MECHANICAL ENGINEERING

Emphasis areas at all levels in control systems, energy conversion, environmental systems, instrumentation, manufacturing processes, materials science, mechanical design and analysis, and thermal science.

The mechanical engineering program is offered in the department of mechanical and aerospace engineering.

Mechanical engineering has broad applications and is one of the most basic of all branches of engineering.

As a mechanical engineer you will be concerned with the conversion and transfer of energy from one form to another, with the design, construction, and operation of all types of machines; and with the selection and design of instrumentation and systems for the control of all types of physical and environmental systems.

You may design products and manufacturing processes, supervise production methods and operations, design and supervise fabrication and testing of individual machines and complete plants, or be involved in applied or basic research.

In your first few semesters as a mechanical engineering student, you will develop a sound background in the fundamental sciences of mathematics, physics, and chemistry, and you will take a broad selection of liberal arts courses. You will also learn to work with computers. Onto this foundation you will add the basic required courses of engineering sciences and technology including stress analysis, machine design, machine dynamics, electricity, electronics, control theory, thermodynamics, heat transfer, energy conversion, fluid mechanics, computer-aided engineering (CAE), and computer-aided design (CAD).

To provide some degree of specialization for those students who are interested in a particular area of mechanical engineering, there are nine hours of technical electives that you can select to concentrate in an emphasis area (such as robotics, manufacturing automation, fluid mechanics, heat transfer, dynamics and controls, solid mechanics, vibrations, and design). If you are interested in getting some background in a closely allied field such as aerospace, petroleum, or nuclear engineering, you can, with the aid of your advisor, select some of your desired technical electives in those fields.

Mission Statement

We will provide a rigorous, productive, and relevant academic learning environment for students, faculty, and staff in the mechanical and aerospace engineering department by continually focusing on our core missions of teaching, research, and service.

We will ensure that graduating students are well-educated and sufficiently prepared in the fundamentals of mechanical and aerospace engineering practice and science, such that they have the ability to solve open-ended problems in these disciplines and the capabilities required in order to become competent, productive, and well-rounded professionals.

We will emphasize scholarship, graduate education, and the development of new knowledge and skills in the traditional areas associated with mechanical and aerospace engineering. Additionally, we will develop cross-cutting multi-disciplinary efforts such that we are widely recognized by local, national, and international research and business communities as respected leaders in research, innovation, and discovery.

We will render meritorious service to our profession through active participation and engagement in service activities in our professional communities at all levels (local, national, and international), as well as in fulfilling campus and departmental governance, outreach, and service activities.

Program Educational Objectives

The mechanical engineering program seeks to prepare its graduates for the following early career and professional accomplishments in their employment by industry, government agencies, academia, or private practice:

- Demonstrated engineering competence, successfully contributing within their career fields with increasing levels of responsibility and influence
- Continuous growth in knowledge and capability, within the mechanical engineering field as well as across interdisciplinary boundaries

It is the goal of the program that graduates will be personally satisfied with how their education from Missouri S&T prepared them for their career.

Student Outcomes

1. Students graduating from this program should have:
   A. an ability to apply knowledge of mathematics, science, and engineering
   B. an ability to design and conduct experiments, as well as to analyze and interpret data
   C. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
   D. an ability to function on multidisciplinary teams
   E. an ability to identify, formulate, and solve engineering problems
   F. an understanding of professional and ethical responsibility
   G. an ability to communicate effectively
   H. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
   I. a recognition of the need for, and an ability to engage in life-long learning
   J. a knowledge of contemporary issues
   K. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
   L. an ability to work professionally in both thermal and mechanical systems areas

Bachelor of Science
Mechanical Engineering

Entering freshmen desiring to study mechanical engineering will be admitted to the Freshman Engineering Program. They will, however, be permitted, if they wish, to state a mechanical engineering preference, which will be used as a consideration for available freshman departmental scholarships. The focus of the Freshman Engineering
The mechanical engineering program at Missouri S&T is characterized by its focus on the scientific basics of engineering and its innovative application; indeed, the underlying theme of this educational program is the application of the scientific basics to engineering practice through attention to problems and needs of the public. The necessary application; indeed, the underlying theme of this educational program is the application of the scientific basics to engineering practice through attention to problems and needs of the public. The necessary inclusion of the humanities or social sciences courses already taken. Foreign language courses numbered 1180 will be considered to satisfy this requirement. Students may receive humanities credit for foreign language courses in their native tongue only if the course is at the 4000-level. All courses taken to satisfy the depth requirement must be taken after graduating from high school.

3. The remaining two courses are to be chosen from the list of approved humanities/social sciences courses and may include one communications course in addition to ENGLISH 1120.

4. Special topics and special problems and honors seminars are allowed only by petition to and approval by the student's department chair.

The mechanical engineering program at Missouri S&T is characterized by its focus on the scientific basics of engineering and its innovative application; indeed, the underlying theme of this educational program is the application of the scientific basics to engineering practice through attention to problems and needs of the public. The necessary interrelations among the various topics, the engineering disciplines, and the other professions as they naturally come together in the solution of real world problems are emphasized as research, analysis, synthesis, and design are presented and discussed through classroom and laboratory instruction.

### Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Credits</th>
<th>Second Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR ENG 1100</td>
<td>1</td>
<td>ECON 1100 or 1200</td>
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<tr>
<td>CHEM 1310</td>
<td>4</td>
<td>MECH ENG 1720</td>
<td>3</td>
</tr>
<tr>
<td>ENGLISH 1120</td>
<td>3</td>
<td>PHYSICS 1135</td>
<td>4</td>
</tr>
<tr>
<td>HISTORY 1200, or 1300, or 1310, or POL SCI 1200</td>
<td>3</td>
<td>MATH 1215</td>
<td>4</td>
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<tr>
<td>CHEM 1319</td>
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<td>Elective-Hum or Soc Sci</td>
<td>3</td>
</tr>
<tr>
<td>MATH 1214</td>
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**Total Credits:** 16

