Aerospace Engineering

Degrees Offered

- Masters of Science, Aerospace Engineering (M.S.A.E.)
- Doctor of Philosophy, Aerospace Engineering (Ph.D.)

Educational objectives of the departmental graduate-level programs:

1. To provide high quality advanced master-level and Ph.D. level education to graduate engineering students to enable successful careers in technology development, innovation and research, with depth and breadth in one or several areas of the aerospace engineering discipline.
2. To develop the capacity of graduates to conduct independent research and/or technology development and innovation, through original contributions to the aerospace engineering discipline and to disseminate the results of their scholarly work.
3. To instill in graduates the drive for leadership in technology development, innovation and research and to contribute to the advancement of the profession in a societal and economic context.

The outcomes of the graduate programs in Aerospace Engineering are as follows:

- Holders of graduate degrees will have an expert-level understanding of the advanced principles of aerospace engineering, which include aerospace systems design, aircraft or spacecraft dynamics, stability and control, flight mechanics and simulation, advanced materials, vehicle propulsion, aerodynamics, aeroelasticity, and computational mechanics.
- Holders of graduate degrees will hold paramount the highest standards of ethical and professional responsibility in the practice of their profession to contribute to the well-being of society and to the advancement of the aerospace engineering profession.
- Holders of Ph.D. degrees will have furthered original research contributions to the state of the art in their specific areas of expertise and will be able to develop innovative research in order to advance the frontiers of knowledge, secure sponsored research, and disseminate its findings through scholarly publications.

Curriculum in Master of Science in Aerospace Engineering

A candidate for the M.S. degree in aerospace engineering must comply with the rules and regulations as outlined in the WVU Graduate Catalog and the specific requirements of the Statler College and the Mechanical and Aerospace Engineering Department.

Program Requirements

All M.S. degree candidates are required to perform research (except those pursuing the coursework-only degree option) and follow a planned program of study. The student’s research advisor, in conjunction with the student’s Advising and Examining Committee (AEC) will be responsible for determining the plan of study appropriate to the student’s needs. The underlying principle of the planned program is to provide the students with the necessary support to complete their degree and prepare them for their career.

Curriculum Requirements

A minimum cumulative GPA of 3.0 is required in all courses.

A minimum of 60% of courses must be from 500 level or above.

Course Requirements *

**Thesis Option (30 credit hours)**

- Technical Electives (6 credit hours)
- Mathematics Requirements (6 credit hours)
- Additional Courses (12 credit hours) - Any BIOM, CE, CHEM, CPE, CS, EE, IENG, MAE, MATH, MINE, PNGE, PHYS, SENG, or STAT courses 400-799, as approved by the student’s AEC
- MAE 697 Research (6 credit hours)
- Written Research Proposal
- Thesis
- Final Oral or Written Examination

**Problem Report Option (33 credit hours)**

- Technical Electives (6 credit hours)
- Mathematics Requirements (6 credit hours)
- Additional Courses (18 credit hours) - Any BIOM, CE, CHEM, CPE, CS, EE, IENG, MAE, MATH, MINE, PNGE, PHYS, SENG, or STAT courses 400-799, as approved by the student’s AEC
- MAE 697 Research (3 credit hours)
Written Research Proposal

Formal Written Report or Professional Report/Paper

Final Oral or Written Examination

**Coursework Option (33 credit hours)**

**Technical Electives (18 credit hours)**

**Mathematics Requirements (6 credit hours)**

Additional Courses (9 credit hours) - Any BIOM, CE, CHE, CHEM, CPE, CS, EE, IENG, MAE, MATH, MINE, PNGE, PHYS, SENG, or STAT courses 400-799, as approved by the student’s AEC

Comprehensive Exam (Written or Oral)

**Total Hours**

30-33

**MATHEMATICS REQUIREMENTS FOR ALL OPTIONS (6 CREDIT HOURS)**

Select two of the following (at least one course with MATH prefix):

