Mechanical and Aerospace Engineering

Web Site: http://www.odu.edu/mae

Sebastian Bawab, Chair
Colin Britcher, Associate Chair

The Mechanical and Aerospace Engineering (MAE) Department offers an undergraduate program leading to a Bachelor of Science in Mechanical Engineering. The program is accredited by the Engineering Accreditation Commission (EAC) of ABET, http://www.abet.org. The Department also offers varied programs of graduate study and research leading to the Master of Engineering, Master of Science, Doctor of Engineering and Doctor of Philosophy degrees in either Mechanical Engineering or Aerospace Engineering. For further information, please visit the Department's web site: www.eng.odu.edu/mae.

Mechanical Engineering Mission

1. To develop and maintain a high quality undergraduate program of study leading to the bachelor's degree in Mechanical Engineering.
2. To develop and maintain high quality graduate programs of study and research leading to master's and doctoral degrees in Mechanical Engineering or Aerospace Engineering.
3. To conduct a relevant and high quality research program in the mechanical and aerospace engineering disciplines.
4. To provide practicing mechanical and aerospace engineers in Virginia the opportunities to develop and maintain up-to-date technical knowledge and skills.
5. To provide the unique skills and knowledge required by the mechanical and aerospace engineering professions to support existing government agencies, consulting firms and industry and help promote the development of new and more competitive industries in Virginia and the nation.

Bachelor of Science in Mechanical Engineering

Sushil Chaturvedi, Chief Departmental Advisor

The mechanical engineering program is among the most basic of all engineering programs, with a curriculum that embraces the major areas of power, design, and fluid or solid mechanics. Seniors may enroll in one of three identified concentration areas, or may select a custom set of courses:

1. Power/energy conversion
2. Mechanical systems/design
3. Aerospace engineering

The program is designed to prepare its graduates for professional practice in many facets of engineering, such as research, development, design, planning, testing, management, and consulting. The graduate is prepared to undertake challenging and creative engineering work in almost any industry, government agency, research organization, or consulting firm. The program also provides an excellent preparation for graduate school and the Fundamentals of Engineering (FE) Exam.

An undergraduate student handbook providing rules and a detailed semester-by-semester plan for the program is available on the department's web site. Courses are routinely scheduled in the late afternoon and evening to accommodate students with current employment.

Outcomes

The Mechanical and Aerospace Engineering Department has adopted, after deliberations by its constituents, 7 outcomes for the BSME program. These outcomes are listed below. The students who qualify for graduation will:

1. Be able to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. Be able to apply the engineering design process to produce solutions that meet specified needs with consideration for public health and safety, and global, cultural, social, environmental, economic, and other factors as appropriate to the discipline.
3. Be able to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
4. Communicate effectively with a range of audiences.
5. Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
6. Recognize the ongoing need to acquire new knowledge, to choose appropriate learning strategies, and to apply this knowledge.
7. Function effectively as a member or leader of a team that establishes goals, plans tasks, meets deadlines, and creates a collaborative and inclusive environment.

Mechanical Engineering Objectives

The program's educational objectives describe the career and professional accomplishments that the program is preparing graduates to attain within a few years after graduation. The educational objectives of the mechanical engineering program, established with participation of all constituencies, are consistent with the mission of Old Dominion University and the Department of Mechanical and Aerospace Engineering.

The objectives of the mechanical engineering undergraduate program at Old Dominion University are that our graduates should accomplish the following:

1. To establish themselves as successful professionals in the general areas of thermal/fluid systems, mechanical systems and design, and materials and manufacturing in industry and government settings by demonstrating their ability to:
   a. Conduct themselves consistently in a responsible, professional and ethical manner.
   b. Participate in continuing education, research and development, and in other lifelong creative efforts in science and technology.
   c. Lead others in support of activities that promote service to, and economic development of, the community, the region, state and nation.

2. To successfully pursue and complete graduate programs in mechanical engineering, aerospace engineering or a related field if they so desire.