### Sophomore Year

<table>
<thead>
<tr>
<th>First Semester</th>
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<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 2222</td>
<td>4</td>
<td>MECH ENG 2761</td>
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<tr>
<td>Programming Elective $^a, b, c$</td>
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<td>MECH ENG 2519</td>
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<td>CIV ENG 2200</td>
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<td>MECH ENG 2360</td>
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<tr>
<td>PHYSICS 2135</td>
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<td>MATH 3304</td>
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<tr>
<td>MECH ENG 2653</td>
<td>3</td>
<td>MET ENG 2110</td>
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**Total Credits:** 17

### Junior Year

<table>
<thead>
<tr>
<th>First Semester</th>
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<th>Second Semester</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECH ENG 3313</td>
<td>3</td>
<td>MECH ENG 3411</td>
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<td>MECH ENG 3521</td>
<td>3</td>
<td>MECH ENG 3131</td>
<td>3</td>
</tr>
<tr>
<td>ELEC ENG 2800</td>
<td>3</td>
<td>MECH ENG 4840</td>
<td>2</td>
</tr>
<tr>
<td>CIV ENG 2210</td>
<td>3</td>
<td>Elective-Communications $^d$</td>
<td>3</td>
</tr>
<tr>
<td>CIV ENG 2211</td>
<td>1</td>
<td>MECH ENG 3708</td>
<td>3</td>
</tr>
<tr>
<td>Elective-Advanced Math/Stat or Comp Sci $^e$</td>
<td>3</td>
<td>MECH ENG 3525</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total Credits:** 16

### Senior Year

<table>
<thead>
<tr>
<th>First Semester</th>
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<th>Second Semester</th>
<th>Credits</th>
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<tbody>
<tr>
<td>MECH ENG 4842</td>
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<td>ENG MGT 1100</td>
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<td>MECH ENG 4479</td>
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<td>MECH ENG 1210</td>
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<tr>
<td>MECH ENG technical elective $^g$</td>
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<td>MECH ENG 4761</td>
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<tr>
<td>Literature elective $^f$</td>
<td>3</td>
<td>MECH ENG 4480</td>
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</tr>
<tr>
<td>Technical elective $^h$</td>
<td>3</td>
<td>MECH ENG 5000-level technical elective $^i$</td>
<td>3</td>
</tr>
<tr>
<td>Elective-Advanced Hum or Soc Sci $^f$</td>
<td>3</td>
<td>Breadth elective $^j$</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total Credits:** 17

**Total Credits: 128**

**Note:** Students must satisfy the common engineering freshman year course requirements, and be admitted into the department, in addition to the sophomore, junior and senior year requirements listed above with a minimum of 128 hours.

- A grade of "C" or better is required in CHEM 1310, MATH 1214, MATH 1215, MATH 2222, MATH 3304, PHYSICS 1135, PHYSICS 2135, programming elective, MET ENG 2110, CIV ENG 2200, CIV ENG 2210, MECH ENG 2519, MECH ENG 2360, and MECH ENG 3411, both as prerequisite for follow-up courses in the curriculum and for graduation.
- MATH 1208 and MATH 1221 may be substituted for MATH 1214 and MATH 1215, respectively.
- The programming elective consists of a lecture and lab combination, and may be selected from COMP SCI 1970/COMP SCI 1980, COMP SCI 1971/COMP SCI 1981, or COMP SCI 1972/COMP SCI 1982, or COMP SCI 1570/COMP SCI 1580. Note that COMP SCI 1570/COMP SCI 1580 requires one more credit hour than the other options.
- This course must be selected from the following: ENGLISH 1160, ENGLISH 3560 or SP&M S 1185, or the complete four course sequence in Advanced ROTC (MIL ARMY 3250, MIL ARMY 3500, MIL ARMY 4250, and MIL ARMY 4500; or MIL AIR 3110, MIL AIR 3120, MIL AIR 4110 and MIL AIR 4120).
- This course must be selected from the following: COMP SCI 3200, MATH 3103, MATH 3108, STAT 3113, STAT 3115 or any 5000-level math or computer science course approved by the student's advisor.
All electives must be approved by the student's advisor. Students must comply with the general education requirements with respect to selection and depth of study. These requirements are specified in the current catalog.

Six hours of technical electives, subject to approval by the student's advisor, must be in the department of mechanical and aerospace engineering. At least three of these technical elective hours must be at the 5000 level. This elective may not include co-op, special problems, or research credits, such as as 3002, 4000, or 4099. Honors students have special requirements for technical electives.

This elective must be a three credit hour course, subject to approval by the student's advisor, from any of the following areas: math, statistics, science, engineering, or computer science. The course must be at the 3000 or higher level, or have a prerequisite that is part of the required mechanical engineering curriculum. Exceptions to the course level may be approved by the student's advisor. The elective may not include co-op, special problems, or research credits, such as 3002, 4000, or 4099.

This elective consists of three credit hours, subject to approval by the student's advisor, and may be satisfied by any of the following: (1) A three credit hour course from any of the following areas: math, statistics, science, engineering, computer science, business, or IST. The course must be at the 3000 or higher level, or have a prerequisite that is part of the required mechanical engineering curriculum. Exceptions to the course level may be approved by the student's advisor; (2) Any three credit hour course in the list of approved courses for the global studies minor; or (3) Any combination of three credit hours from co-op (3002), special problems (3000, 4000, or 5000), research (4099), or design team credit (ENG MGT 2011, 2012, or 2013).

All mechanical engineering students must take the Fundamentals of Engineering Examination prior to graduation. A passing grade on this examination is not required to earn a B.S. degree. However, it is the first step toward becoming a registered professional engineer. This requirement is part of the Missouri S&T assessment process as described in assessment requirements found elsewhere in this catalog. Students must sign a release form giving the university access to their Fundamentals of Engineering Examination score.

