Mechanical Engineering, B.S.M.E.

Degrees Offered

- Bachelor of Science in Mechanical Engineering (B.S.M.E.)
- Dual Degree in Aerospace and Mechanical Engineering

Nature of the Program

Mechanical engineering is a broad technical discipline. It integrates knowledge of the physical sciences and mathematics for the design, construction, and manufacture, testing, analysis, use, and operation of a device, structure, a machine, a process, or a system in service to humanity. Its development parallels the growth of industry. Modern society needs mechanical engineers who have broad and deep training in the fundamentals of engineering and related sciences and who have developed versatility in analyzing and solving complex problems. The mechanical engineer must not only possess a high level of professional expertise but also have an appreciation for the impact of engineering solutions in a societal context, including ethical and economic considerations.

Mechanical engineers are problem-solvers who are scientifically informed and mathematically minded. The mechanical engineering curriculum prepares students to deal effectively with a broad range of engineering problems rather than with narrow specialties. Graduates find employment in a wide range of industries, government agencies, and educational institutions where they are concerned with many functions:

- The use and economic conversion of energy from natural sources into useful energy for power, light, heating, cooling, and transportation;
- The design and production of machines to lighten the burden of human work;
- The planning and development of systems for using energy machines and resources;
- The processing of materials into products useful to mankind; and
- The education and training of specialists who deal with mechanical systems.

The curriculum consists of a judicious combination of fundamentals, including mathematics and sciences, and practical laboratory experience which provides access to modern engineering tools. Mechatronics, which is a study of the interdependence between mechanical engineering and electrical/electronics engineering, is a key part of the mechanical engineering curriculum. Graduates will be able to critically analyze mechanical engineering problems and execute practical solutions. In addition to being able to function independently, it is expected that graduates will be able to function with effective written and oral communication within multidisciplinary teams and be prepared to address several issues such as environmental, social, and economic considerations due to a thorough education in the humanities, social sciences, ethics, safety, and professionalism.

While the undergraduate curriculum is sufficiently broad to permit graduates to select from a wide variety of employment opportunities, it contains sufficient depth to prepare students to enter graduate school to pursue advanced degrees. As modern science and engineering become more complex, the desirability of graduate-level preparation is being recognized by most advanced industries and government agencies.

Students can simultaneously pursue B.S. degrees in both aerospace engineering and mechanical engineering by completing additional courses. Information on this 158 credit-hour, four-and-one-half-year option can be seen at the end of this section.

Students who plan a career in medicine, dentistry, or related areas, but who desire a mechanical engineering degree before entering the appropriate professional school, may substitute eight hours (from a combination of biology and organic chemistry courses) for the required six hours of technical electives. This selection will help the student satisfy admission requirements to the professional schools in the health sciences.

The mechanical engineering program at WVU is administered by the faculty of the Department of Mechanical and Aerospace Engineering. The Bachelor of Science in Mechanical Engineering program is accredited by the Engineering Accreditation Commission of ABET, https://www.abet.org/.

Program Educational Objectives

It is expected that, within a few years of graduation (3 to 5 years), graduates will attain the following Program Educational Objectives (PEO’s):

PEO-1. Proficiency in practicing one or more areas of mechanical engineering.

It is expected that after a few years of graduating (3 to 5 years), graduates will have consolidated professional proficiency as practitioners in at least one technical area of mechanical engineering, as reflected by the responsibilities and accomplishments of their professional practice.

PEO-2. Success in adapting to the demands of the workforce in the dynamic technological arena.

It is expected that, within a few years of graduation (3 to 5 years), graduates will have successfully adapted to the demands of the workforce in a dynamic technological arena through a professional practice that reflects high credentials or development of new technical skills and acumen for administrative functions.
PEO-3. Progress in their personal career development through professional service, continuing education and/or graduate studies.

It is expected that, within a few years of graduation (3 to 5 years), graduates will have made meaningful progress in their professional career, either by promotions to positions of higher responsibility with their employers, by participation in professional service activities, or by technical self-improvement through continuing education or graduate degree programs.

PEO-4. Meaningful involvement in a team that tangibly contributes to industry and/or society through the engineering discipline.

It is expected that, within a few years of graduation (3 to 5 years), graduates will have the experience of being or having been members in a team of professionals successfully making tangible technical contributions to industry or society through an engineering discipline.

Student Outcomes

Upon graduation, all Bachelors of Science students in Mechanical Engineering will have:

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

The primary learning goal of the BSME program is to implement state-of-the-art instructional materials, methods and technologies in order to prepare engineers who are highly proficient in their field of specialty and ready to contribute to the well-being of society through competent practice of the engineering profession, leading to economic development and innovative technological advancements.

The graduates of the BSME program are well prepared to engage in the long-life pursuit of successful engineering careers by quickly adapting to the changing demands of the workforce in a dynamic global environment, by enhancing continuously their professional abilities or skills, and by contributing effectively in multidisciplinary teams to the advancement of existing or anticipated industrial, economical and societal needs.

Spring Semester Study Abroad Opportunity in Rome, Italy

PRIMARILY FOR JUNIOR YEAR ME AND AE UNDERGRADUATE STUDENTS

All MAE undergraduates are invited to consider spending the spring semester of their junior year studying abroad at the University of Rome Tor Vergata ("UTV", for short). This very successful program is taught fully in English at UTV to both Italian undergraduate engineering students and students from other countries all over the world. Through this program WVU students have the opportunity to earn credits towards their WVU BSME or dual BSME/BSAE degrees for a full semester of equivalent WVU engineering courses towards their degrees. Please see the following link for the UTV description of this program:

https://engineering-sciences.uniroma2.it/course-structure/

In order to ensure that, upon successfully passing the UTV class examinations, the credits earned at UTV will transfer back to WVU for the equivalent courses within the MAE degree programs, it is recommended that students should select from the following list of UTV courses only those courses that are regularly taught during their spring semester:

UTV also strongly recommends that WVU students register for Italian Language Class for Foreigners 2.