- **MATH 420** Numerical Analysis 1
- **MATH 441** Applied Linear Algebra
- **MATH 456** Complex Variables
- **MATH 521** Numerical Analysis
- **MATH 522** Numerical Solution of PDE
- **MATH 541** Modern Algebra
- **MATH 543** Linear Algebra
- **MATH 545** Number Theory 1
- **MATH 551** Real Variables 1
- **MATH 555** Complex Variables 1
- **MATH 563** Mathematics Modeling
- **MATH 564** Intermediate Differential Equations
- **MATH 567** Advanced Calculus
- **MATH 568** Advanced Calculus
- **MATH 573** Graph Theory
- **MATH 593** Special Topics (Applied Nonlinear Dynamics Chaos and Modeling)
- **STAT 513** Design of Experiments
- **STAT 545** Applied Regression Analysis
- **STAT 561** Theory of Statistics 1
- **STAT 562** Theory of Statistics 2
- **MAE 515** Analytical Methods in Engineering
- **MAE 623** Conduction Heat Transfer
- **MAE 633** Computational Fluid Dynamics
- **MAE 640** Continuum Mechanics
- **MAE 645** Energy Methods in Applied Mechanics
- **CHE 531** Mathematical Methods in Chemical Engineering
- **EE 463** Digital Signal Processing Fundamentals
- **EE 465** Introduction to Digital Image Processing
- **EE 515** Linear Control Systems
- **EE 517** Optimal Control
- **IENG 518** Technology Forecasting
- **IENG 553** Applied Linear Programming
- **PHYS 461** Thermodynamics and Statistical Mechanics
- **PHYS 611** Introduction to Mathematical Physics

**TECHNICAL AREA COURSES FOR THESIS OR PROBLEM REPORT OPTIONS (6 CREDIT HOURS)**

Select two courses in a single core technical area from the following:

Area A: Fluid Mechanics and Aerodynamics (FMA)
MAE 532  Dynamics of Viscous Fluids
MAE 624  Convection Heat Transfer
or MAE 636  Fundamentals of Turbulent Flow

Area B: Thermal Sciences and Systems (TSS)
MAE 521  Advanced Thermodynamics 1
MAE 532  Dynamics of Viscous Fluids
MAE 624  Convection Heat Transfer

Area C: Dynamics and Controls (D&C)
MAE 642  Intermediate Dynamics
or MAE 653  Advanced Vibrations
MAE 660  Feedback Control in Mechanical Engineering

Area D: Solid Mechanics and Design (SMD)
MAE 543  Advanced Mechanics of Materials
MAE 641  Theory of Elasticity 1
or MAE 653  Advanced Vibrations

Area E: Materials Science (MS)
MAE 580  Crystallography and Crystals
MAE 583  Thermodynamics and Kinetics of Materials
MAE 649  Microscopy of Materials

TECHNICAL AREA COURSES FOR COURSEWORK OPTION (18 CREDIT HOURS)

Required Courses
MAE 521  Advanced Thermodynamics 1
MAE 532  Dynamics of Viscous Fluids
MAE 543  Advanced Mechanics of Materials
MAE 580  Crystallography and Crystals
MAE 653  Advanced Vibrations
MAE 660  Feedback Control in Mechanical Engineering

* Students who do not hold a baccalaureate degree in aerospace engineering will be required to take a set of undergraduate aerospace engineering courses above and beyond the minimum coursework requirements in order to overcome deficiencies in the aerospace engineering area.

Final Examination
M.S. students following the thesis or problem report option must prepare a written research proposal. The proposal must be approved by the student's AEC at least one semester prior to the final oral examination.

All students, regardless of option, are required to pass a final oral or written examination, administered by their AEC, covering the thesis or problem report and/or related course material.

The students request for the comprehensive exam for students in the Coursework Only degree option must be filed at least four weeks in advance of the desired date of the exam. The comprehensive exam for students in the Coursework Only degree option must be passed at least 3 weeks before graduation.

Suggested Plan of Study
The plan below illustrates the Thesis Option. It is important for students to take courses in the order specified as much as possible; all prerequisites and concurrent requirements must be observed. A typical M.S.A.E degree program that completes degree requirements in two years is as follows.