**Energy Conversion Emphasis Area for Mechanical Engineering**

Students desiring to obtain a bachelor of science degree in mechanical engineering with an emphasis area in energy conversion must satisfy all the requirements of the bachelor of science degree in mechanical engineering, with the additional stipulation that four courses must be taken as follows:

- a. Two courses from the following list:
  - MECH ENG 5525: Intermediate Heat Transfer
  - or AERO ENG 5525: Intermediate Heat Transfer
  - MECH ENG 5131: Intermediate Thermofluid Mechanics
  - or AERO ENG 5131: Intermediate Thermofluid Mechanics
  - MECH ENG 5139: Computational Fluid Dynamics
  - or AERO ENG 5139: Computational Fluid Dynamics

- b. One course from the following list:
  - MECH ENG 5519: Advanced Thermodynamics
  - or AERO ENG 5519: Advanced Thermodynamics

- c. One additional course from either list "a" or list "b", or from the following list:
  - ECON 4540: Energy Economics
  - ELEC ENG 5150: Photovoltaic Systems Engineering
  - ENV ENG 5660: Introduction To Air Pollution
  - NUC ENG 4257: Two-phase Flow in Energy Systems - I

**Note:** By using the breadth elective and technical electives to satisfy the above requirements, this emphasis area requires the same total number of credit hours as the BSME degree. A change of major form should be submitted to designate the energy conversion emphasis area.

**Manufacturing Processes Emphasis Area for Mechanical Engineering**

Students desiring to obtain a bachelor of science in mechanical engineering with an emphasis area in manufacturing processes must satisfy all requirements of the bachelor of science in mechanical engineering with the additional stipulation that four courses must be taken as follows:

- a. The following course:
  - MECH ENG 3653: Manufacturing

- b. One course from the following Manufacturing/Automation courses:
  - MECH ENG 5653: Computer Numerical Control of Manufacturing Processes
  - MECH ENG 5655: Manufacturing Equipment Automation
  - MECH ENG 5449: Robotic Manipulators and Mechanisms
  - MECH ENG 5606: Material Processing By High-Pressure Water Jet

- c. One course from the following Design courses:
  - MECH ENG 5763: Principles And Practice Of Computer Aided Design
  - MECH ENG 5656: Design For Manufacture
  - MECH ENG 5702: Synthesis Of Mechanisms

- d. One course from the following list:
  - MECH ENG 5708: Rapid Product Design And Optimization
  - MECH ENG 5758: Integrated Product Development

- e. The Math/Stat elective must be one of the following:
  - STAT 3113: Applied Engineering Statistics
  - STAT 3115: Engineering Statistics

A suggested sequence for the junior and senior years is given below. Note that by using the breadth elective and technical electives to satisfy the above requirements, this emphasis area requires the same total number of credit hours as the BSME degree. A change of major form should be submitted to designate the manufacturing processes emphasis area.

**Junior Year**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>First Semester</td>
<td></td>
<td>Second Semester</td>
<td></td>
</tr>
<tr>
<td>MECH ENG 3313</td>
<td>3</td>
<td>MECH ENG 3411</td>
<td>3</td>
</tr>
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<td>3</td>
<td>MECH ENG 3525</td>
<td>3</td>
</tr>
<tr>
<td>CIV ENG 2210</td>
<td>3</td>
<td>MECH ENG 4840</td>
<td>2</td>
</tr>
<tr>
<td>CIV ENG 2211</td>
<td>1</td>
<td>MECH ENG 3653</td>
<td>3</td>
</tr>
<tr>
<td>STAT 3113 or 3115</td>
<td>3</td>
<td>Elective-Communications</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>
must satisfy all requirements of the bachelor of science in mechanical engineering, with the additional stipulation that four courses must be taken as follows:

a. One design course from the following list:
   - MECH ENG 5709 Machine Design II
   - MECH ENG 5702 Synthesis Of Mechanisms
   - MECH ENG 5704 Compliant Mechanism Design
   - MECH ENG 5708 Rapid Product Design And Optimization
   - MECH ENG 5715 Concurrent Engineering
   - MECH ENG 5656 Design For Manufacture
   - MECH ENG 5757 Integrated Product And Process Design
   - MECH ENG 5760 Probabilistic Engineering Design
   - MECH ENG 5763 Principles And Practice Of Computer Aided Design
   - MECH ENG 5761 Engineering Design Methodology

b. One analysis course from the following list:
   - MECH ENG 5307 Vibrations I
   - MECH ENG 5211 Introduction To Continuum Mechanics
   - MECH ENG 5212 Introduction To Finite Element Analysis
   - MECH ENG 5313 Intermediate Dynamics Of Mechanical And Aerospace Systems

Note that by using the breadth elective and technical electives to satisfy the above requirements, this emphasis area requires the same total number of credit hours as the BSME degree. A change of major form should be submitted to designate the mechanical design and analysis emphasis area.

Darryl Alofs, Emeritus Professor
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PHD Iowa State University

Clark Barker, Emeritus Professor
PHD University of Illinois

Charles Benjamin Basye, Emeritus Professor
PHD Iowa State University

Victor Birman, Professor
PHD Technion, Haifa, Israel

Douglas A Bristow, Associate Professor
PHD University of Illinois Urbana-Champaign

Douglas Carroll, Professor
PHD University of Missouri-Rolla

K Chandrashekara, Curators Professor
PHD Virginia Polytechnic Institute

Ta-Shen Chen, Curators Professor Emeritus
PHD University of Minnesota

Lianyi Chen, Asst Professor
PHD Zhejiang University

Donald Cronin, Emeritus Professor
PHD California Institute of Technology

### Mechanical Design and Analysis Emphasis Area

Students desiring to obtain a bachelor of science in mechanical engineering with an emphasis area in mechanical design and analysis must satisfy all requirements of the bachelor of science in mechanical engineering, with the additional stipulation that four courses must be taken as follows:

a. One design course from the following list:
   - MECH ENG 5653, MECH ENG 5655, MECH ENG 5449, MECH ENG 5606.
   - One of the following design courses:
     - MECH ENG 5763, MECH ENG 5765, MECH ENG 5702.
     - One course from the following list: MECH ENG 5708, MECH ENG 5758.

b. One analysis course from the following list:
   - MECH ENG 5211 Introduction To Continuum Mechanics
   - MECH ENG 5212 Introduction To Finite Element Analysis
   - MECH ENG 5313 Intermediate Dynamics Of Mechanical And Aerospace Systems

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PHD Zhejiang University

Donald Cronin, Emeritus Professor
PHD California Institute of Technology
MECH ENG 1720 Introduction to Engineering Design (LAB 1.0 and LEC 2.0)
Introduction to a systematic approach to engineering design (problem clarification, concept generation, concept selection, prototyping methods, engineering ethics) and fundamental design communication techniques. Computer aided design tools are introduced to assist in design analysis.