Additional courses taught during the UTV fall semester as listed above can also be completed by students who participate in this WVU-UTV student exchange program for their full junior year: e.g., Kinematics and Dynamics of Mechanisms (for WVU courses MAE 342 & MAE 495), Electrical Network Analysis (for WVU course EE 221), and Fluid Machinery (for WVU course MAE 495).

The UTV spring semester classes begin each year in mid-February, with classes ending near the end of June. Examinations are then given during the month of July. WVU students who participate in the WVU-UTV exchange program must pay their normal WVU tuition and fees for their study abroad semester, and are also responsible to cover all of their travel and living expenses while participating in the program. You must complete your transient form (studyabroad.wvu.edu) before your semester abroad. Check with your advisor before registering for courses to approve your course choices. This program is also part of the WVU Statler program to earn the Certificate of Global Competency; see the MAE Department program description in the current WVU Catalog for additional details of this Certificate Program. (http://statler.wvu.edu/international-programs/global-competency (http://statler.wvu.edu/international-programs/global-competency/)).
WVU students must meet the relevant course prerequisites for the WVU course for which they wish to earn credit via a course taken at UTV. Also, because the UTV courses are only taught once a year, WVU students are encouraged to discuss with their academic advisors as early as possible the feasibility of delaying a course listed in the current WVU Catalog for the junior year fall semester in the Suggested Plan of Study for your major.

Study Abroad in the Summer

INDUSTRIAL OUTREACH PROGRAM IN MEXICO

PRIMARILY FOR SENIOR YEAR ME AND AE UNDERGRADUATE STUDENTS

Senior students in good standing in the MAE Department have the opportunity to participate in the Industrial Outreach Program in Mexico (IOPM) during the summer of each year (June and July) to earn a total of 9 credits (described below) toward their BS degree requirements in the BSAE or BSME Degree; this program is also available for other engineering majors. In this program, students are teamed up with Mexican students from local universities and conduct meaningful engineering projects in industrial sites, working full time under the guidance and supervision of practicing industrial engineers and faculty members. The duration of the program is 8 weeks.

The Objectives of this Program are:

1. To add value to student’s education through international experiential learning.
2. To solve meaningful engineering problems of value to industry.
3. To bridge the gap between academia and industry to benefit both.

Practical engineering problems from well-established companies in Mexico are presented to each team, with specific objectives and technical deliverables to be attained during the 8 week duration of the program. A final report and a final presentation are delivered at the end to personnel from industry and faculty members. A poster session is conducted at the closing of the program.

The main venue of this program is in Queretaro City and surroundings. Students are placed in home-stay with local families who provide clean, safe, healthy and friendly environment to students providing a full cultural and professional immersion. Weekends are used for field trips and cultural sightseeing. Fundamental knowledge of Spanish language is recommended but is not essential, as all the Mexican students and engineering liaisons are required to speak English.

Courses with credit:

- MAE 471 Principles of Engineering Design (3 cr) – Capstone Design Course
- MAE 472 Engineering System Design (3 cr) – Project Technical Elective
- FCLT 260 Cultures of Mexico (3 cr) – GEF-F7 Global Studies and Diversity

This is a summer faculty led program administered by WVU Office of International Programs (https://studyabroad.wvu.edu/) and provides eligibility for the Statler College Certificate of Global Competency. (http://statler.wvu.edu/international-programs/global-competency/).

Click here to view the Suggested Plan of Study (p. 7)

General Education Foundations

Please use this link to view a list of courses that meet each GEF requirement. (http://registrar.wvu.edu/gef/)

NOTE: Some major requirements will fulfill specific GEF requirements. Please see the curriculum requirements listed below for details on which GEFs you will need to select.

General Education Foundations

<table>
<thead>
<tr>
<th>F1 - Composition &amp; Rhetoric</th>
<th>3-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 101 &amp; ENGL 102 or ENGL 103</td>
<td>Introduction to Composition and Rhetoric and Composition, Rhetoric, and Research Accelerated Academic Writing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F2A/F2B - Science &amp; Technology</th>
<th>4-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>F3 - Math &amp; Quantitative Reasoning</td>
<td>3-4</td>
</tr>
<tr>
<td>F4 - Society &amp; Connections</td>
<td>3</td>
</tr>
<tr>
<td>F5 - Human Inquiry &amp; the Past</td>
<td>3</td>
</tr>
<tr>
<td>F6 - The Arts &amp; Creativity</td>
<td>3</td>
</tr>
<tr>
<td>F7 - Global Studies &amp; Diversity</td>
<td>3</td>
</tr>
</tbody>
</table>
Degree Requirements

Students must meet the following criteria to qualify for a Bachelor of Science in Mechanical Engineering degree:

- Complete a minimum of 124 credit hours
- Satisfy WVU's undergraduate degree requirements
- Satisfy Statler College's undergraduate degree requirements (http://catalog.wvu.edu/undergraduate/collegeofengineeringandmineralresources/#policies/text)
- Complete all courses listed in the curriculum requirements with the required minimum grades
- Attain an overall grade point average of 2.25 or better
- Attain a WVU grade point average of 2.25 or better
- Attain a Statler grade point average of 2.25 or better
- A maximum of one math or science courses with a grade of D+, D, or D- may apply towards a Statler College degree
- Complete a survey regarding their academic and professional experiences at WVU, as well as post-graduation job placement or continuing education plans.

The Statler GPA is computed based on all work taken at WVU with a subject code within Statler College (BIOM, BMEG, CE, CHE, CPE, CS, CSEE, CYBE, EE, ENGR, IENG, IH&S, MAE, MINE, PDA, PNGE, SAFM, SENG) excluding ENGR 140, ENGR 150, and CS 101. The WVU GPA is computed based on all work taken at WVU. The Overall GPA is computed based on all work taken at WVU and transfer work.