Accreditation

The Bachelor of Science in Mechanical Engineering is accredited by the Engineering Accreditation Commission of ABET www.abet.org. (http://www.abet.org)

Four-Year Plan - Mechanical Engineering - BSME (http://catalog.odu.edu/undergraduate/frankbattencollegeofengineeringandtechnology/mechanicalaerospaceengineering/mechanicalengn-bsme-fouryearplan)

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

Mechanical Engineering Four-Year Plan*

<p>| Freshman |
| First Term | Second Term |</p>
<table>
<thead>
<tr>
<th>Hours</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 211 (grade of C or better required)</td>
<td>4</td>
</tr>
<tr>
<td>MATH 212 (grade of C or better required)</td>
<td>4</td>
</tr>
</tbody>
</table>

* The Bachelor of Science in Mechanical Engineering is accredited by the Engineering Accreditation Commission of ABET www.abet.org.
<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
<th>Second Term Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS 231N (grade of C or better required)</td>
<td>4</td>
<td>MAE 205 (grade of C or better required)</td>
<td>3</td>
</tr>
<tr>
<td>MATH 312 (285)</td>
<td>4</td>
<td>MAE 220 (grade of C or better required)</td>
<td>3</td>
</tr>
<tr>
<td>MAE 204 (grade of C or better required)</td>
<td>3</td>
<td>MAE 225</td>
<td>1</td>
</tr>
<tr>
<td>MAE 201 (grade of C or better required)</td>
<td>3</td>
<td>MATH 307 (280)</td>
<td>3</td>
</tr>
<tr>
<td>MAE 203</td>
<td>1</td>
<td>Interpreting the Past Way of Knowing</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 231C (grade of C or better required)</td>
<td>3</td>
<td>STAT 330</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total credit hours: 128**

* Does not include the University's General Education language and culture requirement. Additional hours may be required.

** ENMA 480 is preferred.

General Education requirements in information literacy and research and impact of technology are met through the major. For additional information consult the department undergraduate handbook.

Mechanical engineering majors must earn a grade of C or better in the following courses in order to continue to progress through the program:

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
<th>Second Term Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 110C</td>
<td>3</td>
<td>English Composition</td>
<td>3</td>
</tr>
<tr>
<td>ENGL 231C</td>
<td>3</td>
<td>Introduction to Technical Writing</td>
<td>3</td>
</tr>
<tr>
<td>MATH 211</td>
<td>4</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 212</td>
<td>4</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 121N</td>
<td>3</td>
<td>Foundations of Chemistry I Lecture</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 211N</td>
<td>4</td>
<td>University Physics I</td>
<td>4</td>
</tr>
<tr>
<td>MAE 201</td>
<td>3</td>
<td>Materials Science</td>
<td>3</td>
</tr>
<tr>
<td>MAE 204</td>
<td>3</td>
<td>Engineering Mechanics I - Statics</td>
<td>3</td>
</tr>
<tr>
<td>MAE 205</td>
<td>3</td>
<td>Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>MAE 220</td>
<td>3</td>
<td>Engineering Mechanics II - Solid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>MAE 303</td>
<td>3</td>
<td>Mechanics of Fluids</td>
<td>3</td>
</tr>
<tr>
<td>MAE 311</td>
<td>3</td>
<td>Thermodynamics I</td>
<td>3</td>
</tr>
<tr>
<td>MAE 332</td>
<td>3</td>
<td>Mechanical Engineering Design I</td>
<td>3</td>
</tr>
<tr>
<td>MAE 434W</td>
<td>3</td>
<td>Project Design and Management I</td>
<td>3</td>
</tr>
</tbody>
</table>

**Senior Concentrations**

1. Power/Energy - Three courses from MAE 411, MAE 412, MAE 413, MAE 414, MAE 417, MAE 438, MAE 440.
2. Mechanical Systems Design - Three courses from MAE 404, MAE 422, MAE 431, MAE 438, MAE 440, MAE 441.
3. Aerospace - Three courses from MAE 403, MAE 406, MAE 417, MAE 420 (or MAE 440), MAE 438 or MAE 460.

Students may also select alternative combinations of 300/400-level courses, in which case they will be considered to have an "undesignated" concentration.

**Continuance Regulations**

It is the policy of the Department of Mechanical and Aerospace Engineering to deny a student eligibility to enroll in program courses after it becomes evident that he or she is either unable or unwilling to maintain reasonable standards of academic achievement. Required courses are all those specifically listed above. Major GPA is calculated based on courses with an MAE prefix.

