690G: Advanced Topics: Advanced Machine Design**

Cr. arr. Repeatable.  
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

**M E 690O: Advanced Topics: Engineering Computation**

Cr. arr. Repeatable.  
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

**M E 690Q: Advanced Topics: Independent Literature Investigation**

Cr. arr. Repeatable.  
Investigation of advanced topics of special interest to graduate students in mechanical engineering.

**M E 690T: Advanced Topics: Biological and Nanoscale Sciences**

Cr. arr. Repeatable. F.S.SS.  
Investigation of Special Topics: Biological and Nanoscale Sciences of special interest to graduate students in mechanical engineering.

**M E 690U: Advanced Topics: Complex Fluid Systems**

Cr. arr. Repeatable. F.S.SS.  
Investigation of Special Topics: Complex Fluid Systems of special interest to graduate students in mechanical engineering.

**M E 690V: Advanced Topics: Clean Energy Technologies**

Cr. arr. F.S.SS.  
Investigation of Special Topics: Clean Energy Technologies of special interest to graduate students in mechanical engineering.

**M E 690W: Advanced Topics: Design and Manufacturing Innovation**

Cr. arr. Repeatable.  
Investigation of Design & Manufacturing Innovation of special interest to graduate students in mechanical engineering.

**M E 690Z: Advanced Topics: Simulation and Visualization**

Cr. arr. Repeatable. F.S.SS.  
Investigation of Special Topics: Simulation and Visualization of special interest to graduate students in mechanical engineering.

**M E 697: Engineering Internship**

Cr. R. Repeatable.  
*Prereq: Permission of Director of Graduate Education, graduate classification*  
One semester and one summer maximum per academic year professional work period. Offered on a satisfactory-fail basis only.

**M E 699: Research**

Cr. arr. Repeatable.  
Offered on a satisfactory-fail basis only.