

# Mechanical and Aerospace Engineering

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**Degrees offered:** Bachelor of Science (BS), Master of Engineering (ME), Master of Science (MS), and Doctor of Philosophy (PhD) in Mechanical Engineering

**Undergraduate Emphases:** *Mechanical Engineering—*  
Aerospace Engineering, Manufacturing Engineering

**Graduate specializations:** Aerospace Engineering, Manufacturing Engineering, Mechanical Engineering

## Undergraduate Programs

### Mission

The Department of Mechanical and Aerospace Engineering provides graduates with a foundation of knowledge and experience upon which to build successful careers in mechanical, manufacturing, or aerospace engineering, or other fields where a strong engineering background is required or desirable. Undergraduate programs emphasize mechanical engineering fundamentals and computer-based problem solving, while teaching students to learn, synthesize, and communicate engineering information. Graduate programs emphasize fundamental and applied research, providing students with enhanced preparation for engineering practice, research, and education. Students, faculty, and staff are committed to excellence in learning, discovery, and engagement in an environment that fosters diversity and mutual respect.

### Undergraduate Program Objectives (Mechanical Engineering)

1. Graduates will succeed in entry-level engineering positions with mechanical, manufacturing, or aerospace firms in regional, national, or international industries, as well as with government agencies.
2. Graduates will succeed in the pursuit of advanced degrees in engineering or other fields where a solid foundation in mathematics, science, and engineering fundamentals is required.
3. Graduates will be able to synthesize mathematics, science, engineering fundamentals, and laboratory and work-based experiences to formulate and solve engineering problems in both thermal and mechanical systems areas.

4. Graduates will have proficiency in computer-based engineering, including modern numerical methods, software design and development, and the use of computational tools.
5. Graduates will be prepared to communicate and work effectively on team-based engineering projects.
6. Graduates will recognize the importance of, and have the skills for, continued independent learning.

### Undergraduate Program Outcomes (Mechanical Engineering)

#### Fundamentals

Students will identify, formulate, and solve basic engineering problems utilizing:

1. linear algebra
2. calculus-based statistics
3. multivariable calculus
4. differential equations
5. calculus-based physics
6. chemistry
7. material science
8. solid mechanics
9. fluid mechanics
10. thermal science
11. manufacturing science

#### Communication

Students will develop and demonstrate the ability to communicate engineering information, including geometry, technical concepts, and results, by:

1. participating in oral presentations.
2. writing proposals and reports.
3. developing engineering drawings and specifications.
4. participating in team-based engineering projects.

#### Laboratory Experiences

Students will participate in and evaluate laboratory experiences, which:

1. include experimental design, data collection, and data analyses.
2. incorporate the use of modern laboratory and data acquisition equipment.
3. utilize statistical analysis and interpretation of data.
4. develop basic manufacturing skills.
5. may include work-based learning experiences, such as internships.

### **Computer-based Engineering**

Students will demonstrate proficiency in the application of computer technology to engineering problem-solving through:

1. application of modern numerical methods and computational techniques.
2. design and development of engineering software.
3. integration of numerical solutions into the engineering process of design and analysis.
4. use of current commercial engineering software.

### **Humanities and Social Sciences**

Students will acquire significant exposure to the humanities and social sciences, so as to:

1. gain an appreciation for the broad impact of engineering solutions on society.
2. demonstrate an understanding of the fundamentals of the history, principles, form of government, and economic system of the United States.
3. demonstrate a knowledge of contemporary global issues.
4. contribute to the development of the individual as a responsible well-rounded citizen.

### **Design and Synthesis**

Students will participate in the design and realization process, in which they will:

1. develop a set of multidisciplinary engineering requirements.
2. synthesize material from mathematics, science, and engineering fundamentals to solve engineering problems.
3. design, develop, and verify software to solve engineering problems.
4. bring a system from requirements definition to concept development, then specification, prototype and testing, and production or fabrication using significant engineering analysis.
5. demonstrate the links between design, prototyping, testing, manufacturing, and other disciplines.
6. manage a project, including budgeting and detailed planning.

### **Independent Learning**

Students will recognize the importance of, and demonstrate the skills required for, independent learning through:

1. independent study required in the engineering curriculum.
2. exposure to case studies in ethics and professional responsibility.
3. exposure to advanced topics in engineering science.
4. exposure to advanced topics in engineering research.
5. studying for and passing the Fundamentals of Engineering Examination.