MECH ENG 2001 Special Topics (IND 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title.
MECH ENG 2340 Statics and Dynamics (LEC 3.0)
An introduction to the principles of mechanics pertaining to problems of equilibrium, motion, and acceleration in two dimensions. Particle and rigid body equilibrium and applications; general planar motion; force, mass, and acceleration; impulse/momentum; work/energy. This course will not satisfy the prerequisite for Civ Eng 2210. Prerequisites: A grade of "C" or better in Physics 1135 or Physics 1111; preceded or accompanied by Math 2222.

MECH ENG 2350 Engineering Mechanics-Dynamics (LEC 2.0)
Application of the principles of mechanics to engineering problems of motion and acceleration. Topics include plane motion; force, mass and acceleration; work and energy; and impulse and momentum. Prerequisites: A grade of "C" or better in each of Civ Eng 2200 and Math 2222.

MECH ENG 2360 Dynamics (LEC 3.0)
The principles of mechanics are used to model engineering systems. Kinematics of particle motion, kinematics of plane- and three-dimensional motions of rigid bodies. Kinetics of particles and of rigid bodies. Energy and momentum methods. Prerequisite: Grade of "C" or better in each of Civ Eng 2200, Math 2222. (Co-listed with Aero Eng 2360).

MECH ENG 2519 Thermodynamics (LEC 3.0)
Energy transformations and the relation of energy to the status of matter. Fundamental laws, concepts, and modes of analysis which underlie all applications of energy conversion in engineering. Prerequisites: A grade of "C" or better in each of Comp Sci 1570 or Comp Sci 1970 or Comp Sci 1971 or Comp Sci 1972, Math 1214 (or Math 1208), Math 1215 (or Math 1221), Math 2222, Math 2222, and Physics 1135.

MECH ENG 2527 Thermal Analysis (LEC 3.0)
Basic principles of thermodynamics and heat transfer. First and second laws of thermodynamics and applications to engineering systems. Fundamentals of heat transfer by conduction, convection, and radiation with applications. Not for mechanical engineering majors. Prerequisites: Math 1215 (or 1221), Physics 1135.

MECH ENG 2653 Introduction To Manufacturing Processes (LEC 2.0 and LAB 1.0)
Introduction into the fundamentals of manufacturing processes. Welding, joining, casting, forming, powder metallurgy and material removal are covered. The material is presented in a descriptive fashion with emphasis on the fundamental working of the processes, their capabilities, applications, advantages and limitations. Prerequisite: Mech Eng 1720.

MECH ENG 2761 Introduction To Design (LEC 2.0 and LAB 1.0)
Introduces the process of design with emphasis on creativity and design visualization. Solid modeling is presented as a design tool. The solid modeling environment will also be used to reinforce the concepts of tolerancing, dimensioning, and multiview representation. Concurrent engineering will be introduced in a group design project. Prerequisites: Mech Eng 1720, Mech Eng 2653, preceded or accompanied by Civ Eng 2200; a grade of "C" or better in each of Math 1214 (or 1208), Physics 1135.

MECH ENG 3001 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.

MECH ENG 3002 Cooperative Engineering Training (IND 0.0-6.0)
On-the-job experience gained through cooperative education with industry, with credit arranged through departmental cooperative advisor. Grade received depends on quality of reports submitted and work supervisor's evaluation.

MECH ENG 3010 Seminar (LEC 1.0)
Discussion of current topics.

MECH ENG 3131 Thermofluid Mechanics I (LEC 3.0)
Principles of viscous and inviscid flow in ducts, nozzles, diffusers, blade passages and application to design; dimensional analysis and laws of similarity; external flows; compressible flows. Prerequisite: A grade of "C" or better in Mech Eng 2519.

MECH ENG 3313 Machine Dynamics (LEC 3.0)
Motion analysis using vector methods is considered for machine elements including linkages, cams, and gears. Dynamic force analysis methods are applied to balancing, flywheels, and single and multicylinder engines. Prerequisites: A grade of "C" or better in each of Comp Sci 1570 or Comp Sci 1970 or Comp Sci 1971 or Comp Sci 1972, Mech Eng 2360 (or Aero Eng 2360), Math 1214 (or Math 1208), Math 1215 (or Math 1221), Math 2222, and Physics 1135.

MECH ENG 3411 Modeling and Analysis of Dynamic Systems (LEC 3.0)
Concepts of modeling mechanical systems as linear systems are studied and applied to hydraulic, pneumatic, and electromechanical systems. Analysis techniques described include matrix formulations, Laplace transforms, and time domain response methods. Prerequisites: A grade of "C" or better in each of Comp Sci 1570 or Comp Sci 1970 or Comp Sci 1971 or Comp Sci 1972, Mech Eng 2360 (or Aero Eng 2360), Math 1214 (or Math 1208), Math 1215 (or Math 1221), Math 2222, Math 3304, Physics 1135, Physics 2135.

MECH ENG 3521 Applied Thermodynamics (LEC 3.0)
Extended study of the laws and concepts of thermodynamics with emphasis on applications to power and refrigeration cycles, gas mixtures, psychrometrics, behavior of real gases and combustion processes. Prerequisite: A grade of "C" or better in Mech Eng 2519.

MECH ENG 3525 Heat Transfer (LEC 3.0)
Fundamental principles of heat transmission by radiation, conduction and convection; application of these principles to the solution of engineering problems. Prerequisites: A grade of "C" or better in each of Comp Sci 1570 or Comp Sci 1970 or Comp Sci 1971 or Comp Sci 1972, Math 3304, Mech Eng 2519.

MECH ENG 3653 Manufacturing (LEC 3.0)
Advanced analytical study of metal forming and machining processes such as forging, rolling, extrusion, wire drawing and deep drawing; mechanics of metal cutting - orthogonal, turning, milling, cutting temperature, cutting tool materials, tool wear and tool life, and abrasive processes. Prerequisites: Mech Eng 2653, Civ Eng 2211, and a grade of "C" or better in Civ Eng 2210.