Curriculum Requirements

University Requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education Foundations (GEF) 1, 2, 3, 4, 5, 6, 7, and 8</td>
<td>31-37</td>
</tr>
<tr>
<td>Outstanding GEF Requirements 1, 5, 6, 7</td>
<td>15</td>
</tr>
<tr>
<td>ENGR 191 First-Year Seminar</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

Fundamentals of Engineering Requirements

A minimum grade of C- is required in all Fundamentals of Engineering courses.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 101</td>
<td>Engineering Problem Solving 1</td>
<td>2</td>
</tr>
<tr>
<td>CHE 102</td>
<td>Introduction to Chemical Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 102</td>
<td>Engineering Problem-Solving 2</td>
<td></td>
</tr>
<tr>
<td>ENGR 103</td>
<td>Introduction to Nanotechnology Design</td>
<td>3</td>
</tr>
<tr>
<td>MAE 102</td>
<td>Introduction to Mechanical and Aerospace Engineering Design</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td></td>
<td><strong>5</strong></td>
</tr>
</tbody>
</table>

Math and Science Requirements

A minimum grade of C- is required in all Math and Science courses.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 115</td>
<td>Fundamentals of Chemistry 1</td>
<td>4</td>
</tr>
<tr>
<td>&amp; 115L</td>
<td>and Fundamentals of Chemistry 1 Laboratory (GEF 2B)</td>
<td>4</td>
</tr>
<tr>
<td>Calculus I (GEF 3):</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>
MATH 155  Calculus 1
MATH 153  Calculus 1a with Precalculus
& MATH 154  and Calculus 1b with Precalculus
MATH 156  Calculus 2 (GEF 8)
MATH 251  Multivariable Calculus
MATH 261  Elementary Differential Equations
PHYS 111  General Physics 1
& 111L  and General Physics 1 Laboratory (GEF 8)
PHYS 112  General Physics 2
& 112L  and General Physics 2 Laboratory (GEF 8)

Total Hours 28

Mechanical Engineering Program Requirements

ECON 201  Principles of Microeconomics (GEF 4) 3
ECON 202  Principles of Macroeconomics 3
EE 221  Introduction to Electrical Engineering 3
EE 222  Introduction to Electrical Engineering Laboratory 1
IENG 302  Manufacturing Processes 2
IENG 303  Manufacturing Processes Laboratory 1
MAE 211  Mechatronics 3
MAE 241  Statics 3
MAE 242  Dynamics 3
MAE 243  Mechanics of Materials 3
MAE 244  Dynamics and Strength Laboratory 1
MAE 316  Analysis-Engineering Systems 3
MAE 320  Thermodynamics 3
MAE 321  Applied Thermodynamics 3
MAE 322  Thermal and Fluids Laboratory 1
MAE 331  Fluid Mechanics 3
MAE 342  Dynamics of Machines 3
MAE 343  Intermediate Mechanics of Materials 3
MAE 411  Advanced Mechatronics 3
MAE 423  Heat Transfer 3
MAE 454  Machine Design and Manufacturing 3
MAE 456  Computer-Aided Design and Finite Element Analysis 3
MAE 460  Automatic Controls 3
MAE 471  Principles of Engineering Design (Fulfills Writing and Communications Skills Requirement) 3

Technical Electives 12

Total Hours 75

Mechanical Engineering Technical Electives

Mechanical Engineering Technical Electives

Students are limited to a total of 3 hours under MAE 491, MAE 495, and/or MAE 496
Students may substitute one technical elective from the substitute technical electives
Students may substitute two technical electives from the pre medical technical electives
BMEG 340  Biomechanics 3
MAE 271  Mechanical and Aerospace Engineering Design 1
& MAE 371  and Mechanical and Aerospace Engineering Design 2
MAE 312  Introduction to Mechanical Design 3
MAE 335  Incompressible Aerodynamics 3
MAE 336  Compressible Aerodynamics 3
MAE 345  Aerospace Structures 3
MAE 412  Mobile Robotics  3
MAE 415  Balloon Satellite Project 1  3
& MAE 417  and Balloon Satellite Project 2  
MAE 425  Internal Combustion Engines  3
MAE 426  Flight Vehicle Propulsion  3
  or MAE 478  Guided Missile Systems  
  or MAE 484  Spacecraft Propulsion  
MAE 427  Heating, Ventilating, and Air Conditioning  3
MAE 430  Microgravity Research 1  3
  or MAE 431  Microgravity Research 2  
MAE 432  Engineering Acoustics  3
MAE 433  Computational Fluid Dynamics  3
MAE 441  Gas Turbine Design and Durability  3
MAE 446  Mechanics of Composite Materials  3
MAE 459  Hybrid Electric Vehicle Propulsion and Control  3
MAE 461  Applied Feedback Control  3
MAE 462  Design of Robotic Systems  3
MAE 472  Engineering Systems Design  3
MAE 473  Bioengineering  3
MAE 474  UAV Design/Build/Fly Comp  1-3
MAE 476  Space Flight and Systems  3
MAE 491  Professional Field Experience  3
MAE 493  Special Topics  3
MAE 495  Independent Study  3
MAE 496  Senior Thesis  3
Any MAE 500 Level Course
Approved ENGR 493 Courses
IENG 445  Project Management for Engineers  3

**Substitute Technical Electives**

Mechanical Engineering students may take one of the following courses with prior approval from the ME curriculum chair. Students may only take one of the substitute courses and must take the other technical elective from the list above.