### **Assessment and Quality Improvement**

The MAE faculty and staff are committed to excellence and to continuous quality improvement. A responsive assessment and feedback process involving major constituencies, including faculty, students, alumni, and industrial employers of students and graduates, is in place and ongoing.

### **Options for Undergraduate Study**

The **Mechanical Engineering** BS degree provides the broadest background of any discipline in the field of engineering. Mechanical Engineering graduates are prepared to pursue careers in such widely diverse industries as aerospace, agricultural equipment, automotive, biotechnical, chemical processing, composite materials, computer equipment, defense, electrical utilities, food processing, industrial equipment, manufacturing, materials processing, nuclear, petroleum, robotics, and solar energy. Most Mechanical Engineering graduates are prepared for graduate studies and enhanced career prospects in engineering or other areas, such as consulting, law, medicine, business management, or teaching. In addition, students who are preparing to apply for admission to medical school will find that Mechanical Engineering provides an excellent foundation for the increasingly technology-oriented field of medicine.

The **Aerospace Engineering** emphasis within the Mechanical Engineering BS degree serves to focus mechanical engineering fundamentals on the mechanics and dynamics of both flight within the atmosphere and space flight. Included within its scope are studies in aerodynamics, aircraft flight dynamics and control, aircraft design, spacecraft orbital mechanics, spacecraft attitude motion and control, and space systems design. Graduates who complete the aerospace engineering emphasis are prepared to pursue careers in aircraft design and development, aircraft flight testing, spacecraft and space systems design, and spacecraft trajectory design and analysis. As fully qualified Mechanical Engineers, graduates with the aerospace engineering emphasis are also well-prepared to pursue graduate studies or careers in the industries listed above under Mechanical Engineering.

The **Manufacturing Engineering** emphasis within the Mechanical Engineering BS degree prepares students to be proficient in the fundamentals of engineering, as well as in materials and manufacturing processes; process, assembly, and product engineering; manufacturing competitiveness; manufacturing systems design; and laboratory experience. Graduates will understand the behavior and properties of materials as they are altered and influenced by processing in manufacturing; the design of products and the equipment, tooling, and environment necessary for their manufacture; the creation of competitive advantage through manufacturing planning, strategy, and control; the analysis, synthesis, and control of manufacturing operations using statistical and calculus based methods; and how to measure manufacturing process variables and make technical inferences about the process. Graduates will have the necessary background to pass the Certified Manufacturing Technologist and Certified Manufacturing Engineer exams. Graduates who complete the Manufacturing Engineering emphasis are prepared to pursue graduate studies or careers in any industry that manufactures a product. For example, the aerospace, automotive, electronics, machine tool, petroleum, and electronics industries all employ manufacturing engineers as product designers, process designers and managers, maintenance engineers, and quality control engineers.

The first two years of the MAE curriculum are structured to concentrate on the fundamentals of mathematics, chemistry, physics, computer science, and basic engineering science. During the second two years, students apply these fundamentals to more concentrated courses in the essentials of mechanical, aerospace, and/or manufacturing engineering. Laboratory activities and computer usage are integrated throughout the curriculum to give students opportunities for hands-on exposure to modern computer hardware and software, as well as other modern hardware and lab-

oratory facilities. Engineering design activities begin during the first two years and progress in depth as the student's proficiency increases. The engineering design experience culminates in a capstone senior design course, integrating the engineering coursework into a focused, realistic design project.

The Mechanical Engineering degree is accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (EAC/ABET). The Aerospace Engineering emphasis and Manufacturing Engineering emphasis are included within the Mechanical Engineering degree.

### **Admission and Graduation Requirements**

Freshman and transfer students must satisfy the admission policies and entrance requirements of both the University and the College of Engineering. Each new student will be assigned an advisor, who will help plan an educational program fulfilling the student's professional goals. Placement of incoming students will depend on high school and/or prior college coursework. Those who complete a portion of the University Studies requirements by examination (CLEP) and/or by advanced placement (AP) credit may complete the requirements for a Bachelor of Science degree in less than four years.

