

UC San Diego

Jacobs School of Engineering

# **Mechanical - Aerospace Engineering**



**2021**

# **PROSPECTIVE STUDENT HANDBOOK**

# **Welcome to the Mechanical and Aerospace Engineering Department**

Congratulations on being admitted to the Department of Mechanical and Aerospace Engineering (MAE) in the Jacobs School of Engineering. We are sure you have questions about what to do next. We hope that this handbook will help you get familiar with our departments policies and expectations. Make sure to contact us if there are questions or concerns that are not answered.

## **MAE Undergraduate Academic Advising**

**The MAE advising staff assists students with their programs of study.  
The advising staff is available in EBU II, first floor.**

### **Undergraduate Advisors**

- **Chad Baldwin (Last names A-L)**
- **Nadia Espinoza (Last names M-Z)**

### **Intake Advisor**

- **Regina Ready**

### **Walk-in Advising:**

**Monday 1:30 PM - 3:00 PM**

**Tuesday 1:30 PM - 3:00 PM**

**Thursday 9:00 AM - 11:30 AM**

**Friday 9:00 AM - 11:30 AM**

### **Appointment Advising:**

**Monday 9:00 AM - 11:30 AM**

**Tuesday 9:00 AM - 11:30 AM**

**Wednesday 9:00 AM - 11:30 AM**

**Thursday 1:30 PM - 3:00 PM**

**Friday 1:30 PM - 3:00 PM**

*The MAE advising program runs parallel to the work of college advisors who assist students with the general-education requirements of each college.*

*If you have questions about your major please contact us at:*

**MAE-UGRADADM@ENG.UCSD.EDU**

## **MAE PROGRAM EDUCATIONAL OBJECTIVES**

### **Our primary educational objectives are:**

To provide our students with a strong technical education that will enable them to have successful careers as engineers, technology leaders and innovators.

To prepare our students for rapid technological change with the core knowledge central to assuring that they are able to further develop their knowledge and skills across a range of disciplines throughout their professional careers and pursue advanced education.

To prepare our students to communicate effectively and to deal knowledgeably and ethically with the impact of technology in our society and on global issues.

## **PROGRAM OUTCOMES**

### **(ABET-accredited programs)**

#### **Aerospace and Mechanical Engineering:**

- An ability to apply knowledge of mathematics, science, and engineering.
- An ability to design and conduct experiments, as well as being able to analyze and interpret data.
- An ability to design a system, component, or process to meet desired needs.
- An ability to function on multi-disciplinary teams.
- An ability to identify, formulate, and solve engineering problems.
- An understanding of professional and ethical responsibility.
- An ability to communicate effectively with written, oral, and visual means.
- The broad education necessary to understand the impact of engineering solutions in a global and societal context.
- A recognition of the need for and an ability to engage in life-long learning.
- A knowledge of contemporary issues.
- An ability to use modern engineering techniques, skills, and computing tools necessary for engineering practice.

#### ***Additionally:***

#### **Aerospace Engineering**

- Knowledge of key topics in aeronautical engineering including aerodynamics, aerospace materials, structures, propulsion, flight mechanics, and stability and control.
- Knowledge of topics in astronautical engineering including attitude determination and control, space structures, orbital mechanics, and rocket propulsion.
- An ability to integrate knowledge of the fundamental topics in the design of an aerospace system.

#### **Mechanical Engineering**

- A familiarity with chemistry, calculus-based physics, and advanced mathematics.
- Familiarity with probability theory, statistics, and linear algebra.
- Ability to work professionally in mechanical systems areas including the design and realization of such systems.
- Ability to work professionally in thermal systems areas including the design and realization of such systems.

## WHAT IS ABET?

### **ABET (Accreditation Board for Engineering and Technology)**

**All majors at USCD are accredited by the Western Association of Schools and Colleges (WASC).** ABET is a specialized accreditation of educational programs in applied science, computing, engineering, and technology. It's a certification recognized in the engineering industry as having satisfied set institutional requirements upon completion of the major. The board places emphasis on the following categories: engineering fundamentals, teamwork, leadership, presentation, creative design and application, and ethics.



## **DURING THE FIRST YEAR:**

By the end of the first year, all students should complete at least the following courses. These courses can be taken at UCSD or transferred in from a different university or community college.

<b>One introductory course</b> <ul style="list-style-type: none"><li>• MAE 3 (For ME)</li><li>• MAE 2 (For AE)</li><li>• MAE 21 (for AE)</li></ul>	<b>Three Math Courses</b> <ul style="list-style-type: none"><li>• Math 20A</li><li>• Math 20B</li><li>• Math 20C</li></ul>	<b>Two Physics Courses</b> <ul style="list-style-type: none"><li>• Physics 2A</li><li>• Physics 2B</li></ul>	<b>General Chemistry</b> <ul style="list-style-type: none"><li>• Chem 6A</li></ul>
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### **Average GPA, MSAT and TSAT Scores of students admitted directly to MAE Majors (2020):**

	Fall 2020			
	M.SAT	SAT	GPA	
<b>Aerospace</b>	730	1420	4.21	
<b>Mechanical</b>	746	1446	4.21	

## **MAJOR ACADEMIC ADVISING**

### **MAE Undergraduate Advising Staff**

The MAE advising staff assists students with their programs of study. The advising staff is available in EBU II, first floor for walk-in advising. Occasionally, we have meetings and need to close advising. You can refer to our online, updated advising calendar ([mae.ucsd.edu/undergrad/advising](http://mae.ucsd.edu/undergrad/advising)) to check if we are temporarily out of the office.

**Walk-in Advising:**      **Monday, Tuesday from 1:30 PM – 3:00 PM**  
**Thursday, Friday from 9:00 AM – 11:30 AM**

**Appointment Advising:** **Monday, Tuesday, Wednesday from 9:00 AM – 11:30 AM**  
**Thursday, Friday from 1:30 PM – 3:00 PM**

The MAE advising program runs parallel to the work of college advisors who assist students with the general-education requirements of each college. If you have any questions about **your major**, then see the MAE advisors.

### **Student Affairs Lobby**

The student lobby is a great resource for students. Here you'll find the MAE course offerings list for the 2021-2022 academic year, four-year plans for all MAE majors, a list of pre-approved technical electives for each major, student petition forms, etc. The MAE Student Affairs lobby is located in EBU II on the first floor. We suggest you come prior to the Fall quarter to familiarize yourself with the lobby and EBU II itself.

## GENERAL EDUCATION/COLLEGE REQUIREMENTS

For graduation, each student must satisfy general-education course requirements determined by the student's college as well as the major requirements determined by the department. The six colleges at UCSD require widely different general-education courses and the number of such courses differs from one college to another. Each student should choose his or her college carefully, considering the special nature of the college and the breadth of general education.