1. Warning. A student will be placed on departmental academic warning if his or her major grade point average falls below 2.0 after six or more hours have been attempted in the major. Students on academic warning are expected to consult with their departmental advisors and to take immediate steps to improve their major GPA.

2. A student will be placed on departmental academic probation whenever his or her major grade point average falls below 2.00 for two consecutive semesters of enrollment. Students on academic probation are expected to improve their major GPA to 2.0 or above in no more
The Department of Mechanical and Aerospace Engineering offers a minor program with two emphases: thermal sciences and mechanics.

Minor in Mechanical Engineering

For completion of a minor, a student must have a minimum overall cumulative grade point average of 2.00 in all courses required for the minor exclusive of lower-level courses, prerequisites and corequisites and complete at least six hours in upper-level courses in the minor requirement through courses offered by Old Dominion University.

Minor in Marine Engineering

For completion of a minor, a student must have a minimum average of 2.00 in all courses required for the minor exclusive of lower-level courses, prerequisites and corequisites and complete at least six hours in upper-level courses in the minor requirement through courses offered by Old Dominion University.

Minor in Motorsports Engineering

The course requirements are as follows:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 407</td>
<td>Ground Vehicle Aerodynamics</td>
<td>3</td>
</tr>
<tr>
<td>MAE 457</td>
<td>Motorsports Vehicle Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>or MET 427</td>
<td>Mechatronic System Design</td>
<td></td>
</tr>
<tr>
<td>MAE 467</td>
<td>Racecar Performance</td>
<td>3</td>
</tr>
<tr>
<td>MET 480</td>
<td>High Performance Piston Engines</td>
<td>3</td>
</tr>
<tr>
<td>or MAE 477</td>
<td>High Performance Piston Engines</td>
<td></td>
</tr>
</tbody>
</table>

Total Hours 12

It may be possible to substitute other appropriate senior-level mechanical and aerospace engineering courses with prior approval of the Mechanical and Aerospace Engineering Department. Exceptions are rare and are not encouraged. All prerequisites and corequisites must be satisfied for all courses taken.

For completion of a minor, a student must have a minimum overall cumulative grade point average of 2.00 in all courses required for the minor exclusive of lower-level courses, prerequisites and corequisites and complete at least six hours in upper-level courses in the minor requirement through courses offered by Old Dominion University.

Minor in Mechanical Engineering

The Department of Mechanical and Aerospace Engineering offers a minor program with two emphases: thermal sciences and mechanics.

Minor in Marine Engineering

The specific minimum courses required are as follows:

**Thermal Sciences**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 303</td>
<td>Mechanics of Fluids</td>
<td>3</td>
</tr>
<tr>
<td>MAE 311</td>
<td>Thermodynamics I</td>
<td>3</td>
</tr>
<tr>
<td>MAE 312</td>
<td>Thermodynamics II</td>
<td>3</td>
</tr>
<tr>
<td>or MAE 414</td>
<td>Introduction to Gas Dynamics</td>
<td></td>
</tr>
<tr>
<td>MAE 315</td>
<td>Heat and Mass Transfer</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Hours 12

**Mechanics**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 332</td>
<td>Mechanical Engineering Design I</td>
<td>3</td>
</tr>
<tr>
<td>MAE 340</td>
<td>Computational Methods in Mechanical</td>
<td>3</td>
</tr>
<tr>
<td>or MAE 350</td>
<td>Engineering</td>
<td></td>
</tr>
<tr>
<td>MAE 404</td>
<td>Vibrations</td>
<td>3</td>
</tr>
<tr>
<td>MAE 436</td>
<td>Dynamic Systems and Control</td>
<td>3</td>
</tr>
</tbody>
</table>

Total Hours 12

It may be possible to substitute other appropriate junior- or senior-level mechanical engineering courses for those specified above with prior approval of the department. Exceptions are rare and are not encouraged. All prerequisites and corequisites must be satisfied for all courses taken.