**Curriculum.** At the beginning of each school year, each student should obtain a detailed, four-year requirement sheet. This sheet, which lists semester requirements for each of the three curricula (mechanical, manufacturing, and aerospace), may be obtained from the departmental office. All students in the department follow the preprofessional engineering curriculum for the freshman and sophomore years. Prior to the junior year, the student must apply for admission to the professional program and, in consultation with the faculty advisor, select an area of emphasis. Students who are unable to take courses during the semester indicated on the curriculum requirement sheet may develop alternative schedules, consistent with prerequisites and the timing of course offerings.

**GPA Requirement.** A 2.3 GPA in all technical courses is the minimum standard which preprofessional students must attain in order to be considered for admission to any MAE professional program.

**Course Requirements.** The specific course requirements for the MAE preprofessional program and the MAE professional programs are quite extensive and may occasionally change. For these reasons, the complete requirements are not listed here. For more information, contact the department or send an Internet e-mail request to [joan.smith@usu.edu](mailto:joan.smith@usu.edu).

A **passing grade on the Fundamentals of Engineering Exam**, the first step in becoming a licensed professional engineer, is required for graduation. Past experience has shown that the USU Mechanical and Aerospace Engineering students are well-prepared for this locally administered, national exam.

For additional information on academic requirements, see the College of Engineering (pages 107-109) and the Undergraduate Graduation Requirements (pages 50-52) sections of this catalog.

### **Financial Support**

Scholarships, assistantships, grants-in-aid, and work-study programs are available to undergraduate students through the University. In addition, the MAE department employs undergraduates to assist in engineering research and development. Aerodynamics, design of instrumentation and payloads for the upper atmosphere and space, buried structures, and manufacturing processes and controls are some of the research programs that involve undergraduate students. Cooperative education and industrial employment opportunities for students are coordinated by the University Placement Office.

### **Concurrent BS/Master's Program**

The concurrent BS/Master's program allows engineering students to begin taking graduate-level classes during their senior year. This permits them to complete requirements for *both* the BS degree *and* the master's degree concurrently during two years. Students in this program have a greater selection of graduate courses, since many graduate courses are taught during alternate years. In addition, the student's senior design project could be a start for a graduate design project or thesis. After completing their BS degree, students in the program can earn a master's degree in only one additional year. Both the BS and the master's degree can generally be earned with 150 total credits, although students should note that a Plan C MS requires 3 extra credits. Finally, students with a master's degree can expect a much higher starting salary following graduation. (For more information, see *College of Engineering* section of this catalog, page 109.)

## **Graduate Programs**

### **Admission Requirements**

All students intending to pursue graduate studies at Utah State University must complete and return an *Application for Admission* to the School of Graduate Studies. In addition to the general graduate admission requirements listed on pages 90-91, the department requires all graduate applicants to have a bachelor's degree from an accredited institution in Mechanical Engineering, Aerospace Engineering, Manufacturing Engineering, or a closely related engineering discipline. A minimum GPA of 3.0 for MS applicants and 3.3 for PhD applicants is required for the last 60 semester or 90 quarter credits earned. All MAE graduate students are expected to be well-acquainted with either the FORTRAN or C programming language. Those students who do not have a BS degree in an appropriate engineering discipline may be admitted with nonmatriculated status and required to complete some remedial requirements. Applicants are also required to submit evidence of potential graduate-level success through GRE scores in the verbal, quantitative, and analytical categories.

### **Specializations**

The Department of Mechanical and Aerospace Engineering offers ME, MS, and PhD degrees in Mechanical Engineering, with specializations in Aerospace Engineering, Manufacturing Engineering, and Mechanical Engineering.

**Aerospace Engineering** addresses atmospheric and space flight. Included are such disciplines as computational fluid dynamics, experimental fluid mechanics, aerodynamics, aircraft flight dynamics, aircraft design, spacecraft orbital mechanics, spacecraft attitude motion and control, aircraft and spacecraft propulsion systems, space system design, thermal management of space deployed systems, and the space environment. Mechanical Engineering graduates choosing the aerospace engineering specialization may pursue careers in such areas as aircraft design and development, aircraft flight testing, spacecraft and space systems design, and spacecraft trajectory design and analysis, as well as the broader, traditional mechanical engineering fields.