In practice, the overwhelming majority of students are happy with their college assignment, even if it was not their first choice originally, and few students apply to switch. Petitions to transfer between colleges are difficult to justify and approved only in exceptional cases. To qualify, you must complete your originally assigned college's writing program, demonstrate that switching to a different college will substantially shorten your time to degree, and have a cumulative grade point average of at least 2.5 with a specified number of completed units. Talk to your college advisor for more information about this.

Each MAE program allows for humanities and social science (HSS) courses so that students can fulfill their college requirements. In the ABET-accredited programs, students must follow a program that includes a total of at least twenty-four units in the arts, humanities, and social sciences, not including subjects such as accounting, industrial management, finance, or personnel administration. It should be noted, however, that some colleges require more than the nine or ten HSS courses indicated in the curriculum tables. Accordingly, students in these colleges could take longer to graduate than the indicated four-year schedule. Students must consult with their college to determine which HSS courses to take.

An approximate guide to the number of college general education courses in addition to those met within MAE major programs:		
	# of Courses	# of Units
<b>Warren</b>	10	40
<b>Marshall</b>	10-11	40-44
<b>Muir</b>	11	44
<b>Sixth</b>	12-14	52-60
<b>ERC</b>	10-15	44-64
<b>Revelle</b>	12-16	52-68
<b>Seventh</b>	14	56

*Units of each GE ranges between 4-6 units per course*

## MAE MAJOR PROGRAMS AND REQUIREMENTS

Specific course requirements for each major program are outlined in tables in this section of the handbook. In addition to the required technical courses specifically indicated, a suggested scheduling of humanities and social science courses (HSS) are distributed in the curricula for students to use to meet college general-education requirements. To graduate, students must maintain an overall GPA of at least 2.0 and they must have received at least a D grade in each course required for the major. Students are allowed only one 'D' letter grade in their major required courses. In the ABET-accredited programs, TE courses are restricted to meet ABET standards. Students are encouraged to complete lower and upper-division courses as suggested in the curriculum tables in a timely fashion and in the sequences outlined.

### **We STRONGLY discourage students deviating from their four-year plan when taking MAE upper-division courses**

Lower-division courses are offered more than once each year to permit students some flexibility in their program scheduling. **However, many MAE upper-division courses are taught only once per year**, and the courses are scheduled to be consistent with the curricula as shown in the tables. Students taking upper-division courses in a different order than that shown in the tables may experience conflicts as the schedules of different courses may overlap. A recommended schedule of course offerings is available from the department each spring for the following academic year. **Courses with a letter grade of F must be repeated before you can move on to the next course in the sequence.** Prerequisites are strictly enforced by the department.

## CAPPED MAJORS

Due to high demand, ALL engineering majors at the Jacobs School have been designated as oversubscribed and have been granted capped status as of Fall 2014.

1. **Mechanical Engineering** (Effective Fall 2009 for freshmen. Effective Fall 2011 for transfers)
2. **Aerospace Engineering** (Effective Fall 2009 for freshmen. Effective Fall 2011 for transfers)

### Acceptance into an Engineering Major

Admission to an engineering major is based on academic excellence demonstrated in high school, community college or other four-year institutions.

Admitted students that have applied to a capped major will be further evaluated by the Office of Admissions and Relations with Schools for admission to the major. Acceptance will be granted up to the maximum number of students in each of these capped major programs. Students who are not admitted to the capped major are placed into the alternate major selected on the UC Undergraduate Application, provided the alternate is not impacted.

Students who would like to switch into a capped MAE major must (1) complete at least one year of academic study at UC San Diego, (2) meet the minimum requirements to apply, and (3) submit an online application through the JSOE Capped Major Application system during an application period. For more information, please contact MAE Student Affairs.

### Freshmen

We highly recommend that freshman applicants list a non-capped major as their alternate choice on the UC Undergraduate Application. If a student lists a capped major as both the first and alternate choices on the UC application, and is not admitted to the first choice major, the Office of Admissions and Relations with Schools will place the student in the Undeclared major. The Undeclared major is not affiliated with the Jacobs School. However, students admitted as undeclared may later seek admission to an engineering major.

### Transfers

We highly recommend that transfer applicants who list a capped engineering major as their first major, choose a non-engineering major as their alternate choice. If a student lists an oversubscribed major as both the first and alternate choices on the UC application, and is not admitted to the first choice major, the Office of Admissions and Relations with Schools will place the student in the Undeclared major. The Undeclared major is not affiliated with the Jacobs School.

It is **strongly recommended** that transfers complete the following preparation for all engineering majors.

- Calculus I—for Science and Engineering (Math 20A)
- Calculus II—for Science and Engineering (Math 20B)
- Calculus and Analytic Geometry (Math 20C)
- Differential Equations (Math 20D)
- Linear Algebra (Math 18)
- Complete calculus-based physics series with lab experience (Physics 2A, B, and C)
- Chemistry 6A
- MATLAB programming course if available.

## **TRANSCRIPTS AND COURSE EQUIVALENTS**

Your major department does not receive, handle, or evaluate your transcripts. If you have questions about your transcript evaluations, please contact the admissions office.

University of California, San Diego  
Office of Admissions and Relations with Schools  
Attn: Transcripts  
9500 Gilman Dr., # 0021  
La Jolla, CA 92093-0021

Some engineering courses may not transfer into MAE so you will need to petition for equivalency. For the MAE Department, a course substitution petition must be submitted through the MAE Undergraduate Online Petition Portal. You must provide documentation from the community college course in the form of a full syllabus (not just the course catalog description). Your complete petition will be reviewed by an MAE faculty member for equivalence.

## **ACADEMIC ENRICHMENT**

### **Cooperative Education (Co-op)**

The Cooperative Education (Co-op) Program is an immersive work experience in which students are employed full-time by a company for up to six months, which includes summer and one academic quarter, to supplement education with real-world experiences. Students with a minimum junior standing and a 3.0 GPA are eligible to apply. Positions are not guaranteed and students must apply and interview such as in any internship/job opportunity. For more information, please see undergraduate advisors.

### **Undergraduate Research and Independent Study (MAE 199)**

Undergraduates may participate in engineering research at UCSD through Independent Study (MAE 199). MAE 199 courses offer qualified and motivated students the opportunity to work closely with faculty and graduate students and gain first-hand experience in conducting research. MAE students may take MAE 199, Independent Study for Undergraduates, under the guidance of an MAE faculty member. This course is taken on a P/NP basis and may qualify as one technical elective under special circumstances.

### **Academic Internships: Special Study (MAE 197)**

The Academic Internship Program coordinates work experiences for undergraduates with industry, government offices, and hospitals. Students work under the supervision of either a faculty member or an industrial supervisor. The position may or may not be salaried. Students may receive up to 12 units of academic credit by registering for MAE 197 Engineering Internship and completing a research paper or technical laboratory report on their internship work. The typical student time commitment to the internship is ten hours per week for every four units of academic credit. However, students may not receive upper division technical elective credit for such internships.