For completion of a minor, a student must have a minimum overall cumulative grade point average of 2.00 in all courses required for the minor exclusive of lower-level courses, prerequisites and corequisites and complete at least six hours in upper-level courses in the minor requirement through courses offered by Old Dominion University.

MECHANICAL AND AEROSPACE ENGINEERING Courses

MAE 111. Mechanical and Aerospace Engineering Information Literacy and Research. 2 Credits.

This course will introduce students to the needs, access, evaluation, use, impact and ethical/legal aspects of information, and to the application of information literacy and research in the fields of mechanical and aerospace engineering. Prerequisites: ENGN 110.
MAE 195. Topics. 1-3 Credits.
Permission of the chair required.

MAE 201. Materials Science. 3 Credits.
Principles of materials science with emphasis on the relationship between structure and properties and their control through composition and processing. Metals, polymers, ceramics, and composite materials are considered. Prerequisites: MATH 211 with a grade of C or better.

MAE 203. Mechanical Engineering Laboratory I - Materials Science. 1 Credit.
This laboratory involves experiments demonstrating lecture material covered in the MAE 201 course. Pre- or corequisite: MAE 201 and CS 150 or ENGN 150.

MAE 204. Engineering Mechanics I - Statics. 3 Credits.
Introduction to mechanical engineering problems and their solutions through the study of statics of particles and rigid bodies. Emphasis will be placed on the relationship of the static loads with the mechanical properties of the materials being considered. Introduction to the concepts of stress and strain and internal forces as applied to static bodies. Prerequisite: MATH 211 with a grade of C or better. Pre- or corequisite: PHYS 231N.

MAE 205. Dynamics. 3 Credits.
Introduction to engineering problems and their solutions through a study of the dynamics of particles and rigid bodies. General force systems are studied including friction. Prerequisite: A grade of C or better in MAE 204 or CEE 204. Pre- or corequisite: MATH 212.

MAE 220. Engineering Mechanics II - Solid Mechanics. 3 Credits.
Introduction to concepts of stress, strain and their relation to each other. Stress and strain in axially loaded members and circular rods and tubes subjected to torsion. Normal and shear stress in beams under bending loads. Additional topics include bending deflection, transformation of stress and strain, Mohr's circles, statically indeterminate problems, combined stress and thin walled pressure vessels. Prerequisite: A grade of C or better in MAE 204 or CEE 204.

MAE 225. Mechanical Engineering Laboratory II - Solid Mechanics. 1 Credit.

MAE 303. Mechanics of Fluids. 3 Credits.
Fundamental concepts, fluid statics, basic equations in integral form, open-channel flow, Bernoulli's equation, dimensional analysis and similitude, incompressible viscous flow, pipe friction, boundary layers, introduction to differential analysis. Prerequisites: MATH 307, MATH 312, and a grade of C or better in MAE 205.

MAE 305. Mechanical Engineering Laboratory III - Thermo/Fluids. 1 Credit.
An introduction to thermo-fluid experimentation and measurement; basic flow phenomena demonstrated; measurement techniques for flow temperature, pressure and properties; report writing and data reduction methods, including statistical treatment of data; formal oral reports. Prerequisite: Junior standing. Pre- or corequisite: MAE 303 and MAE 311.

MAE 311. Thermodynamics I. 3 Credits.
Essential definitions of thermodynamics, first law, physical properties, ideal and real gases, second law, reversibility, irreversibility and consequences of thermodynamic cycles. Prerequisites: MATH 312.

MAE 312. Thermodynamics II. 3 Credits.
Concepts and principles dealing with thermodynamic cycles, relations and generalized charts, mixtures of fluids, chemical reactions, chemical and phase equilibrium, thermodynamic aspects of fluid flow; introduction to compressible flow, isentropic and normal shock wave relations. Prerequisites: MATH 307, and a grade of C or better in MAE 303, and a grade of C or better in MAE 311.

MAE 315. Heat and Mass Transfer. 3 Credits.
Fundamental laws of heat transfer by conduction, convection, and radiation; boundary-layer concepts; simultaneous heat, mass, and momentum transfer. Prerequisites: A grade of C or better in MAE 303, and a grade of C or better in MAE 311.