<table>
<thead>
<tr>
<th>First Year</th>
<th>Fall</th>
<th>Hours</th>
<th>Spring</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Technical Area Course</td>
<td>3</td>
<td>Technical Area Course</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Math Course</td>
<td>3</td>
<td>Math Course</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Additional Course</td>
<td>3</td>
<td>Additional Course</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td></td>
<td>9</td>
</tr>
</tbody>
</table>
Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Hours Spring</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional Course</td>
<td>3 Additional Course</td>
<td>3</td>
</tr>
<tr>
<td>MAE 697</td>
<td>3 MAE 697</td>
<td>3</td>
</tr>
</tbody>
</table>
-----------------------|--------------|-------|

Total credit hours: 30

Curriculum in Doctor of Philosophy – Aerospace Engineering

A candidate for the Ph.D. degree with a major in aerospace engineering must comply with the rules and regulations as outlined in the WVU Graduate Catalog and the specific requirements of the Statler College and the Mechanical and Aerospace Engineering Department.

Program Requirements

The doctor of philosophy degree with a major in aerospace engineering is administered through the college’s interdisciplinary Ph.D. program. The research work for the doctoral dissertation must show a high degree of originality on the part of the student and must constitute an original contribution to the art and science of aerospace engineering.

All Ph.D. degree candidates are required to perform research and follow a planned program of study. The student’s research advisor, in conjunction with the student’s Advising and Examining Committee (AEC) will be responsible for determining the plan of study appropriate to the student’s needs. The underlying principle of the planned program is to provide the students with the necessary support to complete their degree and prepare them for their career.

The doctoral courses of study are selected to fit the particular interests and objectives of the student, with proper attention given to broadening related areas of study. The research work for the doctoral dissertation may entail a fundamental investigation into a specialized area or a broad and comprehensive study in a related subject.

All students pursuing a Ph.D. degree in the MAE department are expected to engage in research and complete and successfully defend a Ph.D. dissertation. They should identify a subject for their Ph.D. dissertation, form a five-member advisory and examining committee, and file a plan of study by the end of their second semester of enrollment in the graduate program. At least one member of the graduate faculty from outside the department is required to serve on the advisory and examining committee.

Curriculum Requirements

A minimum cumulative GPA of 3.0 is required in all courses.

Course Requirements

Technical Area Courses

Select one course in the relevant core technical area from the following:

Area A: Fluid Mechanics and Aerodynamics (FMA)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 532</td>
<td>Dynamics of Viscous Fluids</td>
</tr>
<tr>
<td>MAE 624</td>
<td>Convection Heat Transfer</td>
</tr>
<tr>
<td>MAE 636</td>
<td>Fundamentals of Turbulent Flow</td>
</tr>
</tbody>
</table>

Area B: Thermal Sciences and Systems (TSS)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 521</td>
<td>Advanced Thermodynamics 1</td>
</tr>
<tr>
<td>MAE 532</td>
<td>Dynamics of Viscous Fluids</td>
</tr>
<tr>
<td>MAE 624</td>
<td>Convection Heat Transfer</td>
</tr>
</tbody>
</table>

Area C: Dynamics and Controls (D&C)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 642</td>
<td>Intermediate Dynamics</td>
</tr>
<tr>
<td>MAE 653</td>
<td>Advanced Vibrations</td>
</tr>
<tr>
<td>MAE 660</td>
<td>Feedback Control in Mechanical Engineering</td>
</tr>
</tbody>
</table>

Area D: Solid Mechanics and Design (SMD)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 543</td>
<td>Advanced Mechanics of Materials</td>
</tr>
<tr>
<td>MAE 641</td>
<td>Theory of Elasticity 1</td>
</tr>
<tr>
<td>MAE 653</td>
<td>Advanced Vibrations</td>
</tr>
</tbody>
</table>

Area E: Materials Science (MS)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 580</td>
<td>Crystallography and Crystals</td>
</tr>
<tr>
<td>MAE 583</td>
<td>Thermodynamics and Kinetics of Materials</td>
</tr>
<tr>
<td>MAE 649</td>
<td>Microscopy of Materials</td>
</tr>
</tbody>
</table>
Mathematics Requirements