### **Opportunities Abroad**

Engineering is already a global field offering jobs throughout the world. You can prepare yourself for these opportunities with an exciting study or internship experience abroad. Through the Study Abroad Office, students may receive credit for international study through a variety of programs. For information on EAP and OAP programs, contact the Study Abroad Office (858-534-1123, [abroad@ucsd.edu](mailto:abroad@ucsd.edu), or [studyabroad.ucsd.edu](http://studyabroad.ucsd.edu)).

### **Freshman Seminar Series**

Informal seminars (MAE 87) are offered to new freshmen to provide them with the opportunity to explore an intellectual topic with a faculty member in a small seminar setting. Topics vary quarter by quarter.



## Teams in Engineering Service (TIES)

Teams in Engineering Service are an innovative service-learning academic program putting UCSD undergraduates and their technical and creative skills to work for San Diego non-profit organizations. Multi-disciplinary teams of UCSD students design, build, and deploy projects that solve technology-based problems for community partners.

TIES projects can range from working with orthopedists and physical therapists to developing and building mechanical tools or prosthetics for the developmentally disabled and to working with agriculture to develop new irrigation solutions for local farming communities.

The benefits for student's involvement in TIES are numerous, and include improved communication, organizational, and leadership skills, start-to-finish design experience, multi-disciplinary teamwork, experience in project and resource management, ethics training and responsibility, as well as customer and community awareness. Finally, TIES provides demonstrable and measurable outcomes of undergraduate engineering theoretical knowledge, technical skills, teamwork, communication, ethical responsibility and value for professional development. Mechanical majors students are eligible to receive 4 units of technical elective credit. Note: The Aerospace major does not currently offer technical elective credit for either ENG 100 or ENG 100L.

## Team Internship Program (TIP)

Today's employers are looking for engineers who have both technical skills and the ability to collaborate and function as a team. Summer Team Internships are part of the Jacobs School's effort to enhance our students' education through real-world engineering experiences in a team setting. Students work on-site with local, domestic, and international industry partners as a multi-disciplinary team of 2-5 students, focused on a clearly defined and significant project. TIP is a 10-12 week, full time, paid internship program during the summer. Undergraduate and graduate students of all levels in all engineering departments are eligible to apply. All application and resumes are screened by the TIP Office and candidates who best meet the criteria are forwarded to companies for review. TIP also offers resume guidance and professional development training to all applicants. This is designed to help students make the best impression at their interviews. TIP, in collaboration with the Corporate Affiliates Program (CAP), works with some of the top engineering companies. TIP students are often offered full time employment upon finishing their internship.

## Some Participating Companies



# **AEROSPACE ENGINEERING**

Aerospace engineering is a four-year curriculum that begins with fundamental engineering courses in mechanics, thermodynamics, materials, solid mechanics, fluid mechanics, and heat transfer. Additional courses are required in aerospace structures, aerodynamics, flight mechanics, propulsion, controls, and aerospace design. Graduates of this program normally enter the aerospace industry to develop aircraft and spacecraft, but also find employment in other areas that use similar technologies, such as mechanical and energy-related fields. Examples include automobile, naval, and sporting equipment manufacturing. This program received ABET accreditation in 2002.

***This four-year plan is tentative and should be used as a guide.***  
***Please refer to the MAE website for the most updated curriculum plan.***

<u>FALL QUARTER</u>	<u>WINTER QUARTER</u>	<u>SPRING QUARTER</u>
<b>Year 1</b>		
Math 20A	Math 20B	Math 20C
MAE 2-Intro to Aerospace	Phys 2A	Phys 2B
Chem 6A	GE	GE
GE (General Education)	GE	GE
<b>Year 2</b>		
Math 20D	Math 18	Math 20E
Phys 2C + Phys 2CL	MAE 8- Intro to MATLAB	MAE 131A- Solid Mechanics
MAE 21-Aerospace Materials Science	MAE 30A - Kinematics	MAE 30B- Dynamics and Vibrations
GE	GE	GE
<b>Year 3</b>		
MAE 11 – Thermodynamics	MAE 101A - Intro to Fluids	MAE 101B - Advanced Fluids
MAE 105 – Mathematical Physics	MAE 143A - Signals and Systems	MAE 143B- Linear Control
MAE 107- Computational Methods	TE (Technical Elective)	MAE 170- Experimental Technique
MAE 180A – Spacecraft Guidance I	SE 160A- Aerospace Structural Mechanics I	SE 160B- Aerospace Structural Mechanics II
<b>Year 4</b>		
MAE 101C - Heat Transfer	MAE 155A - Aerospace Design	MAE 155B- Aeronautics Design
MAE 104 - Aerodynamics	MAE 175A - Engineering Lab	GE
GE	MAE 142 - Dynamics and Controls	GE
GE	MAE 113 - Propulsion	TE

## **AEROSPACE ENGINEERING**

Chem 6AH may be taken in place of Chem 6A

In fulfilling the General Education requirements, students must take at least 24 units in the arts, humanities, and social sciences, not including subjects such as accounting, industrial management, finance, or personnel administration. Twelve GE courses are listed here; individual college requirements may be higher or lower.

Technical Elective (TE) courses must be upper-division or graduate courses in the engineering sciences, natural sciences or mathematics. See the MAE Student Affairs Office or website for a list of pre-approved Technical Electives.



**Photos courtesy of the MAE 2 course of 2008**

First-year aerospace engineering students work in teams to design, build, and fly multi-disciplinary payload experiments on balloon satellites to near-space. Students gain real-world engineering experience developing and assembling sub-systems on space flight critical systems.



# **MECHANICAL ENGINEERING**

The Mechanical Engineering program has a traditional ABET-accredited four-year curriculum involving mechanics, vibrations, thermodynamics, fluid flow, heat transfer, materials, control theory and mechanical design. Graduates of this program find employment in the high-technology elector-mechanical industry as well as in the mechanical and aerospace industry.