MAE 332. Mechanical Engineering Design I. 3 Credits.
Introduction to machine design including review of stress and deflection analysis. Statistical considerations in design, strength of mechanical elements with emphasis on theories of failure and fatigue design. Prerequisites: MAE 201, a grade of C or better in MAE 205, a grade of C or better in MAE 220, and MET 120. Pre- or corequisite: MAE 225.

MAE 336. Electromechanical Systems. 3 Credits.
Introduction to analog and digital circuits; sensors, actuators and signals; laboratory instrumentation (oscilloscope, function generator, etc.); data acquisition; and embedded microcontroller systems. Students will perform electronics experiments as homework assignments. Prerequisites: CS 150 or ENGN 150 and PHYS 232N.

MAE 340. Computational Methods in Mechanical Engineering. 3 Credits.
A survey of modern computing techniques for mechanical engineers. Numerical algorithms are presented to solve practical problems in mechanical engineering as found in solid mechanics, fluid mechanics, dynamics, and heat transfer. Emphasis is on providing computational experience in applied numerical methods using computers. Topics include roots of equations, simultaneous equations, differentiation, integration, regression analysis, interpolation and differential equations. Analysis, understanding, and quantification of computational errors are included in all topics and applications. Prerequisites: ENGN 150 or CS 150, MATH 307 and MATH 312.

MAE 367. Cooperative Education. 1-3 Credits.
Available for pass/fail grading only. Student participation for credit based on the academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and Career Development Services. Prior to the semester in which the work experience is to take place. Prerequisites: Approval by department and Career Development Services in accordance with the policy for granting credit for Cooperative Education programs.

MAE 368. Internship. 1-3 Credits.
Available for pass/fail grading only. Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students to gain short duration career-related experience. Prerequisites: Approval by department and Career Development Services.

MAE 369. Practicum. 1-3 Credits.
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students an opportunity to gain short duration career-related experience. Prerequisites: Approval by department and Career Development Services.

MAE 403/503. Flight Mechanics. 3 Credits.
Aircraft concepts including performance prediction and optimization, flight and maneuver envelopes, and steady flight performance. Additional topics: longitudinal static stability and trim; aircraft dynamics; development, separation and solution of aircraft equations of motion; natural modes; dynamic stability; sensors and actuators; and design of stability augmentation and autopilot systems. Prerequisites: MAE 303 with a grade of C or better and MAE 340. Pre- or corequisite: MAE 436.

MAE 404/504. Vibrations. 3 Credits.
Free and forced vibrations of undamped and damped, single-degree of freedom, multi-degree of freedom, and continuous systems. Exact and approximate methods to find natural frequencies. Prerequisites: A grade of C or better in MAE 205, a grade of C or better in MAE 220; MAE 340 and MATH 312.
MAE 406/506. Flight Vehicle Aerodynamics. 3 Credits.
Inviscid flow concepts including: Euler equations, stream function, velocity potential, singularities, vorticity and circulation laws. Viscous flow topics including boundary layers, separation, and turbulent flow. In addition, external flows, lift and drag, thin airfoil theory, finite wing theory and airfoil design will be discussed. Prerequisites: A grade of C or better in MAE 303; MAE 312 and MAE 340.

MAE 407/507. Ground Vehicle Aerodynamics. 3 Credits.
Review of basic fluid mechanics of the incompressible flow of air. Introduction to bluff body aerodynamics, production and performance (race car) automotive aerodynamics, as well as truck and bus aerodynamics. Discussion of experimental and computational methods for evaluating vehicle aerodynamic performance. Optimization of high performance vehicle design for low drag and/or high downforce and the facilities and techniques required. Introduction to the aerodynamics of other surface vehicles such as sailboats and trains. Lecture and wind tunnel experiments. Prerequisites: A grade of C or better in MAE 303 or MET 330 or CEE 330.

MAE 411/511. Mechanical Engineering Power Systems Theory and Design. 3 Credits.
Thermodynamic properties of gases and vapors relating to power generating devices, work-energy relations, combustion, and heat exchangers. Performance analyses and design concepts of gas turbines, internal combustion engines, steam power plants and heat exchanger equipment from theoretical and applied viewpoints. Prerequisites: MAE 312 and MAE 315.