**Manufacturing Engineering** concentrates on the theory of manufacturing systems, including manufacturing processes, the design of manufacturing systems, product design, productivity, quality, and life cycle analysis. Principal areas of emphasis include manufacturing automation, machining theory, and mold flow analysis, as well as flexible manufacturing systems and computer-integrated manufacturing. Manufacturing engineers are prepared to pursue product and process design careers in any electronics, food processing, and petroleum industries.

**Mechanical Engineering** deals with the creation of the mechanical systems and machines that serve society. Areas of emphasis include solid mechanics, thermal/fluids, and dynamics and control. The **solid mechanics** emphasis is concerned with the mechanics of displacement and stress analysis combined with material science for selection of an optimum design. Students learn to use the finite element method as well as classical methods for the determination of stresses, strains, and displacements. Included are studies of elasticity, plasticity, and failure in traditional metals and high-tech composite materials. The **thermal/fluids** emphasis is concerned with the transport of mass, momentum, and energy in solids, liquids, and gasses. Included within its scope are the fundamental studies of thermodynamics, heat transfer, and fluid mechanics. The **dynamics and control** emphasis is concerned with describing and controlling the motion of mechanical systems. Included within its scope are the fundamental studies of dynamics, kinematics, vibrations, control theory, hydraulics and pneumatics, electromechanical systems, and machine design. Graduates who select the broad mechanical engineering specialization are prepared to pursue careers in such widely diverse disciplines as aerospace, automotive, building, chemical, defense, electronics, environmental engineering, food processing, heating and air conditioning, heavy equipment, machine tools, manufacturing, nuclear, petroleum, public utilities, and solar energy.

### ***Degree Programs***

The **Plan A MS Degree** requires 6 credits of graduate-level coursework in Mechanical Engineering fundamentals; 12 credits of 6000-level (or above) engineering coursework, exclusive of MAE 6930, 6950, 6970, and 6990; a minimum of 3 credits of 5000-level (or above) coursework in approved mathematics; and 9 credits selected from any one of five declared areas of emphasis. A minimum of 30 credits is required beyond the BS, including a 6-credit thesis (MAE 6970). The thesis must meet School of Graduate Studies requirements.

The **Plan B MS Degree** requires 6 credits of graduate-level coursework in Mechanical Engineering fundamentals; 12 credits of 6000-level (or above) engineering coursework, exclusive of MAE 6930, 6950, 6970, and 6990; a minimum of 3 credits of 5000-level (or above) coursework in approved mathematics; and

either 12 credits selected from any one of five declared areas of emphasis *or* 15 credits selected from any two of the areas. A minimum of 30 credits is required beyond the BS, which includes a 3-credit report written to thesis standards.

The **Plan C MS Degree** requires 6 credits of graduate-level coursework in Mechanical Engineering fundamentals; 18 credits of 6000-level (or above) engineering coursework, exclusive of MAE 6930, 6950, 6970, and 6990; a minimum of 3 credits of 5000-level (or above) coursework in approved mathematics; and either 12 credits selected from any one of five declared areas of emphasis, or 15 credits selected from any two of the areas. A minimum of 33 credits is required beyond the BS, which may not include a thesis (MAE 6970), but may include up to 3 credits of Design Project (MAE 6950). MAE 6950 requires a report written to thesis standards.

The **Master of Engineering Degree** requires 6 credits of graduate-level coursework in Mechanical Engineering Fundamentals; 15 credits of 6000-level (or above) engineering coursework exclusive of MAE 6930, 6950, 6970, 6990, 7930, 7970, and 7990; a minimum of 3 credits of 5000-level (or above) coursework in approved mathematics; and either 15 credits selected from Group A or at least 9 credits from Group A and the remainder chosen from Group B. A minimum of 30 credits is required beyond the BS, which may not include a thesis (MAE 6970), but may include up to three credits of Design Project (MAE 6950). MAE 6950 requires a report written to thesis standards. Students are not required to defend the report. However, the report must be approved by the major professor.