CHE 366  Materials Science  3
CHE 463  Polymer Composites Processing  3
CE 322  Hydrotechnical Engineering  3
CE 347  Introduction to Environmental Engineering  4
CE 443  Environmental Science and Technology  3
CE 463  Steel Design  3
CE 464  Timber Design  3
CS 430  Advanced Software Engineering  3
CS 440  Database Design and Theory  3
CS 453  Data and Computer Communications  3
CS 455  Computer Architecture  3
EE 327  Signals and Systems 1  3
EE 335  Electromechanical Energy Conversion and Systems  3
EE 345  Engineering Electromagnetics  3
EE 463  Digital Signal Processing Fundamentals  3
ENGR 310  Energy Engineering  3
IENG 377  Engineering Economy  3
IENG 405  Design for Manufacturability  3
MATH 441  Applied Linear Algebra  3
MATH 456  Complex Variables  3
MATH 465 Partial Differential Equations 3
PHYS 314 Introductory Modern Physics 4
PHYS 321 Optics 3
PHYS 332 Theoretical Mechanics 2 3
PHYS 451 Introductory Quantum Mechanics 3
PHYS 463 Nuclear Physics 3
PHYS 471 Solid State Physics 3

Pre-Medical Technical Electives

Students who plan a career in medicine, dentistry, or related area may substitute the following courses to count as the technical elective requirement.

Choose two of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 233 &amp; 233L</td>
<td>Organic Chemistry 1 and Organic Chemistry 1 Laboratory</td>
<td></td>
</tr>
<tr>
<td>CHEM 234 &amp; 234L</td>
<td>Organic Chemistry 2 and Organic Chemistry 2 Laboratory</td>
<td></td>
</tr>
<tr>
<td>BIOL 115 &amp; 115L</td>
<td>Principles of Biology and Principles of Biology Laboratory</td>
<td></td>
</tr>
<tr>
<td>BIOL 117 &amp; 117L</td>
<td>Introductory Physiology and Introductory Physiology Laboratory</td>
<td></td>
</tr>
</tbody>
</table>

Suggested Plan of Study

First Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Fall Hours</th>
<th>Spring Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGL 101 (GEF 1)</td>
<td></td>
<td>3 ENGR 102</td>
<td>3</td>
</tr>
<tr>
<td>MATH 155 (GEF 3)</td>
<td></td>
<td>4 MATH 156 (GEF 8)</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 115 &amp; 115L (GEF 2B)</td>
<td></td>
<td>4 PHYS 111 &amp; 111L (GEF 8)</td>
<td>4</td>
</tr>
<tr>
<td>ENGR 101</td>
<td></td>
<td>2 GEF 6</td>
<td>3</td>
</tr>
<tr>
<td>ENGR 191</td>
<td></td>
<td>1 GEF 7</td>
<td>3</td>
</tr>
<tr>
<td>GEF 5</td>
<td></td>
<td>3</td>
<td></td>
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</tbody>
</table>

| Total | 17 |

Second Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Fall Hours</th>
<th>Spring Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 211</td>
<td></td>
<td>3 ECON 201 (GEF 4)</td>
<td>3</td>
</tr>
<tr>
<td>MAE 241</td>
<td></td>
<td>3 MAE 242</td>
<td>3</td>
</tr>
<tr>
<td>MATH 251</td>
<td></td>
<td>4 MAE 243</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 112 &amp; 112L (GEF 8)</td>
<td></td>
<td>4 MAE 244</td>
<td>1</td>
</tr>
<tr>
<td>ENGL 102 (GEF 1)</td>
<td></td>
<td>3 MATH 261</td>
<td>4</td>
</tr>
</tbody>
</table>

| Total | 17 |

Third Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Fall Hours</th>
<th>Spring Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 316</td>
<td></td>
<td>3 MAE 321</td>
<td>3</td>
</tr>
<tr>
<td>MAE 320</td>
<td></td>
<td>3 MAE 322</td>
<td>1</td>
</tr>
<tr>
<td>MAE 343</td>
<td></td>
<td>3 MAE 331</td>
<td>3</td>
</tr>
<tr>
<td>EE 221</td>
<td></td>
<td>3 MAE 342</td>
<td>3</td>
</tr>
<tr>
<td>EE 222</td>
<td></td>
<td>1 IENG 302</td>
<td>2</td>
</tr>
<tr>
<td>ECON 202</td>
<td></td>
<td>3 IENG 303</td>
<td>1</td>
</tr>
<tr>
<td>Technical Elective</td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

| Total | 16 |
### Fourth Year

<table>
<thead>
<tr>
<th></th>
<th>Fall</th>
<th>Hours</th>
<th>Spring</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 454</td>
<td>3</td>
<td>MAE 411</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MAE 456</td>
<td>3</td>
<td>MAE 423</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MAE 471</td>
<td>3</td>
<td>MAE 460</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Two Technical Electives</td>
<td>6</td>
<td>Technical Elective</td>
<td>3</td>
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<tr>
<td>Total credit hours:</td>
<td>15</td>
<td>12</td>
<td></td>
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</tr>
</tbody>
</table>

**Student Outcomes**

Upon graduation, all Bachelors of Science students in Mechanical Engineering will have:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, ethical, economic, and societal factors
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The graduates of the BSME program are well prepared to engage in the long-life pursuit of successful engineering careers by quickly adapting to the changing demands of the workforce in a dynamic global environment, by enhancing continuously their professional abilities or skills, and by contributing effectively in multidisciplinary teams to the advancement of existing or anticipated industrial, economical and societal needs.

**MAE 102. Introduction to Mechanical and Aerospace Engineering Design. 3 Hours.**

PR: ENGR 101 with a minimum grade of C and (MATH 154 or MATH 155 with a minimum grade of C) and PR or CONC: PHYS 111. Engineering problem solving techniques related to mechanical and aerospace engineering topics through teamwork, written and oral communications, and using the computer, for algorithm development and computer aided design. Discussion of engineering professional and ethical behavior.

**MAE 191. First-Year Seminar. 1-3 Hours.**

Engages students in active learning strategies that enable effective transition to college life at WVU. Students will explore school, college and university programs, policies and services relevant to academic success. Provides active learning activities that enable effective transition to the academic environment. Students examine school, college and university programs, policies and services.

**MAE 211. Mechatronics. 3 Hours.**

PR: ENGR 102 or CHE 102 or MAE 102. Selection of mechanical and electronic components and integration of these components into complex systems. Hands-on laboratory and design experiments with components and measurement equipment used in the design of mechatronic products. (2 hr. lec., 3 hr. lab.)