MAE 412/512. Environmental Control. 3 Credits.
Engineering principles as applied to the analysis and design of systems for automatically controlling man or machine environments. Course encompasses fundamentals of heating, ventilating, air conditioning, refrigeration, cryogenics, and design of building energy systems. Prerequisites: MAE 312 and MAE 315.

MAE 413/513. Energy Conversion. 3 Credits.
Introduction of relevant kinetic theory, solid state, and thermodynamic principles; operation and analysis of thermoelectric, photovoltaic, thermionic, magnetohydrodynamic devices, fuel cell, isotopic, and solar power generators. Course seeks to define engineering limits of converter efficiency and other performance criteria. Prerequisite: MAE 312.

MAE 414/514. Introduction to Gas Dynamics. 3 Credits.
One-dimensional compressible flow considering isentropic flow, normal shocks, flow in constant area ducts with friction, flow in ducts with heating and cooling, oblique shocks, Prandtl-Meyer expansions, shock-expansion theory, flow around diamond shaped airfoils, and wind tunnel mechanics. Prerequisites: A grade of C or better in MAE 303 and a grade of C or better in MAE 311.

MAE 416/516. Introduction to Solar Energy Engineering. 3 Credits.
Basic solar radiation processes, engineering analysis of solar collectors, energy storage methods, system design and simulation, applications to heating, cooling, and power generation. Prerequisites: MAE 315.

MAE 417/517. Propulsion Systems. 3 Credits.
Basic principles of design, operation and performance of propulsion systems - including turbojet, turboprop, turbofan, and ramjet engines. Introduction to chemical rockets, ion and plasma thrusters. Prerequisites: MAE 312 or MAE 414.

MAE 420/520. Aerospace Structures. 3 Credits.
Analysis of aircraft and space vehicle structural components. Effects of bending, torsion and shear on typical aerospace structural components, statically indeterminate beams, shear center and shear flow. Introduction to typical aerospace structures. Introduction to composite structures. Prerequisites: MAE 332 with a grade of C or better.

MAE 422/522. Modern Engineering Materials. 3 Credits.
Limitations of conventional materials; inter-relationship among materials, design and processing, material selection criteria and procedures; strengthening mechanisms in metals; superelasticity; shape memory effect, amorphous metals; structure-property relationship in polymers; polymers crystallinity; thermostatic and thermosets; high-temperature restraint polymers; ceramics; toughening mechanisms in ceramics. Prerequisites: MAE 201, MAE 203, and a grade of C or better in MAE 220; MAE 332.

MAE 431/531. Mechanics Analysis and Design. 3 Credits.
Basic relations necessary for analysis of plane motion mechanisms, numerical and analytical solutions for some of the basic mechanisms, methods of calculating rolling and sliding velocities and accelerations of contacting bodies, cams, and gears. Prerequisites: A grade of C or better in MAE 205, a grade of C or better in MAE 332, and MATH 312 or MATH 285.

MAE 433. Mechanical Engineering Design II. 3 Credits.
Statistical considerations in design, strength of mechanical elements with emphasis on theories of failure and fatigue design in mechanical elements such as screws, fasteners, connections, welded joints, and flexible mechanical elements. Kinematic analysis, force analysis, and design of spur, helical, worm, and bevel gears. Antifriction bearings, lubrication and journal bearings, shaft design, mechanical spring design, design of clutches, brakes and couplings. Prerequisites: A grade of C or better in MAE 332 and senior standing.

MAE 434W. Project Design and Management I. 3 Credits.
This course prepares students to complete their design projects in MAE 435. Lecture topics include engineering economics; project planning; costing and risk analysis; and product realization techniques. Course involves written and oral presentations for students to improve communication and teamwork skills. This is a writing intensive course. Prerequisites: A grade of C or better in MAE 332, ENGL 211C or ENGL 221C or ENGL 231C. Pre- or corequisite: MAE 433.

MAE 435. Project Design and Management II. 3 Credits.
Conceptual design ideas are expanded into detailed design ideas. Product realization is applied to complete hardware. Course covers Gantt charts, preliminary design, evaluation and trading matrices, detailed design and analysis, oral and technical reporting including cost analysis. Ethics and patent issues are also included. Prerequisites: MAE 433 and MAE 434W.