Select two of the following (at least one course with MATH prefix):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 420</td>
<td>Numerical Analysis 1</td>
</tr>
<tr>
<td>MATH 441</td>
<td>Applied Linear Algebra</td>
</tr>
<tr>
<td>MATH 456</td>
<td>Complex Variables</td>
</tr>
<tr>
<td>MATH 521</td>
<td>Numerical Analysis</td>
</tr>
<tr>
<td>MATH 522</td>
<td>Numerical Solution of PDE</td>
</tr>
<tr>
<td>MATH 541</td>
<td>Modern Algebra</td>
</tr>
<tr>
<td>MATH 543</td>
<td>Linear Algebra</td>
</tr>
<tr>
<td>MATH 545</td>
<td>Number Theory 1</td>
</tr>
<tr>
<td>MATH 551</td>
<td>Real Variables 1</td>
</tr>
<tr>
<td>MATH 555</td>
<td>Complex Variables 1</td>
</tr>
<tr>
<td>MATH 563</td>
<td>Mathematics Modeling</td>
</tr>
<tr>
<td>MATH 564</td>
<td>Intermediate Differential Equations</td>
</tr>
<tr>
<td>MATH 567</td>
<td>Advanced Calculus</td>
</tr>
<tr>
<td>MATH 568</td>
<td>Advanced Calculus</td>
</tr>
<tr>
<td>MATH 573</td>
<td>Graph Theory</td>
</tr>
<tr>
<td>MATH 593</td>
<td>Special Topics (Applied Nonlinear Dynamics Chaos and Modeling)</td>
</tr>
<tr>
<td>STAT 513</td>
<td>Design of Experiments</td>
</tr>
<tr>
<td>STAT 545</td>
<td>Applied Regression Analysis</td>
</tr>
<tr>
<td>STAT 561</td>
<td>Theory of Statistics 1</td>
</tr>
<tr>
<td>STAT 562</td>
<td>Theory of Statistics 2</td>
</tr>
<tr>
<td>MAE 515</td>
<td>Analytical Methods in Engineering</td>
</tr>
<tr>
<td>MAE 623</td>
<td>Conduction Heat Transfer</td>
</tr>
<tr>
<td>MAE 633</td>
<td>Computational Fluid Dynamics</td>
</tr>
<tr>
<td>MAE 640</td>
<td>Continuum Mechanics</td>
</tr>
<tr>
<td>MAE 645</td>
<td>Energy Methods in Applied Mechanics</td>
</tr>
<tr>
<td>CHE 531</td>
<td>Mathematical Methods in Chemical Engineering</td>
</tr>
<tr>
<td>EE 463</td>
<td>Digital Signal Processing Fundamentals</td>
</tr>
<tr>
<td>EE 465</td>
<td>Introduction to Digital Image Processing</td>
</tr>
<tr>
<td>EE 515</td>
<td>Linear Control Systems</td>
</tr>
<tr>
<td>EE 517</td>
<td>Optimal Control</td>
</tr>
<tr>
<td>IENG 518</td>
<td>Technology Forecasting</td>
</tr>
<tr>
<td>IENG 553</td>
<td>Applied Linear Programming</td>
</tr>
<tr>
<td>PHYS 461</td>
<td>Thermodynamics and Statistical Mechanics</td>
</tr>
<tr>
<td>PHYS 611</td>
<td>Introduction to Mathematical Physics</td>
</tr>
</tbody>
</table>

Research

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE 797</td>
<td>Research</td>
</tr>
</tbody>
</table>

Any BIOM, CE, CHEM, CPE, CS, EE, IENG, IH&S, MAE, MATH, MINE, PNGE, PHYS, SAFM, SENG, or STAT courses 500-799

Examinations

Qualifying Exam (Ph.D. qualifying examination)

Candidacy Exam (Dissertation research proposal defense)

Final Exam (Final dissertation defense)

The "Publication Requirement" must be satisfied prior to scheduling the final dissertation defense

Total Hours

42

* Students who do not hold a baccalaureate degree in aerospace engineering are required to take a set of undergraduate aerospace courses above and beyond the minimum coursework requirements.

** For these students, a minimum of fifty-four hours of coursework and thirty hours of independent research beyond a bachelor’s degree, or eighteen hours of coursework and twenty-four hours of independent research beyond an M.S. degree are required.