MECH ENG 3708 Machine Design I (LEC 3.0)
Analysis of machine elements such as shafts, springs, screws, belts, bearings, and gears; analytical methods for the study of fatigue; comprehensive treatment of failure, safety, and reliability. Introduction to finite element methods in mechanical design. Prerequisites: Mech Eng 2653; accompanied or preceded by Mech Eng 2761; Met Eng 2110 or Aero Eng 3877; and a grade of "C" or better in Civ Eng 2210.

MECH ENG 4000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MECH ENG 4001 Special Topics (LEC 0.0 and LAB 0.0)
This course is designed to give the department an opportunity to test a new course. Variable title.
MECH ENG 4099 Undergraduate Research (IND 0.0-6.0)
Designed for the undergraduate student who wishes to engage in research. Not for graduate credit. Not more than six credit hours allowed for graduation credit. Subject and credit to be arranged with the instructor.

MECH ENG 4479 Automatic Control Of Dynamic Systems (LEC 3.0)
Use of classical control methods to analyze mechanical systems. Topics include root locus, Bode plots, and Nyquist diagrams. Applications to design situations are examined. Prerequisite: A grade of "C" or better in Mech Eng 3411.

MECH ENG 4480 Control System Laboratory (LAB 1.0)
Experiments dealing with data acquisition, manipulation, and control of systems with particular emphasis on computer data acquisition and control applied to mechanical engineering systems. Microcomputer systems are used as measurement and control devices. Prerequisites: Preceded or accompanied by Mech Eng 4479.

MECH ENG 4761 Engineering Design (LEC 1.0 and LAB 2.0)
Real-life design projects emphasize problem definition, conceptualization, modeling, approximation techniques and optimization. Teamwork, communication, leadership and group discussions are encouraged. Student group and professional expert presentations bring awareness to diverse design issues and methodology, and professional engineering practice. Prerequisites: Preceded or accompanied each of Mech Eng 3708, 3525, 3131, 4479.

MECH ENG 4840 Mechanical Instrumentation (LAB 2.0)
A basic course in the theory and application of instrumentation to typical measurement problems in mechanical and aerospace engineering. Experiments employing basic devices to measure quantities such as strain, pressure, force, temperature, motion, flow, sound level are performed. Accepted procedures for recording, interpretation, and presentation of experimental results are illustrated. Prerequisites: A grade of "C" or better each of Math 3304, Mech Eng 2519, Physics 2135.

MECH ENG 4842 Mechanical Engineering Systems (LAB 2.0)
A laboratory course focusing on experimental design and evaluation of complete mechanical engineering systems. Analysis of both mechanical and thermodynamic systems is included. Emphasis is on evaluating system performance and improving student written and oral communication skills. Prerequisites: Mech Eng 4840, 3521, 3131, 3525, 3313.

MECH ENG 5000 Special Problems (IND 0.0-6.0)
Problems or readings on specific subjects or projects in the department. Consent of instructor required.

MECH ENG 5001 Special Topics (LEC 0.0-6.0)
This course is designed to give the department an opportunity to test a new course. Variable title. (Co-listed with Aero Eng 5001).

MECH ENG 5131 Intermediate Thermofluid Mechanics (LEC 3.0)
Derivation of Navier-Stokes equations, analytical solutions of viscous flows; flow in pipes, flow networks; intermediate treatment of boundary layer theory; micro-fluidics and MEMS; introduction to numerical methods for solving fluid flows; and, preliminary treatise on turbulence. Prerequisite: Mech Eng 3131 or Aero Eng 3131. (Co-listed with Aero Eng 5131).

MECH ENG 5135 Fluid Machinery (LEC 3.0)
Fundamental investigation of positive displacement and turbomachinery including pumps, fans, compressors, turbines, and oil hydraulic systems. Operating characteristics, selection, and comparison of types are studied. Prerequisite: Mech Eng 3131 or Aero Eng 5135.

MECH ENG 5139 Computational Fluid Dynamics (LEC 3.0)
Introduction to the numerical solution of the Navier-Stokes equations, by finite difference methods, in both stream function-vorticity and primitive variable formulations. Course format emphasizes student development of complete computer programs utilizing a variety of solution methods. Prerequisites: Comp Sci 1570 or 1970 or 1971; one course in fluid mechanics. (Co-listed with Aero Eng 5139).

MECH ENG 5205 Lubrication (LEC 3.0)
Development of basic principles of bearing analysis including manufacture and properties of lubricants, hydrodynamics and hydrostatic lubrication, journal and thrust bearings, ball and roller bearings, boundary considerations, and bearing materials. Prerequisite: Mech Eng 3131.

MECH ENG 5211 Introduction To Continuum Mechanics (LEC 3.0)
Introductory cartesian tensor analysis to aid in the development of the theory of a continuum. Kinematics of deformation, stress tensor, equations of motion, equations of mass and energy balance. Examples from specific material theories in solid and fluid mechanics. Prerequisites: Civ Eng 2210, Math 3304.

MECH ENG 5212 Introduction to Finite Element Analysis (LEC 3.0)
Variational formulation of the governing equations. Finite element model, interpolation functions, numerical integration, assembly of elements and solution procedures. Applications to solid mechanics, fluid mechanics and heat transfer problems. Two-dimensional problems. Computer implementation and use of commercial finite element codes. Prerequisite: Mech Eng 3708 or Aero Eng 4253 or consent of instructor for majors that do not require either of these courses, or graduate standing. (Co-listed with Aero Eng 5212).

MECH ENG 5214 Applications Of Numerical Methods To Mechanics Problems (LEC 3.0)
Numerical solutions of statics, vibrations, and stability problems. Direct stiffness formulations are developed and user-oriented computer codes are used to solve practical structures problems. Computer graphics techniques are utilized to prepare data and display results. Prerequisites: Civ Eng 2210; Mech Eng 2360 or Aero Eng 2360.