**MAE 212. Introduction to Computer Aided Design. 1 Hour.**

PR: ENGR 101 with a minimum grade of C-. Introduction to the process of drawing and creating mechanical objects using a computer. Basics of engineering graphics and creation of computer-based models of components and assemblies.

**MAE 215. Intro to Aerospace Engineering. 3 Hours.**

PR: (ENGR 102 or CHE 102 or MAE 102) and (MATH 154 or MATH 155 with grade of C- or higher). Fundamental physical quantities of a flowing gas, standard atmosphere, basic aerodynamic equations, airfoil nomenclature, lift, drag and aircraft performance. Digital computer usage applied to aerodynamic and performance problems and aircraft design. (3 hr. lec.).

**MAE 216. Intermediate Engineering Computation. 1 Hour.**

PR: (ENGR 102 or MAE 102 or CHE 102) with a minimum grade of C-. This course will use basic coding skills learned in ENGR 102 / MAE 102 / CHE 102 and apply them to intermediate complex coding problems. Students will learn to use the software debugger to solve coding issues that arise in more complex routines. Students will work individually to solve intermediate difficult engineering-oriented problems.
MAE 241. Statics. 3 Hours.
PR: WVU sections require PHYS 111 and (MATH 154 or MATH 155) all with a grade of C- or better, WVUIT sections require MATH 155 as a prerequisite. Engineering applications of force equilibrium. Vector operations, couples and moments, resultants, centers of gravity and pressure, static friction, free-body diagrams, trusses and frames.

MAE 242. Dynamics. 3 Hours.
PR: WVU sections require MATH 156 with a grade of C- or better and MAE 241, WVUIT sections require MATH 156 and MAE 241 as prerequisites. Newtonian dynamics of particles and rigid bodies. Engineering applications of equations of motion, work and energy, conservative forces, acceleration in several coordinate systems, relative motion, instantaneous centers, and plane motion.

MAE 243. Mechanics of Materials. 3 Hours.
PR: WVU sections require MATH 156 with a grade of C- or better and MAE 241, WVUIT sections require MATH 156 and MAE 241 as prerequisites. Stress deformation, and failure of solid bodies under the action of forces. Internal force resultants, stress, strain, Mohr's circle, and mechanical properties of materials, generalized Hooke's law. Axial bending and buckling loads, and combinations.

MAE 244. Dynamics and Strength Laboratory. 1 Hour.

MAE 253. Fundamentals of Materials Engineering. 2 Hours.
PR: CHEM 115 and PHYS 111 with a minimum grade of C- in both. Atomic and crystallographic structure of materials, thermal and mechanical processing influences on microstructure, and composition and microstructural effects on mechanical and physical properties attributes.

MAE 254. Materials Engineering Laboratory. 1 Hour.
PR: CHEM 115 and PHYS 111 and PR or CONC: MAE 253 with a minimum grade of C- in all. Introduction to microscopy and spectroscopy material microstructure characterization techniques; materials macroscopic physical properties based on processing history, chemistry, crystal structure and microstructure; and methods to identify material needs for engineering application.

MAE 271. Mechanical and Aerospace Engineering Design 1. 1 Hour.
PR: Consent. Hands-on applications of concepts learned in other courses to meet specified performance or competition criteria of capstone design courses. Introductory concepts of an integrated sophomore-junior-senior design team.

MAE 275. Aerospace Design 1. 1 Hour.
PR: Consent. Hands-on applications of concepts learned in other courses to meet specified performance or competition criteria of aerospace capstone design courses. Introductory concepts of an integrated sophomore-junior-senior design team.

MAE 293. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

MAE 298. Honors. 1-6 Hours.
PR: Students in the Honors Program and consent by the honors director. Independent reading, study, or research.

MAE 312. Introduction to Mechanical Design. 3 Hours.
Introduction to the process of designing mechanical objects and machines composed of multiple objects. Basics of engineering graphics, and creation of computer-based models of machine components and assemblies.

MAE 316. Analysis-Engineering Systems. 3 Hours.
PR: MATH 261 with a grade of C- or better, (ENGR 102 or CHE 102 or MAE 102), and MAE 242. Analytical, numerical, and computational techniques to analyze and solve engineering problems. Mathematical modeling, solution strategies, and analysis of results. Statistical techniques including probability distribution functions, regression analysis, and curve fitting.

MAE 320. Thermodynamics. 3 Hours.
PR: WVU sections require PHYS 111 and MATH 156, WVUIT sections require MATH 156 as a prerequisite. Principles of thermodynamics; properties of ideal gases and vapors; first and second laws of thermodynamics; basic gas and vapor cycles; basic refrigeration.

MAE 321. Applied Thermodynamics. 3 Hours.
PR: WVU sections require MAE 320, WVUIT sections require MAE 320 and CHEM 115 and CHEM 115L. Applications to mechanical systems of fundamentals from thermodynamics; availability analysis; applied gas and vapor power cycles; applied refrigeration and psychrometry; mixtures of real gases and vapors; combustion; choked flow nozzles. (3 hr. lec.).

MAE 322. Thermal and Fluids Laboratory. 1 Hour.
PR: MAE 320. Experiments demonstrating fundamental concepts of thermal-fluid systems; hydrostatics, dynamic pressure forces, dimensional analysis, pipe pressure losses, drag on external bodies, flow measurements devices, engine performance, fan and turbine performance, saturated vapor curve determination. (3 hr. lab.).

MAE 331. Fluid Mechanics. 3 Hours.
PR: WVU sections require MATH 251 with a grade of C- or better and MAE 241, WVUIT sections require MATH 156 and MAE 242 as prerequisites. Properties of fluids, fluid statics, inviscid fluid dynamics, fluid kinematics, thermodynamic principles, mass momentum and energy principles, similitude and dimensional analysis, laminar and turbulent flow, viscous effects, flow in pressure conduits and external flows.
MAE 335. Incompressible Aerodynamics. 3 Hours.