** PhD students who also earn their MS degree in the MAE Department are expected to select the third core course in their technical area.
First Year
Fall  |  Hours  |  Spring  |  Hours
---   | ---     | ---      | ---
Technical Area Course | 3 | Math Course | 3
Math Course | 3 | Additional Course | 3
MAE 797 | 3 | MAE 797 | 3
---   | ---     | ---      | ---
9 | | 9 |

Second Year
Fall  |  Hours  |  Spring  |  Hours
---   | ---     | ---      | ---
Additional Course | 3 | Additional Course | 3
MAE 797 | 3 | MAE 797 | 3
---   | ---     | ---      | ---
6 | | 6 |

Third Year
Fall  |  Hours  |  Spring  |  Hours
---   | ---     | ---      | ---
MAE 797 | 6 | MAE 797 | 6
---   | ---     | ---      | ---
6 | | 6 |

Total credit hours: 42

JOURNAL PAPER PUBLICATION REQUIREMENT FOR ALL PHD STUDENTS:

Beginning with all PhD students admitted for the summer or fall of 2016 and thereafter, every Ph.D. student, prior to his/her dissertation defense, will be required to provide written documentation that they have received formal proof of submission of either:

a.) At least one manuscript, generally co-authored with their research supervisor and about some portion of their PhD dissertation research, to an archival journal for publication, or

b.) At least one patent disclosure, also generally about some portion of their PhD dissertation research.

This publication requirement will have to be satisfied prior to scheduling the defense of the Ph.D. Dissertation.

Major Learning Goals

AEROSPACE ENGINEERING

The MAE Department is committed to deliver high quality education and research experience to all graduate students in order to enable them to achieve success in their careers, though the following Learning Goals:

• Expertise, depth and breadth in a chosen field of aerospace engineering.
• Capacity to engage in original research, advanced technological discovery and innovation in order to advance the frontiers of knowledge in the science of the aerospace engineering discipline.
• Capacity of effective high level communication in order to document, disseminate and transfer knowledge of the science of the aerospace engineering discipline in educational, research or applied workplace settings.
• Appreciation and understanding of the role of the science of the aerospace engineering discipline in a global and societal context.

Thesis Based Master's Degrees

All the requirements for thesis based master's degrees (M.S.A.E., M.S.M.E. and M.S.M.S.&E.) in the MAE Department must be completed within eight years preceding the student's graduation. All students in these programs are required to engage in research, complete and successfully defend a master's thesis. They must identify a subject for their thesis research, form a three-member advisory and examining committee (AEC), and file a plan of study by the end of their second semester of enrollment in the graduate program. A minimum of twenty-four credit hours of coursework with a minimum overall GPA of 3.0/4.0 and six credit hours of M.S. thesis research are required for the thesis based master's degrees. Students must pass a final examination administered by their advisory and examining committee before being certified for the degree. All thesis based master's degree students have to comply with core requirements by selecting a "core area" and taking two of the courses listed in that area, and in addition they have to comply with the mathematics requirements by taking two courses from an approved list. Four additional courses can be selected from a list of technical electives, or from the core and mathematics lists to complete the coursework requirements, with no more than three courses at the 400 level.

Course Based Master's Degree

A course-only master's degree option is available (M.S.E.), in which students are required to complete thirty-three credit hours of coursework with a minimum overall GPA of 3.0/4.0 and pass a comprehensive examination administered by an advisory and examining committee. Students pursuing a course-only master's degree option are not eligible to receive financial support from the MAE Department. All the requirements for this degree option must also be completed within eight years preceding the student's graduation.
Ph.D. Degrees

The MAE Department offers Ph.D. Programs in Aerospace Engineering, in Mechanical Engineering and in Materials Science and Engineering. These programs require a minimum of eighteen credit hours of graduate level coursework plus a minimum of twenty-four credit hours of research. Students in the Ph.D. program must take and pass the Ph.D. Qualifier examination by the second semester of the program with a second attempt no later than the third semester in the program if necessary. After the qualifier examination, students are expected to produce a dissertation proposal and defend it before a five-member advising and examining committee (AEC). Subsequent the successful proposal defense, students must comply with the journal paper publication (or patent disclosure) requirement in order to attain Ph.D. Candidacy. Finally Ph.D. candidates must successfully defend a Ph.D. dissertation and submit it to WVU library through the ETD protocol to fulfill all the requirements for the degree.