***This four-year plan is tentative and should be used as a guide.***  
***Please refer to the MAE website for the most updated curriculum plan.***

<u>FALL QUARTER</u>	<u>WINTER QUARTER</u>	<u>SPRING QUARTER</u>
<b>Year 1</b>		
Math 20A	Math 20B	Math 20C
Chem. 6A	Phys 2A	Phys 2B
GE (General Education)	GE	MAE 3- Graphics and Design
GE	GE	GE
<b>Year 2</b>		
Math 20D	Math 18	Math 20E
Phys. 2C	MAE 30A - Kinematics	MAE 131A- Solid Mechanics
MAE 20- Materials Science	MAE 8- Intro to MATLAB	MAE 30B – Dynamics and Vibrations
GE	GE	TE (Technical Elective)
<b>Year 3</b>		
MAE 105 - Mathematical Physics	MAE 101A - Intro to Fluids	MAE 101B - Advanced Fluids
MAE 11- Thermodynamics	MAE 143A - Signals and Systems	MAE 143B- Linear Control
MAE 40- Linear Circuits	TE	MAE 170- Experimental Techniques
MAE 107- Computational Methods	MAE 160 or MAE 131B	GE
<b>Year 4</b>		
MAE 101C - Heat Transfer	MAE 156A - Design Lab I	MAE 156B- Design Lab II
MAE 150 - Computer-Aided Design	MAE 171A - Engineering Lab I	TE
TE	TE	GE
GE	GE	GE

## MECHANICAL ENGINEERING

Chem 6AH and 6BH may be taken in place of Chem 6A and 6B.

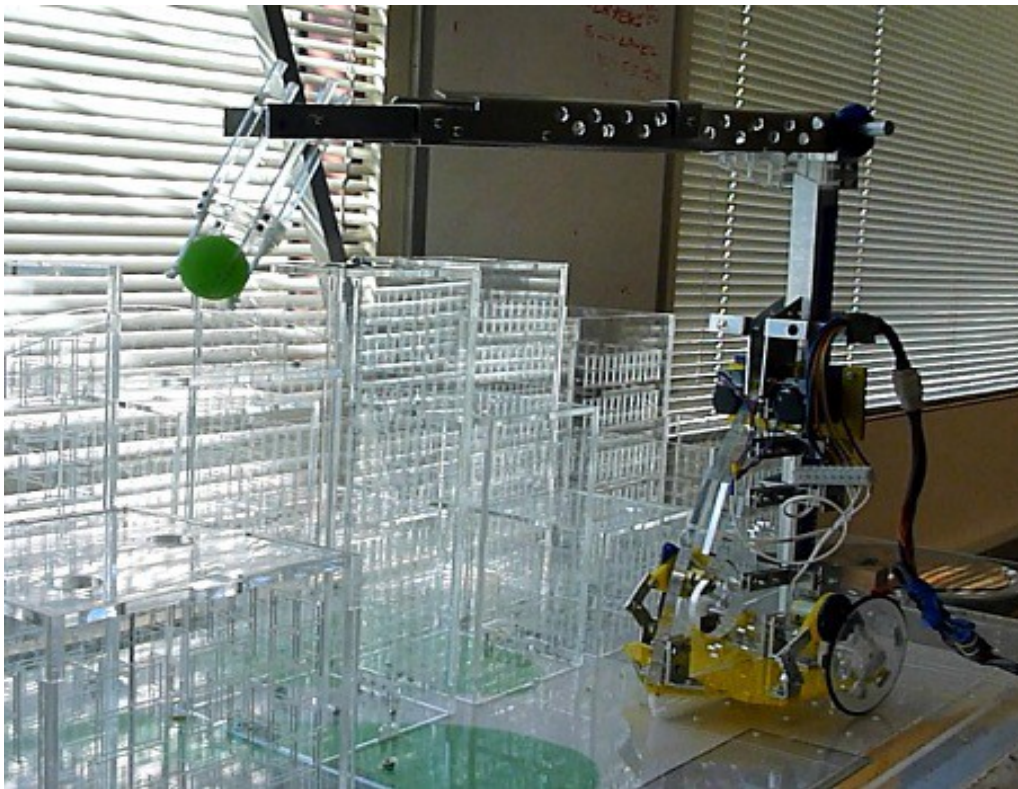
In fulfilling the General Education (GE) requirements, students must take at least 24 units in the arts, humanities, and social sciences, not including subjects such as accounting, industrial management, finance, or personnel administration. Twelve GE courses are listed here; individual college requirements may be higher or lower.

Technical Elective (TE) courses must be upper-division or graduate courses in the engineering sciences, natural sciences or mathematics. See the MAE Student Affairs Office for a list of pre-approved Technical Electives.

### Mechanical Engineering Specializations (Optional)

Students will have the option to take four out of five technical electives from a list of preapproved technical electives in a selected specialization in a particular topic. This optional specialization will show on the student's transcript and final degree. The specializations are:

- Controls and Robotics
- Fluid Mechanics and Thermal Systems
- Mechanics of Materials
- Materials Science and Engineering
- Renewable Energy and Environmental Flows (REEF)



Example of an MAE 3 Project

This course introduces the fundamentals of engineering graphics and the design. Emphasis is placed on **applying** engineering tools to design and fabrication of working machines. Course material will be centered around two projects:

- Model Clock Project (2.5 weeks): Students will use AutoCAD to design an escapement wheel and pendulum for a model clock, and make the model using shop tools.
- Robot Design Project (7.5 weeks): Teams of students will design and build a machine for a competition using DC motors, solenoids, and fabrication tools.

## FREQUENTLY ASKED QUESTIONS

### “What are the Criteria and Requirements to Apply to a Capped Major?”

Continuing students who wish to change into any MAE major must submit an online application through the JSOE Capped Major Application system during an application period. Applications will be accepted once a year. **Admission is based on available space, and meeting these requirements does not guarantee admission. On average, those admitted to the major will exceed the minimum GPA required to apply.**

All students who wish to apply MUST meet the minimum requirements as listed below:

- (A) Complete at least one year/three quarters in residence at UCSD.
- (B) Complete ALL of the following lower-division requirements.

#### **Freshmen Applicants:**

- Math 20A, 20B and 20C
- Physics 2A and 2B
- Chemistry 6A

Note: For capped status, the Freshmen class level is determined by number of registered quarters-not number of units completed.

#### **For Sophomore/Transfer Applicants**

- Math 20A, 20B, 20C, 20D, 20E, and 18 (or 20F)
- Physics 2A, 2B, 2C
- Chemistry 6A
- MAE 8 (or NANO 15 or CENG 15 or SE 9)

(C) Must have a minimum GPA of 2.5.

(D) Students will be ranked based on GPA of required math and science courses, and will be admitted according to rank.

### “Which of the seven UC San Diego colleges do engineering students choose?”

Each undergraduate college at UC San Diego is comprised of all types of majors so there is no “particular” college for engineering students. The main difference is that each college has its own general education requirements to graduate, mission, philosophy, traditions, and housing/dining facilities.

### “Which courses should I take at my community college to prepare for transferring to MAE?”

It is **strongly recommended** that transfers complete the following preparation for all engineering majors.

- Calculus I—for Science and Engineering (Math. 20A)
- Calculus II—for Science and Engineering (Math. 20B)
- Calculus and Analytic Geometry (Math. 20C)
- Differential Equations (Math. 20D)
- Linear Algebra (Math. 18 or 20F)
- Complete calculus-based physics series with lab experience (Physics 2A, B, and C)
- Chemistry 6A
- Highest level of introductory computer programming language course offerings at the community college

### “Can I double major?”

UC San Diego does allow students to double major. However, you cannot double major or major and minor in two engineering majors. For example, you can double major in Economics and Mechanical Engineering but you cannot double major in Electrical Engineering and Mechanical Engineering.