MAE 436. Dynamic Systems and Control. 3 Credits.
Analysis and synthesis of feedback systems; functional description of dynamic systems; basic controllers; sensitivity, stability and error analysis; transient and steady-state response using computational techniques, root locus and frequency response methods; state-space analysis of control systems. Prerequisites: A grade of C or better in MAE 205; MAE 336, MATH 307 and MATH 312.

MAE 438/538. Applied Analog and Digital Control. 3 Credits.
Computer-aided analysis and design of practical control systems. Introduction to state-space, digital signal processing and digital control. Laboratory sessions on aliasing, analog, system identification, and real-time control. Prerequisite: a grade of C or better in MAE 436.

MAE 440/540. Introduction to Finite Element Analysis. 3 Credits.
Basic concepts of finite-element method, method of weighted residuals, interpolation functions, numerical implementation of finite-element method, applications to engineering problems such as beam deflection, heat conduction, and plate elastic problems. Prerequisites: MAE 340.

MAE 441. Computer-Aided Design of Mechanical Systems. 3 Credits.
Case studies are used to introduce students to CAD software; design processes involving modeling, analysis and design, and verification. Typical case studies are beam and plate designs, turbine blade design, and pipe networks. Advanced topics include: thermal stress analysis and plates and shells. Prerequisites: ENGN 150 or CS 150, and a grade of C or better in MAE 220; MATH 312. Pre- or corequisite: MAE 332.

MAE 450/550. Principles of Naval Architecture. 3 Credits.
Basic principles of naval architecture related to ship geometry, stability, strength, resistance, propulsion, vibration and motions in waves and controllability. Prerequisites: MATH 212 with a grade of C or better.

MAE 457/557. Motorsports Vehicle Dynamics. 3 Credits.
Basic mechanics governing vehicle dynamic performance. Analytical methods in vehicle dynamics. Laboratory consists of various vehicle dynamics tests on model vehicles and full-size racecars. Prerequisites: A grade of C or better in MAE 205 or MET 310.
MAE 460/560. Introduction to Space Systems Engineering. 3 Credits.
Introduction to spacecraft systems starting from mission design and space environment considerations and proceeding through propulsion, altitude control, spacecraft structural design, thermal control, power and communications for spacecraft. Prerequisites: MATH 307 and PHYS 232N.

MAE 467/567. Racecar Performance. 3 Credits.
On-track performance of typical racecars (Legends and Baby Grand) to demonstrate and evaluate the interplay between vehicle aerodynamics, suspension system geometry adjustments, tire selection and operating pressure on overall racecar performance and handling. Laboratory testing via on-board instrumentation during skid pad and road course evaluation; computer simulation to investigate various car set-ups. Prerequisites: MAE 303 with a grade of C or better, or MET 330 and MAE 205 with a grade of C or better, or MET 310.

MAE 477/577. High Performance Piston Engines. 3 Credits.
A study of the fundamental principles and performance characteristics of spark ignition and diesel internal combustion engines. Overview of engine types and their operation, engine design and operating parameters; ideal and semi-empirical models of engine cycles; combustion, fluid flow and thermal considerations in engine design and performance. Laboratory evaluation of engine performance using flow and dynamometer systems. Prerequisites: MAE 312, MAE 315 or MET 300, MET 350.

MAE 495/595. Topics in Mechanical and Aerospace Engineering. 1-3 Credits.
Special topics of interest with emphasis placed on recent developments in mechanical and aerospace engineering or engineering mechanics. (offered fall, spring, summer) Prerequisites: Senior standing; Permission of the chair is required.

MAE 496. Topics in Mechanical and Aerospace Engineering. 1-3 Credits.
Special topics of interest with emphasis placed on recent developments in mechanical engineering or engineering mechanics. (offered fall, spring, summer) Prerequisites: senior standing; permission of the chair is required.

MAE 497/597. Independent Study in Mechanical and Aerospace Engineering. 1-3 Credits.
Individual analytical, computational, and/or experimental study in an area selected by student. Supervised and approved by the advisor. Prerequisites: Senior standing; Permission of the chair is required.