MECH ENG 5220 Advanced Mechanics of Materials (LEC 3.0)
Comprehensive insight into mechanics of materials. Topics to include: theories of failure, torsion of noncircular sections, shear flow and shear center, unsymmetric bending, bending of curved members, beams on elastic foundation and pressurization of thick walled cylinders. Prerequisites: Civ Eng 2210, Math 3304. (Co-listed with Aero Eng 5220).

MECH ENG 5222 Introduction To Solid Mechanics (LEC 3.0)
Review of basic concepts in continuum mechanics. Finite elasticity; some universal solutions for isotropic materials; application of special mechanical models. Linear elasticity: compatibility, stress functions, superposition, special examples such as extension, torsion, bending, and plane problems. Elements of plasticity. Prerequisite: Mech Eng 5211. (Co-listed with Aero Eng 5222).

MECH ENG 5229 Smart Materials And Sensors (LEC 2.0 and LAB 1.0)
Smart structures with fiber reinforced polymer (FRP) composites and advanced sensors. Multi-disciplinary topics include characterization, performance, and fabrication of composite structures; fiber optic, resistance, and piezoelectric systems for strain sensing; and applications of smart composite structures. Laboratory and team activities involve manufacturing, measurement systems, instrumented structures, and performance tests on a large-scale smart composite bridge. Prerequisites: Senior standing and Math 3304. (Co-listed with Aero Eng 5229, Elec Eng 5270 and Civ Eng 5118).
MECH ENG 5234 Stability of Engineering Structures (LEC 3.0)
Solution of stability problems with applications to columns, plates and shell structures. Torsional and lateral buckling of columns. Buckling under high temperatures. Effect of imperfections introduced by a technological process on stability. Design issues related to stability requirements. Prerequisites: Civ Eng 2210; Math 3304; and Mech Eng 2350 or Mech Eng 2360 or Aero Eng 2360. (Co-listed with Aero Eng 5234).

MECH ENG 5236 Fracture Mechanics (LEC 3.0)
Linear elastic and plastic mathematical models for stresses around cracks; concepts of stress intensity; strain energy release rates; correlation of models with experiment; determination of plane stress and plane strain parameters; application to design. Prerequisite: Civ Eng 2210. (Co-listed with Aero Eng 5236).

MECH ENG 5238 Fatigue Analysis (LEC 3.0)
The mechanism of fatigue, fatigue strength of metals, fracture mechanics, influence of stress conditions on fatigue strength, stress concentrations, surface treatment effects, corrosion fatigue and fretting corrosion, fatigue of joints, components and structures, and design to prevent fatigue. Prerequisite: Civ Eng 2210. (Co-listed with Aero Eng 5238).

MECH ENG 5254 Variational Formulations Of Mechanics Problems (LEC 3.0)
Introduction and study of variational problems in classical dynamics and solid mechanics emphasizing the concepts of virtual work, minimum potential energy, and complementary energy. Variational inequalities. Prerequisites: Civ Eng 2210; Math 3304; and Mech Eng 2350 or Mech Eng 2360 or Aero Eng 2360. (Co-listed with Mech Eng 354).

MECH ENG 5282 Introduction to Composite Materials & Structures (LEC 3.0)
Introduction to fiber-reinforced composite materials and structures with emphasis on analysis and design. Composite micromechanics, laminate theory and failure criteria. Design procedures for structures made of composite materials. An overview of fabrication and experimental characterization. Prerequisite: Civ Eng 2210. (Co-listed with Aero Eng 5282).

MECH ENG 5283 Industrial Applications Of Composite Materials Technology (LEC 3.0)
Composite materials-industrial applications. Fibers and matrices. Fabrication and NDI. Lamination theory overview. Composite joints. Postbuckling. Fatigue and environmental effects. Testing and certification of composite structures. A majority of the presentations will be made by engineers in the industry. Prerequisite: Civ Eng 2210. (Co-listed with Aero Eng 5283).

MECH ENG 5307 Vibrations I (LEC 3.0)
Equations of motion, free and forced vibration of single degree of freedom systems and multidegree of freedom systems. Natural frequencies, resonance, modes of vibration and energy dissipation are studied. The vibration of continuous systems is introduced. Prerequisites: Mech Eng 3411 and 3313, or Aero Eng 3613 and Math 3304. (Co-listed with Aero Eng 5307).

MECH ENG 5309 Engineering Acoustics I (LEC 3.0)
Introduction to acoustical theory and measurement with emphasis on mechanical and aerospace engineering applications. Plane and spherical wave propagation, resonators and filters, absorption, room acoustics, human response to noise, noise legislation, noise control. Use of common instrumentation in several projects. Prerequisites: Mech Eng 3411 and 3313, or Aero Eng 3613 and Math 3304. (Co-listed with Aero Eng 5309).

MECH ENG 5313 Intermediate Dynamics Of Mechanical And Aerospace Systems (LEC 3.0)
Principles of dynamics are applied to problems in the design of mechanical and aerospace systems; basic concepts in kinematics and dynamics; dynamics of systems of particles; dynamics of rigid bodies, three-dimensional effects in machine elements; dynamic stability, theory and applications; methods of analytical dynamics. Prerequisite: Mech Eng 3313 or Aero Eng 3613. (Co-listed with Aero Eng 5313).

MECH ENG 5420 Signal Processing for Instrumentation and Control (LEC 3.0)
The course presents fundamental techniques for analysis and processing of experimental data and real-time signals. Continuous- and discrete-time development of signal spectra, Fourier Transform, convolution, filter design, and system identification. The emphasis is on practical problems that arise in instrumentation and control applications. Prerequisites: Math 3304; Mech Eng 3411 or permission of instructor for non-Mech Eng majors.

MECH ENG 5449 Robotic Manipulators and Mechanisms (LAB 1.0 and LEC 2.0)
Overview of industrial applications, manipulator systems and geometry. Manipulator kinematics; hand location, velocity and acceleration. Basic formulation of manipulator dynamics and control. Introduction to machine vision. Projects include robot programming, vision-aided inspection and guidance, and system integration. Prerequisites: Mech Eng 3313; Comp Sci 1970 or Comp Sci 1971 or Comp Sci 1972 or Comp Sci 1570. (Co-listed with Aero Eng 5449).