### “What companies recruit UC San Diego students?”

Various engineering companies actively recruit students from the Jacobs School of Engineering and a majority of these companies belong to our Corporate Affiliates Program (CAP). Below are just some of the companies affiliated with UCSD through CAP.



# Course Descriptions

2021-2022

Please refer to [The Schedule of Classes](#) for the most up-to-date course information and prerequisite

## Lower-Division

### MAE 02. Introduction to Aerospace Engineering (4)

An introduction to topics in aeronautical and astronautical engineering including aerodynamics, propulsion, flight mechanics, structures, materials, orbital mechanics, design, mission planning, and environments. General topics include historical background, career opportunities, engineering ethics, and professionalism. Must be taken for a letter grade. **Prerequisites:** none.

### MAE 03. Introduction to Engineering Graphics and Design (4)

Introduction to design process through a hands-on design project performed in teams. Topics include problem identification, concept generation, project management, risk reduction. Engineering graphics and communication skills are introduced in the areas of: Computer-Aided Design (CAD), hand sketching, and technical communication. **Prerequisites:** PHYS 2A or 4A.

### MAE 05. Quantitative Computer Skills (4)

Introductory course for nonengineering majors. Use of computers in solving problems; applications from life sciences, physical sciences, and engineering. Students run existing computer programs and complete some programming in BASIC. **Prerequisites:** none.

### MAE 07. Spatial Visualization (1)

(Cross-listed with SE 7.) Spatial visualization is the ability to manipulate 2-D and 3-D shapes in one's mind. In this course, students will perform exercises that increase their spatial visualization skills. P/NP grades only. Students may not receive credit for SE 7 and MAE 7. **Prerequisites:** none.

### MAE 08. MATLAB Programming for Engineering Analysis (4)

Computer programming in MATLAB with elementary numerical analysis of engineering problems. Arithmetic and logical operations, arrays, graphical presentation of computations, symbolic mathematics, solutions of equations, and introduction to data structures. **Prerequisites:** Math 20A and 20B or consent of instructor.

### MAE 11. Thermodynamics (4)

Fundamentals of engineering thermodynamics: energy, work, heat, properties of pure substances, first and second laws for closed systems and control volumes, gas mixtures. Application to engineering systems, power and refrigeration cycles, combustion. **Prerequisites:** PHYS 2C and CHEM 6A.

### MAE 20. Elements of Materials Science (4)

The structure of materials: metals, ceramics, glasses, semiconductors, superconductors, and polymers to produce desired, useful properties. Atomic structures. Defects in materials, phase diagrams, microstructural control. Mechanical and electrical properties are discussed. Time temperature transformation diagrams. Diffusion. **Prerequisites:** Phys 2A or 4A, Chem 6A or Chem 6AH, and Math 20C.

### MAE 21. Aerospace Materials Science (4)

Atomic structure and physical properties of engineering materials including metals, ceramics, glasses, polymers, and composite materials. Defects and phase diagram of materials. Material testing and processing. Program or materials fees may apply. **Prerequisites:** PHYS 2A or 4A, CHEM 6A or CHEM 6AH, and MATH 20B.

### MAE 30A. Kinematics (4)

Statics: statics of particles and rigid bodies in 3-D. Free body diagrams. Moment of a force, couples, equivalent systems of forces. Distributed forces, centroids, and centers of gravity. Introduction to dynamics: 3-D relative motion, kinematics, and kinetics of particles. Newton's equations of motion. Equilibrium problems with friction. **Prerequisites:** PHYS 2A and MATH 31BH or MATH 20C.

### MAE 30B. Dynamics and Vibrations (4)

Dynamics: energy methods for motion of particles and rigid bodies, including virtual work, power, and Lagrange's equations. Impact and impulses. Systems of particles. Introduction to 3-D dynamics of rigid bodies. Introduction to vibrations: free and harmonically forced vibrations of undamped and damped single degree of freedom systems. **Prerequisites:** MAE 30A.

### MAE 40. Linear Circuits (4)

Steady-state and dynamic behavior of linear, lumped-parameter electrical circuits. Kirchoff's laws. RLC circuits. Node and mesh analysis. Operational amplifiers. Signal acquisition and conditioning. Electric motors. Design applications in engineering. **Prerequisites:** Math 20D or 21D, 20F, and Phys 2B.

### MAE 87. Freshman Seminar (1)

The Freshman Seminar program is designed to provide new students with the opportunity to explore an intellectual topic with a faculty member in a small seminar setting. Freshman Seminars are offered in all campus departments and undergraduate colleges. Topics vary from quarter to quarter. Enrollment is limited to fifteen to twenty students, with preference given to entering freshmen. **Prerequisites:** none.

### MAE 92A. Design Competition—Design, Build, and Fly Aircraft (1)

(Cross-listed with SE 10A.) Student teams design, build, and fly unmanned aircraft for a national student competition. Students concentrate on vehicle system design including aerodynamics, structures, propulsion, and performance. Teams engineer, fabricate the aircraft, submit a design report, and prep aircraft for competition. **Prerequisites:** consent of instructor.

### MAE 93. Design Competition—Design, Build, and Test Race Car (1)

Student teams design, build, and test a formula-style racing car for an international student competition. Students concentrate on vehicle system analysis and design, manufacturability, and performance. Teams engineer, fabricate car, submit a design report, and prep car for competition. **Prerequisites:** department approval.

### MAE 98. Directed Group Study (2)

Directed group study on a topic or in a field not included in the regular departmental curriculum. P/NP grades only. May be taken for credit two times. Credit may not be received for a course numbered 97, 98, or 99 subsequent to receiving credit for a course numbered 197, 198, or 199. **Prerequisites:** department approval.

### MAE 99H. Independent Study (1)

Independent study or research under direction of a member of the faculty. **Prerequisites:** student must be of first-year standing and a Regent's Scholar; approved Special Studies form.

## Upper-Division

### MAE 101A. Introductory Fluid Mechanics (4)

Fluid statics; fluid kinematics; integral and differential forms of the conservation laws for mass, momentum, and energy; Bernoulli equation; potential flows; dimensional analysis and similitude. **Prerequisites:** Phys 2A, Math 20D or 21D and Math 20E, or consent of instructor.

### MAE 101B. Advanced Fluid Mechanics (4)

Laminar and turbulent flow. Pipe flow including friction factor. Boundary layers, separation, drag, and lift. Compressible flow including shock waves. **Prerequisites:** 101A or CENG 101A or CENG 103A, and MAE 110A or CENG 102, or consent of instructor.