MAE 336. Compressible Aerodynamics. 3 Hours.
PR: MAE 320 and (MAE 215 or MAE 331). Analysis and design of compressible, inviscid flows; isentropic flow, shock waves, Prandtl-Meyer expansions, supersonic nozzles and diffusers. Airfoils in compressible flow and small perturbation theory, introduction to hypersonic-flow theory.

MAE 342. Dynamics of Machines. 3 Hours.
PR: WVU sections require MAE 242 and PR or CONC: MATH 261, WVUIT sections require PR or CONC: MAE 242. Analysis and design of compressible, inviscid flows; isentropic flow, shock waves, Prandtl-Meyer expansions, supersonic nozzles and diffusers. Airfoils in compressible flow and small perturbation theory, introduction to hypersonic-flow theory.

MAE 334. Intermediate Mechanics of Materials. 3 Hours.

MAE 345. Aerospace Structures. 3 Hours.

MAE 353. Intermediate Mechanics of Materials. 3 Hours.
PR: MAE 243 and (MATH 251 with a minimum grade of C-). Strength under combined stresses, failure methods, energy methods, column theory, unsymmetrical bending, composite materials, fundamentals of fatigue and fracture, and vibrations.

MAE 354. Materials Processing and Manufacturing. 3 Hours.
PR: MAE 253 or CHE 366. Processing and manufacturing methods for metals, ceramics, polymers, composites, and hybrid materials; considerations for nano-, micro-, and macro-scale; relationships between process method, material structure, properties, cost, process energy requirements, and geometric limitations; and process selection based on materials selection and desired properties.

MAE 355. Mechanical and Physical Properties of Materials. 3 Hours.
PR: MAE 253 or CHE 366. Mechanical, electrical, magnetic, optical properties of materials; relationships between materials synthesis, microstructure and physical properties; and selection of materials for application.

MAE 361. Introduction to Unmanned Aerial Systems. 3 Hours.
PR: MAE 215. Introduction to history, current domestic regulations, and policies on unmanned aerial systems. Vehicle aerodynamics, propulsion, structures, launch and recovery, mission planning, weapons and sensor payloads, and ground and airborne system data links. Use of numerical tools, computer-aided design tools, and common engineering planning tools.

MAE 365. Flight Dynamics. 3 Hours.

MAE 370. Aviation Ground School. 3 Hours.
Nomenclature of aircraft, aerodynamics, civil air regulations, navigation, meteorology, aircraft, and aircraft engines. May serve as preparation for private pilot written examinations. (2 hr. lec., 2 hr. lab.) (Not approved as a technical elective.)

MAE 371. Mechanical and Aerospace Engineering Design 2. 2 Hours.
PR: MAE 271 with a grade of C or better or Consent. Continued applications of concepts learned in other courses to meet specified performance or competition criteria of capstone design courses. Intermediate concepts of an integrated sophomore-junior-senior design team.

MAE 375. Aerospace Design 2. 2 Hours.
PR: MAE 275 with a minimum grade of C- or consent. Continued applications of concepts learned in other courses to meet specified performance or competition criteria of aerospace capstone design courses. Intermediate concepts of an integrated sophomore-junior-senior design team.

MAE 411. Advanced Mechatronics. 3 Hours.
PR: MATH 261 with a grade of C or better and MAE 211 and EE 221 and EE 222. Instrumentation and measurements emphasizing systems that combine electronics and mechanical components with modern controls and microprocessors. First and second order behavior, transducers and intermediate devices, measurement of rapidly changing engineering parameters, microcontrollers and actuators. (2 hr. lec., 3 hr. lab.).

MAE 412. Mobile Robotics. 3 Hours.
PR: Consent. Introduction to fundamental topics in Mobile robotics; methods of locomotion; common mobile robot sensors, state estimation and navigation algorithms; path planning and obstacle avoidance methods; robot decision making and control processes; and mobile robot systems design.

MAE 413. Robotic Manipulators. 3 Hours.
PR: MATH 251 and (ENGR 102 or CHE 102 or MAE 102) and MAE 242 with a minimum grade of C- in all. Fundamentals of robotic manipulators including forward and inverse kinematics, mechanics, modeling, and control. Introduction to robot motion planning and robot programming. Applications of robotic manipulators.

MAE 415. Balloon Satellite Project 1. 1 Hour.
Student teams propose, design, construct, and test experimental packages, launched as payloads via a weather balloon that is tracked and recovered. Data acquired by the experimental payloads is analyzed.
MAE 417. Balloon Satellite Project. 2 Hours.
PR: MAE 415. Student teams propose, design, construct, and test complex experimental packages, launched as payloads via a weather balloon that is tracked and recovered. Data acquired by the experimental payloads is analyzed.

MAE 422. Energy Conversion Laboratory. 1 Hour.
PR: MAE 321 or MAE 426. Experiments demonstrating renewable and fossil-derived sources energy conversion including wind, solar, fuel cells, heat engines and refrigeration devices. Statistical analysis of data.

MAE 423. Heat Transfer. 3 Hours.
PR: WVU sections require MATH 261 with a grade of C- or better and MAE 320 and (MAE 331 or MAE 335), WVUIT sections require MAE 331 and MAE 321 as prerequisites and MAE 419 concurrently. One-, two-, three-dimensional steady state conduction; transient conduction; free and forced convection; radiation; heat exchangers; heat and mass transfer by analytical, numerical analogical and experimental methods; design of thermal systems.

MAE 424. Applications in Heat Transfer. 3 Hours.
PR: MAE 423. Application of basic heat transfer theory and digital computation techniques to problems involving heat exchangers, power plants, electronic cooling, manufacturing processes, and environmental problems. (3 hr. lec.).

MAE 425. Internal Combustion Engines. 3 Hours.
PR: WVU sections require MAE 320, WVUIT sections require MAE 321. IC engine operating characteristics; engine cycles; thermochemistry and fuels; air and fuel induction; fluid motion within combustion chamber; combustion; exhaust flow; emissions and air pollution; heat transfer in engines; friction and lubrication; advanced engine concepts.