MECH ENG 5478 Mechatronics (LEC 2.0 and LAB 1.0)
This course will introduce students to the basics of mechatronics (i.e., the integration of mechanical, electrical, computer, and control systems). Students will learn the fundamentals of sensors and actuators for mechanical systems, computer interfacing, microcontrollers, real-time software, and control. Prerequisite: Mech Eng 4479 or equivalent. (Co-listed with Aero Eng 5478, Elec Eng 5870 and Comp Eng 5820).

MECH ENG 5481 Mechanical And Aerospace Control Systems (LEC 3.0)
Synthesis of mechanical and aerospace systems to perform specific control functions. Response and stability are studied. Singular value analysis for stability margins is introduced. Prerequisite: Mech Eng 4479 or Aero Eng 3361. (Co-listed with Aero Eng 5481).

MECH ENG 5519 Advanced Thermodynamics (LEC 3.0)
After a short review of classical thermodynamics, the elements of chemical reactions, chemical equilibrium, statistical thermodynamics, and the basic concepts of kinetic theory are presented. Prerequisite: Mech Eng 2519. (Co-listed with Aero Eng 5519).

MECH ENG 5523 Transport Phenomena In Manufacturing Processes (LEC 3.0)
A study of the important role that transport phenomena (heat and mass transfer and fluid flow) play during various manufacturing processes including metal casting, joining and welding extrusion, forging, crystal growth, chemical deposition, and thermal spray deposition. Prerequisites: Mech Eng 3525 and 3131.

MECH ENG 5525 Intermediate Heat Transfer (LEC 3.0)
Analytical study of conduction; theory of thermal radiation and applications; energy and momentum equations in convective heat transfer and review of empirical relations. Current topics are included. Prerequisite: Mech Eng 3525. (Co-listed with Aero Eng 5525).
**MECH ENG 5527 Combustion Processes** (LEC 3.0)
Application of chemical, thermodynamic, and gas dynamic principles to the combustion of solid, liquid, and gaseous fuels. Includes stoichiometry, thermochemistry, reaction mechanism, reaction velocity, temperature levels, and combustion waves. Prerequisite: Mech Eng 3521. (Co-listed with Aero Eng 5527).

**MECH ENG 5533 Internal Combustion Engines** (LEC 3.0)
A course dealing primarily with spark ignition and compression ignition engines. Topics include: thermodynamics, air and fuel metering, emissions and their control, performance, fuels, and matching engine and load. Significant lecture material drawn from current publications. Prerequisite: Mech Eng 3521.

**MECH ENG 5537 Fuel Cell Principles** (LEC 3.0)
Fuel cell fundamentals including thermodynamics, reaction kinetics, mass transport, characterization, and modeling are discussed. Different types of fuel cells such as proton exchange membrane and solid oxide are covered together with subsystem design and system integration as well as environmental impacts. Prerequisites: MECH ENG 3521.

**MECH ENG 5541 Applied Energy Conversion** (LEC 3.0)
The study of the principles of energy conversion. Specific applications include fuel cells and other direct energy conversion devices used in plug-in hybrid electric vehicles. Prerequisite: Mech Eng 3521.

**MECH ENG 5544 Non-Intrusive Measurement Methods** (LEC 3.0)
Fundamentals of non-contact measurement methods for engineers. Basic engineering optics with a focus on radiation measurement methods including the effects of various sources and detectors. Prerequisites: Phys 2135; Mech 3525 or consent of instructor for non-Mech Eng majors.

**MECH ENG 5566 Solar Energy Technology** (LEC 3.0)
Introduction to the nature of solar radiation and associated thermal energy transfers. Methods of collecting and storing solar energy. Analysis and design of systems for utilizing solar energy, including heating and cooling. Prerequisite: Mech Eng 3525, or consent of instructor for non-Mech Eng majors.

**MECH ENG 5567 Heat Pump And Refrigeration Systems** (LEC 3.0)
The various methods used in the thermal design and analysis of both refrigeration and heat pumps systems are investigated. Various methods of producing heating and cooling are examined including vapor compression, absorption, air cycle, steam jet, and thermoelectric systems. Prerequisites: Mech Eng 3521, 3525.

**MECH ENG 5570 Plasma Physics I** (LEC 3.0)
Single particle orbits in electric and magnetic fields, moments of Boltzmann equation and introduction to fluid theory. Diffusion of plasma in electric and magnetic fields. Analysis of laboratory plasmas and magnetic confinement devices. Introduction to plasma kinetic theory. Prerequisite: Aero Eng 3131 or Mech Eng 3131 or Physics 3211 or Nuc Eng 3221 or Elec Eng 3600. (Co-listed with Aero Eng 5570, Nuc Eng 4370, Physics 4543).

**MECH ENG 5571 Environmental Controls** (LEC 3.0)
Theory and applications of principles of heating, ventilating, and air conditioning equipment and systems; design problems. Physiological and psychological factors relating to environmental control. Prerequisites: Mech Eng 3521 and accompanied or preceded by Mech Eng 3525; or Mech Eng 2527 and Civ Eng 3330. (Co-listed with Arch Eng 5872).

**MECH ENG 5575 Mechanical Systems For Environmental Control** (LEC 3.0)
Analysis of refrigeration, heating, and air-distribution systems. Synthesis of environmental control systems. Prerequisites: Mech Eng 3521 and 3525; or Mech Eng 2527 and Civ Eng 3330.

**MECH ENG 5606 Material Processing By High-Pressure Water Jet** (LEC 3.0)
Methods of generating high pressure water jets; standard equipment, existing techniques, and basic calculations. Application of water jets to materials cutting and mineral processing. Safety rules. The course will be supported by laboratory demonstrations. Prerequisite: Mech Eng 3131 or undergraduate fluids course. (Co-listed with Min Eng 4413).

**MECH ENG 5644 Interdisciplinary Problems In Manufacturing Automation** (LEC 2.0 and LAB 1.0)
The course will cover material necessary to design a product and the fixtures required to manufacture the product. Participants will gain experience with CAD/CAM software while carrying out an actual manufacturing design project. (Co-listed with Chem Eng 4310, Eng Mgt 5315).