### MAE 101C. Heat Transfer (4)

Extension of fluid mechanics in MAE 101A–B to viscous, heat-conducting flows. Application of the energy conservation equation to heat transfer in ducts and external boundary layers. Heat conduction and radiation transfer. Heat transfer coefficients in forced and free convection. Design applications. **Prerequisites:** MAE 101A or CENG 101A or CENG 103A, MAE 101B, and MAE 105, or consent of instructor.

### MAE 101D. Intermediate Heat Transfer (4)

Course builds on the MAE fluids sequence, offering more advanced concepts in conduction, convection, radiation, and heat exchanger design. This course covers numerical methods in conduction, boiling, condensation and evaporation analysis, natural and turbulent convection, spectral and directional radiative transfer, heatpipes, thermal design of spacecraft, heat exchanger analysis and design. **Prerequisites:** senior standing and MAE 101C, or consent of instructor.

### MAE 104. Aerodynamics (4)

Basic relations describing flow field around wings and bodies at subsonic and supersonic speed. Thin-wing theory. Slender-body theory. Formulation of theories for evaluating forces and moments on airplane geometries. Application to the design of high-speed airplanes. **Prerequisites:** open to MC 25, MC 27, MC 28 and SE 27 only. MAE 101A and 101B, or consent of instructor.

### MAE 105. Introduction to Mathematical Physics (4)

Fourier series, Sturm Liouville theory, elementary partial differential equations, integral transforms with applications to problems in vibration, wave motion, and heat conduction. **Prerequisites:** admission to engineering major. Phys 2A and B, and Math 20D or 21D.

### MAE 107. Computational Methods in Engineering (4)

Introduction to scientific computing and algorithms; iterative methods, systems of linear equations with applications; nonlinear algebraic equations; function interpolation and differentiation and optimal procedures; data fitting and least-squares; numerical solution of ordinary differential equations. **Prerequisites:** engineering majors only. MAE 8 or 9, and Math 20F.

### MAE 108. Probability and Statistical Methods for Mechanical and Environmental Engineering (4)

Probability theory, conditional probability, Bayes theorem, random variables, densities, expected values, characteristic functions, central limit theorem. Engineering reliability, elements of estimation, random sampling, sampling distributions, hypothesis testing, confidence intervals. Curve fitting and data analysis. **Prerequisites:** Math 20F.

### MAE 110. Thermodynamic Systems (4)

Thermodynamic analysis of power cycles with application to combustion driven engines: internal combustion, diesel, and gas turbines. Thermodynamics of mixtures and chemical and phase equilibrium. Computational methods for calculating chemical equilibrium. **Prerequisites:** MAE 11 or 110A. (Course not offered every year.)

### MAE 113. Fundamentals of Propulsion (4)

Compressible flow, thermodynamics, and combustion relevant to aircraft and space vehicle propulsion. Analysis and design of components for gas turbines, including turbines, inlets, combustion chambers and nozzles. Fundamentals of rocket propulsion. **Prerequisites:** engineering majors MC 25, MC 27 and MC 28 only. MAE 11 or CENG 102, and MAE 101A or CENG 101A, and MAE 101B or CENG 101C.

### MAE 117A. Elementary Plasma Physics (4)

(Cross-listed with Physics 151.) Particle motions, plasmas as fluids, waves, diffusion, equilibrium and stability, nonlinear effects, controlled fusion. Recommended preparation: Phys 100B–C or ECE 107. **Prerequisites:** Math 20D or 21D, or consent of instructor.

### MAE 118. Introduction to Energy Systems (4)

Overview of present day primary energy sources and availability; fossil fuel, renewable, and nuclear; heat engines; energy conservation, transportation, air pollution, and climate change. Students may not receive credit for both MAE 118 and MAE 118A. **Prerequisites:** MAE 101A or CENG 101A, or consent of instructor.

### MAE 119. Introduction to Renewable Energy: Solar and Wind (4)

Basic principles of solar radiation—diffuse and direct radiation; elementary solar energy engineering—solar thermal and solar photovoltaic; basic principles of wind dynamics—hydrodynamic laws, wind intermittency, Betz's law; elementary wind energy engineering; solar and wind energy perspectives; operating the California power grid with 33 percent renewable energy sources. Students may not receive credit for both MAE 118B and MAE 119. **Prerequisites:** MAE 101A or CENG 101A, or consent of instructor.

### MAE 120. Introduction to Nuclear Energy (4)

Overview of basic fission and fusion processes. Elementary fission reactor physics and engineering; environmental and waste disposal issues. Survey of fusion technology issues and perspectives. May not receive credit for both MAE 118C and MAE 120. **Prerequisites:** MAE 101A or CENG 101A, or consent of instructor.

### MAE 122. Flow and Transport in the Environment (4)

Introduction to the air and aquatic environments. Buoyancy, stratification, and rotation. Earth surface energy balance. Introduction to the atmospheric boundary layer. Advection and diffusion. Turbulent diffusion and dispersion in rivers and in the atmospheric boundary layer. Surface waves and internal gravity waves. **Prerequisites:** MAE 101A or CENG 101A, or consent of instructor.



**MAE 123. Introduction to Transport in Porous Media (4)**

Introduction to groundwater flow. Pollution transport through the water table. Fundamentals of flow. Single- and multi-phase flow. Darcy law. Well hydraulics. Diffusion and dispersion. Gravity currents and plumes in porous media. Chemistry of fluid-solid interactions. Fundamentals of adsorption and surface reactions. **Prerequisites:** MAE 101C or CENG 101B, and MAE 105 and 107.

**MAE 124. Environmental Challenges: Science and Solutions (4)**

(Cross-listed with ESYS 103.) This course explores the impacts of human social, economic, and industrial activity on the environment. It highlights the central roles in ensuring sustainable development played by market forces, technological innovation and governmental regulation on local, national, and global scales. **Prerequisites:** Math 20B or Math 10A-C, or consent of instructor.

**MAE 126A. Environmental Engineering Laboratory (4)**

Analysis of experiments in Environmental Engineering: Drag in a water tunnel, shading effects on solar photovoltaic, buoyant plume dispersion in a water tank, atmospheric turbulence, and others. Use of sensors and data acquisition. Laboratory report writing; error analysis; engineering ethics. **Prerequisites:** MAE 101A or CENG 101A; MAE 170 and MAE 122.

**MAE 126B. Environmental Engineering Design (4)**

Fundamental principles of environmental design. Building a working prototype or computer model for an environmental engineering application. Work in teams to propose and design experiments and components, obtain data, complete engineering analysis, and write a report. Engineering ethics and professionalism. **Prerequisites:** MAE 126A.