MAE 426. Flight Vehicle Propulsion. 3 Hours.

MAE 427. Heating, Ventilating, and Air Conditioning. 3 Hours.
PR: WVU sections require MAE 320 or consent, WVUIT sections require MAE 423. Air and humidity relations; comfort and indoor air quality; building heat transfer; design heating and cooling loads; air distribution; refrigeration; systems and equipment; system energy analysis; control systems.

MAE 430. Microgravity Research 1. 3 Hours.
Student team conceives and proposes a unique research experiment, to be flown on NASA microgravity research aircraft. Team also begins design, construction, and testing of apparatus.

MAE 431. Microgravity Research 2. 3 Hours.
PR: MAE 430. Student team completes design, construction, and testing of research experiment; that is then flown on NASA microgravity research aircraft. Data required from experiment is analyzed and reported.

MAE 432. Engineering Acoustics. 3 Hours.
PR: MATH 261 or consent. Theory of sound propagation and transmission. Important industrial noise sources and sound measurement equipment. Selection of appropriate noise criteria and control methods. Noise abatement technology. Laboratory studies and case histories. (3 hr. lec.).

MAE 433. Computational Fluid Dynamics. 3 Hours.
PR: MAE 316 and (MAE 331 or MAE 335) with a grade of C or better in each, or consent. Introduction to modern computational fluid dynamics. Development and implementation of finite-difference schemes for numerical flow solution. Grid Generation. Explicit, implicit, and iterative techniques. Emphasis on applications. Validation and verification of solution. (3 hr. lec.).

MAE 434. Experimental Aerodynamics. 2 Hours.
PR: MAE 336. Aerodynamic testing and instrumentation. Supersonic and low-speed wind tunnel testing including shock waves, aerodynamic forces, pressure distribution on an airfoil and boundary layers. Application of schlieren optics, thermal anemometry and laser doppler velocimetry. (1 hr. lec., 3 hr. lab.).

MAE 437. Vertical/Short Takeoff and Landing Aerodynamics. 3 Hours.
PR: MAE 336. Fundamental aerodynamics of V/STOL aircraft. Topics include propeller and rotor theory, helicopter performance, jet flaps, ducted fans, and propeller-wing combinations. (3 hr. lec.).

MAE 438. Introduction to Gas Dynamics. 3 Hours.
PR: MAE 331 or consent. Fundamentals of gas dynamics, one-dimensional gas dynamics and wave motion, measurement, effect of viscosity and conductivity, and concepts of gas kinetics. (3 hr. lec.).

MAE 439. Hypersonic Gas Dynamics. 3 Hours.
PR: MAE 336 or consent. Hypersonic shock and expansion wave relations; hypersonic inviscid flowfields: approximate and numerical methods, blast wave theory; hypersonic boundary layers and aerodynamic heating. (3 hr. lec.).

MAE 441. Gas Turbine Design and Durability. 3 Hours.
PR: MAE 320 and (MAE 335 or MAE 331). Design of gas turbine engines for aircraft propulsion and industrial power generation. Theory of operation and characteristics of gas turbines. Design considerations, component operation, and durability of the individual components.
MAE 442. Mechanical Vibrations. 3 Hours.
PR: MAE 316 and MAE 343 with a minimum grade of C- in both. Response analysis of one, two, and multi degree of freedom systems; natural frequencies and modes of vibrations; damping; methods to avoid excessive vibrations; whirling of rotating shafts; balancing; vibration isolation; vibration measurements; and instrumentation.

MAE 446. Mechanics of Composite Materials. 3 Hours.
PR: MATH 251 and MAE 243. Fundamental methods for structural analysis of fiber reinforced composites. Particularities of composite applications in design and manufacturing of structural components: performance tailoring, failure criteria, environmental effects, joining and processing. (3 hr. lec.).

MAE 447. Aeroelasticity. 3 Hours.
PR: MAE 345. Vibrating systems of single degree and multiple degrees of freedom, flutter theory and modes of vibration, torsional divergence and control reversal. (3 hr. lec.).

MAE 454. Machine Design and Manufacturing. 3 Hours.
PR: WVU sections require MATH 261 with a grade of C- or better and MAE 342 and MAE 343, WVUIT sections require MAE 243 as a prerequisite and PR or CONC: MAE 342. Working stresses, theories of failure, fatigue, welded joints, design of machine elements such as shafting, screws, springs, belts, clutches, brakes, gears, bearings, and miscellaneous machine elements. Design for manufacturability considerations.

MAE 456. Computer-Aided Design and Finite Element Analysis. 3 Hours.
PR: WVU sections require MATH 261 with a grade of C- or better and MAE 342 or MAE 345, WVUIT sections require MATH 251 and MAE 454 and MAE 455. Computer aided design fundamentals and formulation of the stiffness matrix and load vector 1D and 2D elements based on variational principles. Analytical and finite element solution of vibration and heat transfer problems. Explore applications of CAD/FEM packages in design case studies.

MAE 457. UAV Path Planning and Trajectory Tracking. 3 Hours.
PR: MAE 365 or MAE 466 or consent of instructor, prior experience with Matlab and Simulink. Introduction to algorithms for unmanned aerial vehicle (UAV) path planning and trajectory tracking: development, implementation, and testing through simulation.

MAE 459. Hybrid Electric Vehicle Propulsion and Control. 3 Hours.
Hybrid electric vehicle propulsion system modeling and simulation. Hybrid electric vehicle powertrain architectures. Mathematical modeling of hybrid vehicle components including vehicle longitudinal dynamics, batteries, electric motors, engines, transmissions, inverters. Development of hybrid supervisory control algorithms for powertrain management and optimization.

MAE 460. Automatic Controls. 3 Hours.
PR: WVU sections require MATH 261 with a grade of C- or better, WVUIT sections require EE 221 and MATH 261. Modeling and simulation of mechanical systems using transfer functions. 1st and 2nd order systems with associated specification. Block algebra and concept of Equivalent Transfer Function. Steady state errors. Routh-Hurwitz criteria for stability. Root locus based design of proportional controllers and compensators. Introduction to state variables modeling.