The **PhD Degree** requires 12 credits of graduate-level coursework in Mechanical Engineering fundamentals; 24 credits of 6000-level (or above) engineering coursework, exclusive of MAE 6930, 6950, 6970, 6990, 7930, 7970, and 7990; a minimum of 6 credits of 5000-level (or above) coursework in approved mathematics; and 18 credits selected from any one of five declared areas of emphasis. A minimum of 90 credits is required beyond the BS, including a dissertation (MAE 7970). The dissertation must meet School of Graduate Studies requirements and be at least 24 credits, but no more than 39 credits. A Qualifying Exam is required and must be passed before completing 18 credits at the PhD level. A paper with the student as author or co-author, submitted for publication in a refereed journal, is also required.

**GPA Requirement.** A 3.0 GPA is the minimum acceptable for an ME or MS degree from USU. A PhD degree from USU requires a minimum GPA of 3.3.

**Course Requirements.** The specific course requirements for the ME, MS, and PhD degrees offered through the department may occasionally change. For this reason, prospective students are advised to seek current details concerning graduate degree requirements and program coursework by contacting the department or sending an Internet e-mail request to: [joan.smith@usu.edu](mailto:joan.smith@usu.edu).

### ***Research***

The Department of Mechanical and Aerospace Engineering is conducting research in all three of the areas of specialization listed above. Departmental research projects are funded by both government agencies and private industry. Current research topics include analytical and experimental structural dynamics, computational and experimental fluid dynamics, aerodynamics, plastics

and composite materials, numerical modeling and design of composite structures, buried structures, thermodynamics, heat transfer, cryogenics, intelligent control systems, manufacturing automation, spacecraft control, design and analysis of space systems, orbital mechanics, remote sensing, robotics, life-cycle engineering, design theory and methodology, and production modeling and simulation.

### **Financial Assistance**

A number of teaching and research assistantships are available to graduate students through the department, and are awarded on a competitive basis each year. In addition, scholarships covering the nonresident portion of tuition are available each semester, on a competitive basis, to nonresident students who hold a graduate assistantship paying at least \$250 per month. Students interested in working part time as teaching or research assistants should apply to the department by March 31 for the coming academic year.

Acceptance to pursue graduate studies in the Department of Mechanical and Aerospace Engineering does not imply a commitment to any type of financial aid. All awards for financial aid are made on a competitive basis after applicants are admitted to graduate school. All students who receive any type of financial support from the University or who are supplied University space for study or research must carry a minimum of 9 credits of approved coursework for an MS or ME degree or a minimum of 12 credits of approved coursework for a PhD degree each semester while receiving such support.

## **Mechanical and Aerospace Engineering Faculty**

### **Professors**

*Alma P. Moser*, engineering mechanics, piping systems

*Warren F. Phillips*, aerodynamics, flight mechanics

*Robert E. Spall*, thermal/fluids

*Byard D. Wood*, solar energy for heating and cooling, heat and mass transfer

### **Trustee Professor Emeritus**

*J. Clair Batty*, thermal science, cryogenics, space systems

### **Professors Emeriti**

*P. Thomas Blotter*, structural dynamics

*Ralph H. Haycock*, mechanics, manufacturing

*Russell M. Holdredge*, heat transfer, fluid mechanics

*Owen K. Shupe*, nuclear, material science

*Carl D. Spear*, material science

*Edward W. Vendell, Jr.*, cryogenics, heat transfer, thermal systems design

### **Associate Professors**

*Steven L. Folkman*, applied mechanics, structural dynamics, space structures

*Thomas H. Fronk*, mechanics of composites and materials

*R. Rees Fullmer*, manufacturing, controls, robotics, dynamics, spacecraft

### **Assistant Professors**

*Ning Fang*, manufacturing

*Thomas Hauser*, computational fluid dynamics

*Leijun Li*, manufacturing

*Todd J. Mosher*, space engineering

*Barton L. Smith*, thermal/fluids

*Brent E. Stucker*, advanced manufacturing and materials

*Wenbin Yu*, advanced structures, solid mechanics, computational solid mechanics (FEM)

### **Adjunct Assistant Professors**

*Scott M. Jensen*, thermal management of space systems

*Paul J. Mueller*, thermal science, propulsion

*Steven R. Wassom*, controls, dynamic spaceflight

### **Principal Lecturer**

*Carl G. Wood*, design, manufacturing

### **Adjunct Lecturer**

*Angie Minichiello*, thermal/fluids

## **Course Descriptions**

Mechanical and Aerospace Engineering (MAE), pages 431-434