**MAE 130. Advanced Vibrations (4)**

Harmonically excited vibrations. Vibration of multiple degree-of-freedom systems. Observations, including beat frequencies, static and dynamic coupling, traveling and standing wave phenomena. Vibration of continuous systems. Hamilton's equations. Distributed and point forces and moments in continuous systems and the generalized Dirac distribution. Response to impact and impulse excitation. Modeling continuous systems with approximate discrete models. **Prerequisites:** MATH 18 or MATH 20F or MATH 31AH and MAE 30B or MAE 130B.

**MAE 131A. Solid Mechanics I (4)**

Concepts of stress and strain. Hooke's Law. Axial loading of bars. Torsion of circular shafts. Shearing and normal stresses in beam bending. Deflections in beams. Statically determinate and indeterminate problems. Combined loading. Principal stresses and design criteria. Buckling of columns. **Prerequisites:** Math 20D, and MAE 130A or SE 101A.

**MAE 131B. Fundamentals of Solid Mechanics II (4)**

Continuous mechanics of solids and its application to the mechanical response of machine and structural elements. Stress and strain in indicial notation; field equations and constitutive relations. Linear elastic stress analysis in torsion, plane stress and plane strain; stress concentrations; fracture mechanics. Extremum principles and structural stability. Viscoelasticity, plasticity, and failure criteria. Theorems of plastic limit analysis. **Prerequisites:** MAE 131A or SE 110A, and MAE 105 (or concurrent), and admission to engineering major.

**MAE 133. Finite Element Methods in Mechanical and Aerospace Engineering (4)**

Development of stiffness and mass matrices based upon variational principles and application to static, dynamic, and stability design problems in structural and solid mechanics. Architecture of computer codes for linear and nonlinear finite element analysis and basic computer implementation. The use of general purpose finite element structural analysis computer codes. **Prerequisites:** MAE 131A or SE 110A.

**MAE 142. Dynamics and Control of Aerospace Vehicles (4)**

The dynamics of vehicles in space or air are derived for analysis of the stability properties of spacecraft and aircraft. The theory of flight, lift, drag, dutch roll and phugoid modes of aircraft are discussed. Optimal state space control theory for the design of analog and digital controllers (autopilots). **Prerequisites:** admission to the engineering major. MAE 104 and MAE 143B or ECE 171A, or consent of instructor.

**MAE 143A. Signals and Systems (4)**

Dynamic modeling and vector differential equations. Concepts of state, input, output. Linearization around equilibria. Laplace transform, solutions to ODEs. Transfer functions and convolution representation of dynamic systems. Discrete signals, difference equations, z-transform. Continuous and discrete Fourier transform. **Prerequisites:** Math 20D or 21D, Math 20E, Math 20F, and MAE 105, or consent of instructor.

**MAE 143B. Linear Control (4)**

Analysis and design of feedback systems in the frequency domain. Transfer functions. Time response specifications. PID controllers and Ziegler-Nichols tuning. Stability via Routh-Hurwitz test. Root locus method. Frequency response: Bode and Nyquist diagrams. Dynamic compensators, phase-lead and phase-lag. Actuator saturation and integrator wind-up. **Prerequisites:** MAE 143A or CENG 100, or consent of instructor.

**MAE 144. Embedded Control and Robotics (4)**

Each student builds, models, programs, and controls an unstable robotic system built around a small linux computer. Review/synthesis of: A) Modern physical and electrical CAD. B) Dynamics, Signals & Systems, Linear Circuits. PWMs, H-bridges, quadrature encoders. C) Embedded linux, C, graphical programming. Multithreaded applications. Bus communication to supporting ICs. D) Classical control theory in both continuous-time (CT) and discrete-time (DT). Interconnection of CT and DT elements. **Prerequisites:** upper division standing or graduate student, and MAE 143B, or consent of instructor.

**MAE 145. Introduction to Robotic Planning and Estimation (4)**

This course is an intro to robotic planning algorithms and programming. Topics: sensor-based planning (bug algorithms), motion planning via decomposition and search (basic search algorithms on graphs, A\*), the configuration-space concept, free configuration spaces via sampling, collision detection algorithms, (optimal) planning via sampling (probabilistic trees), environment roadmaps, and (extended) Kalman filtering for robot localization and environment mapping (SLAM). **Prerequisites:** senior standing or consent of instructor.

**MAE 146 Introduction to Machine Learning Algorithms (4)**

An introduction to the principles used to design and implement machine learning algorithms, as well as an understanding of their advantages and limitations. The topics covered are: python review, supervised learning (linear, logistic/sigmoid regression, generalized linear models, nonlinear regression via kernels), neural network types (convolutional, recurrent, deep NN), unsupervised learning (k-means clustering). Application of ML in different examples.

**MAE 148: Introduction to Autonomous Vehicles (4)**

Fundamentals of Autonomous Vehicles. Working in small teams, students will develop 1/8 scale autonomous cars that must perform on a simulated city track. Topics include: Robotics System Integration, Computer Vision, Algorithms for Navigation, On-vehicle vs. off-vehicle computation, Computer Learning Systems such as Neural Networks, Locomotion Systems, Vehicle Steering, Dead Reckoning, Odometry, Sensor Fusion, GPS Auto-Pilot limitations, Wiring, and Power Distribution and Management. **Prerequisites:** ECE 15 or ECE 35, MAE 2 or MAE 3

**MAE 149. Sensor Networks (4)**

(Cross-listed with ECE 156 and SIO 238.) Characteristics of chemical, biological, seismic and other physical sensors; signal processing techniques supporting distributed detection of salient events; wireless communication and networking protocols supporting formation of robust sensor fabrics; current experience with low power, low-cost sensor deployments. **Prerequisites:** upper-division standing and consent of instructor, or graduate student in science or engineering.

**MAE 150. Computer-Aided Design (4)**

Computer-aided analysis and design. Design methodology, tolerance analysis, Monte Carlo analysis, kinematics and computer-aided design of linkages, numerical calculations of moments of inertia, design of cams and cam dynamics; finite element analysis, design using Pro-E, Mechanica Motion and Mechanica Structures. **Prerequisites:** MAE 30A, MAE 107 or SE 121, MAE 3, and senior standing in engineering major, or consent of instructor.

**MAE 152 Introduction to Manual and CNC Machining (1)**

In this class, students are introduced to precision machining. Students will learn the proper safe operating procedures of a manual mill & lathe, band saws, and hand tools. Other topics include: the basics of tolerancing, design (Fusion 360) and operation of CNC milling and turning.

**MAE 154. Product Design and Entrepreneurship (4)**

This course will teach teams of students how to develop concepts and business plans in the design of new and innovative products. Emphasis will be placed on identifying user needs, concept generation, and prototype fabrication. **Prerequisites:** upper-division standing and consent of instructor.