MAE 461. Applied Feedback Control. 3 Hours.
PR: MAE 460 or Consent. Application of automatic control theory. Transfer functions and block diagrams for linear physical systems. Proportional, integral, and derivative controllers. Transient and frequency response using Laplace transformation. (3 hr. lec.).

MAE 462. Design of Robotic Systems. 3 Hours.
PR: Consent. Mechanical automation design associated with robotic systems, including economic justification and ethics. Geometric choices and controller specifications for programmable manipulators. Workstation strategies such as CNC and CIM for computer-based flexible manufacturing. (3 hr. lec.).

MAE 465. Flight Mechanics 2. 3 Hours.
PR: MAE 365 or MAE 466. Fundamental concepts of feedback control system analysis and design. Automatic flight controls, and human pilot plus airframe considered as a closed loop system. Stability augmentation. (3 hr. lec.).

MAE 466. Spacecraft Dynamics. 3 Hours.

MAE 467. Introduction to Flight Simulation. 3 Hours.
PR: MAE 365 or MAE 466. Fundamental concepts of flight simulation are introduced through interaction with tools of different complexity from simplified linear and non-linear models to a six degrees-of-freedom motion based flight simulator.

MAE 469. UAV Guidance, Navigation & Control. 3 Hours.
PR: MAE 365 or MAE 466. Introduction to multi-rotor unmanned aerial vehicle (UAV) dynamics. Basic filters for UAV state estimation. Introduction to UAV attitude stabilization and altitude holding controllers. Simplified UAV path planning algorithmshms.

MAE 471. Principles of Engineering Design. 3 Hours.
PR: MAE 320 and MAE 331 and MAE 342 and MAE 343. Topics include design problems in mechanical engineering, deal with analytical and experimental methodologies in fluid, thermal, and structural areas, decision-making techniques, optimization, computer aided design and economic consideration.
MAE 472. Engineering Systems Design. 3 Hours.
PR: MAE 320 and MAE 331 and MAE 342 and MAE 343. Identification and solution of challenging engineering problems through rational analysis and creative synthesis. Planning, designing, and reporting on complex systems on individual and group basis. (6 hr. lab.).

MAE 473. Bioengineering. 3 Hours.
PR: MAE 243 or consent. Introduction to human anatomy and physiology using an engineering systems approach. Gives the engineering student a basic understanding of the human system so that the student may include it as an integral part of the design. (3 hr. lec.).

MAE 474. UAV Design/Build/Fly Comp. 1-3 Hours.
PR: Consent. Hands-on applications of concepts learned in other courses to meet specified flight performance and competition criteria. Advanced aerodynamic and materials concepts are utilized by an integrated sophomore-junior-senior team.

MAE 475. Flight Vehicle Design-Capstone. 3 Hours.
PR: (ENGL 102 or ENGL 103) and MAE 215 and MAE 365. Preliminary design of flight vehicles; with regard for performance and stability requirements, considering aerodynamics, weight and balance, structural arrangement, configuration, cost safety, guidance, and propulsion effects.

MAE 476. Space Flight and Systems. 3 Hours.
PR: MAE 316. Introduction to fundamental concepts of space flight and vehicles, emphasizing performance aspects and basic analytical expressions. Common analysis methods and design criteria for launch vehicles, orbital mechanics, atmospheric re-entry, stabilization, thermal, power, and attitude control.

MAE 478. Guided Missile Systems. 3 Hours.

MAE 482. Flight Simulation for Aircraft Safety. 3 Hours.
PR: MAE 365 or MAE 466 or consent. Introduction to flight modeling and simulation tools for aircraft health management through analysis and accommodation of abnormal flight conditions.

MAE 484. Spacecraft Propulsion. 3 Hours.
PR: MAE 336. Brief introduction to aircraft propulsion including turbojets. Introduction to rocket and spacecraft propulsion. The rocket equation, staging, liquid rocket engines and solid rocket motors, thermochemistry, and combustion.

MAE 485. Flight Vehicle Design 2. 3 Hours.
PR: MAE 475. Detailed design of a major aircraft component and evaluation through experiments or simulation of performance and design requirements compliance.

MAE 486. Spacecraft Design 1. 3 Hours.
PR: MAE 215 and MAE 476. Engages students into the process of designing spacecraft and space missions as it is executed in both government and industry. Addresses each of the major subsystems found in most modern spacecraft. Includes computer and hands-on laboratory assignments.

MAE 487. Spacecraft Design 2. 3 Hours.
PR: MAE 486. The course is focused on a team-based design exercise to develop an end-to-end spacecraft mission concept. Typical process issues are addressed such as science investigation, trajectory analysis, detailed design of each spacecraft subsystem, discussion of engineering trade studies, risk analysis, budget, and schedule.

MAE 490. Teaching Practicum. 1-3 Hours.
PR: Consent. Teaching practice as a tutor or assistant.

MAE 491. Professional Field Experience. 1-18 Hours.
PR: Consent. (May be repeated up to a maximum of 18 hours.) Prearranged experiential learning program, to be planned, supervised, and evaluated for credit by faculty and field supervisors. Involves temporary placement with public or private enterprise for professional competence development.

MAE 493. Special Topics. 1-6 Hours.
PR: Consent. Investigation of topics not covered in regularly scheduled courses.

MAE 494. Seminar. 1-3 Hours.
PR: Consent. Presentation and discussion of topics of mutual concern to students and faculty.

MAE 495. Independent Study. 1-6 Hours.
Faculty supervised study of topics not available through regular course offerings.

MAE 496. Senior Thesis. 1-3 Hours.
PR: Consent.

MAE 497. Research. 1-6 Hours.
Independent research projects.

MAE 498. Honors. 1-3 Hours.
PR: Students in Honors Program and consent by the honors director. Independent reading, study or research.