**MECH ENG 5653 Computer Numerical Control of Manufacturing Processes** (LEC 2.0 and LAB 1.0)
Fundamental theory and application of computer numerical controlled machine tools from the viewpoint of design principles, machine structural elements, control systems, and programming. Projects include manual and computer assisted part programming and machining. Prerequisites: Preceded or accompanied by Mech Eng 3653.

**MECH ENG 5655 Manufacturing Equipment Automation** (LEC 2.0 and LAB 1.0)
Manufacturing automation at the equipment level. Topics include sensors, actuators, and computer interfacing for manufacturing equipment, dynamic modeling and control of manufacturing equipment, interpolation, coordinated motion control, kinematic and geometric error modeling, and runout. Prerequisites: Preceded or accompanied by Mech Eng 4479 or equivalent.

**MECH ENG 5656 Design For Manufacture** (LEC 3.0)
Course covers the approach of concurrent product and process design. Topics includes: principle of DFM, New product design process, process capabilities and limitations, Taguchi method, tolerancing and system design, design for assembly and AI techniques for DFM. Prerequisites: Mech Eng 3708, Mech Eng 3653.

**MECH ENG 5702 Synthesis Of Mechanisms** (LEC 3.0)
Synthesis of planar mechanisms for function generation, path generation, and motion generation. Emphasis is on analytical methods for synthesis. Prerequisite: Mech Eng 3313.

**MECH ENG 5704 Compliant Mechanism Design** (LEC 3.0)
Introduction to compliant mechanisms; review of rigid-body mechanism analysis and synthesis methods; synthesis of planar mechanisms with force/energy constraints using graphical and analytical methods; pseudo-rigid-body models; force-deflection relationships; compliant mechanism synthesis methods; and special topics, e.g. bistable mechanisms, constant-force mechanisms, parallel mechanisms, and chain algorithm in design. Emphasis will be on applying the assimilated knowledge through a project on compliant mechanisms design. Prerequisites: Mech Eng 3313, Civ Eng 2210.

**MECH ENG 5708 Rapid Product Design And Optimization** (LEC 3.0)
Product Life cycle design; Finding design solutions using optimization technique; Rapid product realization using rapid prototyping and virtual prototyping techniques. Prerequisite: Mech Eng 3708.
MECH ENG 5709 Machine Design II (LEC 3.0)
A continuation of the study of machine elements; bearings, spur, bevel, worm, and helical gearing, and indeterminate machine elements; impact and shrink stresses. Prerequisite: Mech Eng 3708.

MECH ENG 5715 Concurrent Engineering (LEC 3.0)
Students will be introduced to the concurrent engineering approach to product development. They will learn to set up quantitative requirements and then use a quantitative rating process to identify the critical requirements relating to the desired product. The interaction between design, manufacturing, assembly, cost, and supportability will be covered. The students will form teams and practice the concurrent engineering process for simple products. Prerequisites: Mech Eng 3313 or Aero Eng 3131, and Civ Eng 2210. (Co-listed with Aero Eng 5715).

MECH ENG 5757 Integrated Product And Process Design (LEC 3.0)
Emphasize design policies of concurrent engineering and teamwork, and documenting of design process knowledge. Integration of product realization activities covering important aspects of a product life cycle such as "customer" needs analysis, concept generation, concept selection, product modeling, process development, and end of product life options. Prerequisites: Junior or above standing. (Co-listed with Eng MGT 5515).

MECH ENG 5758 Integrated Product Development (LEC 1.0 and LAB 2.0)
Students in design teams will simulate the industrial concurrent engineering development process. Areas covered will be design, manufacturing, assembly, process quality, cost, supply chain management, and product support. Students will produce a final engineering product at the end of the project. Prerequisite: Eng Mgt 5515 or Mech Eng 5757 or Mech Eng 3653 or Mech Eng 5708. (Co-listed with Eng Mgt 5516).

MECH ENG 5760 Probabilistic Engineering Design (LEC 3.0)
The course deals with uncertainties in engineering analysis and design at three levels - uncertainty modeling, uncertainty analysis, and design under uncertainty. It covers physics-based reliability analysis and reliability-based design, robustness assessment and robust design, their integration with design simulations, and their engineering applications. Prerequisite: Mech Eng 3708 or Aero Eng 3361. (Co-listed with Aero Eng 5760).

MECH ENG 5761 Engineering Design Methodology (LEC 3.0)
This course examines structured engineering design theory and methodologies for conceptual design and redesign of products. Topical coverage includes customer needs gathering, functional modeling, engineering specifications creation (OFD), concept generation, selection and design embodiment. Team work/hands-on projects emphasized. Prerequisite: At least Senior standing in engineering.

MECH ENG 5763 Principles And Practice Of Computer Aided Design (LEC 2.0 and LAB 1.0)
Lectures cover the fundamentals of computer-aided design with emphasis on geometric modeling of curves, surfaces and solids, CAD/CAM data exchange, and computer graphics. In the lab session, students practice with commercial CAD/CAM systems including NX and SolidWorks to gain practical experience. Prerequisites: Comp Sci 1570 or Comp Sci 1970 or Comp Sci 1971, Mech Eng 2761, Math 2222, at least Junior standing.

MECH ENG 5764 Introduction to Decision Analysis (LEC 3.0)
This course is an introduction to decision analysis, a decision-making method under uncertainty. The course topics include probability theory, influence diagram, decision tree, subjective probability, sensitivity analysis, value of information, risk attitude, and utility models. Prerequisite: Stat 3111 or Stat 3113 or Stat 3115 or Stat 3117.

MECH ENG 5830 Applied Computational Methods (LEC 3.0)
Detailed study of computational methods for efficient solution of selected fluids, structures, thermodynamics, and controls problems in aerospace and mechanical engineering. Besides basic numerical techniques, topics covered include gradient-based optimization and uncertainty quantification. Prerequisite: Comp Sci 1570 or 1970 or 1981; Math 3304. (Co-listed with Aero Eng 5830).