**MAE 155A. Aerospace Engineering Design I (4)**

Fundamental principles of aerospace vehicle design including the conceptual, preliminary, and detailed design phases. Aeronautical or astronautical design project that integrates all appropriate engineering disciplines as well as issues associated with optimization, teamwork, manufacturability, reporting, and professionalism. **Prerequisites:** MAE 2, MAE 104, MAE 113, MAE 30B, MAE 142, MAE 150, SE 2, and SE 160B, or consent of instructor. Students may enroll concurrently with MAE 113, 142, and 150.

**MAE 155B. Aerospace Engineering Design II (4)**

Fundamental principles of aerospace vehicle design including the conceptual, preliminary, and detailed design phases. Aeronautical or astronautical design project that integrates all appropriate engineering disciplines as well as issues associated with optimization, teamwork, manufacturability, reporting, and professionalism. Program or material fee may apply. **Prerequisites:** MAE 113, MAE 142, MAE 150, MAE 155A, and MAE 170, or consent of instructor.

**MAE 156A. Fundamental Principles of Mechanical Design I (4)**

Fundamental principles of mechanical design and the design process. Application of engineering science to the design and analysis of mechanical components. Initiation of team design projects that culminate in MAE 156B with a working prototype designed for a real engineering application. Professional ethics discussed. Program or material fee may apply. **Prerequisites:** MAE 3, MAE 30B, MAE 131A, MAE 150, and MAE 170, or consent of instructor. Open to major code MC 27 only.

**MAE 156B. Fundamental Principles of Mechanical Design II (4)**

Fundamental principles of mechanical design and the design process. Culmination of a team design project initiated in MAE 156A which results in a working prototype designed for a real engineering application. **Prerequisites:** grades of C- or better in MAE 156A in the immediately preceding quarter, MAE 101C, MAE 143B, and MAE 160, or consent of instructor. Open to major code MC 27 only.

**MAE 160. Mechanical Behavior of Materials (4)**

Elasticity and inelasticity, dislocations and plasticity of crystals, creep, and strengthening mechanisms. Mechanical behavior of ceramics, composites, and polymers. Fracture: mechanical and microstructural. Fatigue. Laboratory demonstrations of selected topics. **Prerequisites:** MAE 20, MAE 30A and MAE 131A, or consent of instructor.

**MAE 165. Fatigue and Failure Analysis of Engineering Components (4)**

The engineering and scientific aspects of crack nucleation, slow crack growth, and unstable fracture in crystalline and amorphous solids. Microstructural effects on crack initiation, fatigue crack growth and fracture toughness. Methods of fatigue testing and fracture toughness testing. Fractography and microfractography. Design safe methodologies and failure prevention. Failure analysis of real engineering structures. **Prerequisites:** consent of instructor. Not offered every year.

**MAE 170. Experimental Techniques (4)**

Principles and practice of measurement and control and the design and conduct of experiments. Technical report writing. Lectures relate to dimensional analysis, error analysis, signal-to-noise problems, filtering, data acquisition and data reduction, as well as background of experiments and statistical analysis. Experiments relate to the use of electronic devices and sensors. **Prerequisites:** Phys 2 and Phys 2CL or MAE 40.

**MAE 171A. Mechanical Engineering Laboratory I (4)**

Design and analysis of experiments in fluid mechanics, solid mechanics, and control engineering. Experiments in wind tunnel, water tunnel, vibration table and material testing machines, and refined electromechanical systems. Laboratory report writing; error analysis; engineering ethics. **Prerequisites:** MAE 101A and MAE 170.

**MAE 175A. Aerospace Engineering Laboratory I (4)**

Analysis of aerospace engineering systems using experimental facilities in undergraduate laboratories: wind tunnel, water channel, vibration table, and testing machine. Students operate facilities, obtain data, complete engineering analysis and write major reports. **Prerequisites:** MAE 101C or CENG 101B; MAE 143B or CENG 120; and MAE 170, or consent of instructor.

**MAE 180A. Spacecraft Guidance I (4)**

Astrodynamics, orbital motion, perturbations, coordinate systems and frames of reference. Geosynchronous orbits, stationkeeping. Orbital maneuvers, fuel consumption, guidance systems. Observation instrument point, tracking, control. Basic rocket dynamics. Navigation, telemetry, re-entry, and aero-assisted maneuvers. Mission design. Students perform analyses based on mission requirements. **Prerequisites:** upper-division standing in physics, mathematics, or engineering department.

**MAE 181. Space Mission Analysis and Design (4)**

Space mission concepts, architectures, and analysis. Mission geometry. Astrodynamics. Orbit and constellation design. Space environment. Payload and spacecraft design and sizing. Power sources and distribution. Thermal management. Structural design. Guidance and navigation. Space propulsion. Orbital debris and survivability. Cost modeling and risk analysis. **Prerequisites:** upper-division standing or consent of instructor.

**MAE 184 Flight Simulation Techniques (4)**

Students will develop software and methods to simulate the motion characteristics of flight vehicles. Six degree-of-freedom equations of motion will be reviewed with emphasis on computer implementation. Algorithms for data modeling, numerical integration, equilibrium, and linearization will be introduced. Three-dimensional visualization techniques will be explored for

representing operator and observer viewpoints. Applications include aircraft, automobiles, and marine vessels.

**MAE 190: Topics in Mechanical and Aerospace Engineering (4)**  
Topics of special interest in mechanical and aerospace engineering.

**MAE 191. Topics in Mechanical and Aerospace Engineering with Laboratory (4)**  
Topics of special interest in mechanical and aerospace engineering with laboratory. May be repeated for credit as topics vary. Prerequisites: upper-division standing.

**MAE 192. Senior Seminar in Aerospace, Environmental or Mechanical Engineering (1)**  
The Senior Seminar Program is designed to allow senior undergraduates to meet with faculty members in a small group setting to explore an intellectual topic in aerospace, environmental or mechanical engineering (at the upper-division level). Topics will vary from quarter to quarter. Senior Seminars may be taken for credit up to four times, with a change in topic and permission from the department. Enrollment is limited to twenty students, with preference given to seniors. **Prerequisites:** department stamp or consent of instructor.

**MAE 197. Engineering Internship (1-12)**

Students work in local industry or hospitals under faculty supervision. Units may not be applied toward graduation requirements. Salaried or unsalaried. Number of units determined by enrollment frequency. First quarter up to four units. Subsequent quarters cannot exceed one unit. **Prerequisites:** consent of instructor and department stamp, 2.50 overall GPA minimum, at least ninety units.

**MAE 198. Directed Group Study (1-4)**

Directed group study on a topic or in a field not included in the regular department curriculum, by special arrangement with a faculty member. May be taken P/NP only. **Prerequisites:** consent of instructor.

**MAE 199. Independent Study for Undergraduates (4)**

Independent reading or research on a problem by special arrangement with a faculty member. P/NP grades only. **Prerequisites:** consent of instructor.

