

AEROSPACE ENGINEERING UNDERGRADUATE STUDIES AT THE UNIVERSITY OF MICHIGAN



[ENGIN.UMICH.EDU/AERO](http://engin.umich.edu/aero)



COLLEGE OF ENGINEERING
AEROSPACE ENGINEERING
UNIVERSITY OF MICHIGAN

WELCOME



Michigan Aerospace is proud to be publicly named the first aeronautics program in the nation, established in 1914, just 11 years after the historic flights at Kitty Hawk. The first course was taught by Felix Pawlowski, who had been a student of Professor Lucien Marchis at the University of Paris in the first course in aeronautics given anywhere.

Since then, the Department has graduated more than 4,000 aeronautical and aerospace engineers. Our alumni have gone on to distinguished careers in essentially all areas of the aerospace enterprise, in related fields, in government and in academia. We graduated individuals such as Kelly Johnson, the famous Lockheed Skunk Works designer of many innovative aircraft including the SR-71. Several astronauts were educated in our department, five were astronauts who orbited Earth. Three went to the moon.

Michigan Aerospace is one of the most highly-ranked undergraduate and graduate aerospace engineering departments in the US, we provide a very vibrant environment of intellectual challenge and excitement that is at the same time collegial and conducive to higher learning. Our faculty members have a high level of enthusiasm and accessibility and a strong dedication to excellence in teaching our undergraduate and graduate students. Curriculum and research activities focus on fundamental and advanced topics organized within Gas Dynamics, Structures and Materials, Space Systems, and Dynamics and Control. Our world-class facilities are accessible to all Aerospace students for coursework and research activities. The University of Michigan has a distinguished heritage of student project teams engaging students at all levels, from first-year undergraduates to graduate students, which you will learn more about in this brochure.

All in all, this is the place to be for your undergraduate studies and I look forward to seeing you here.

Luis Bernal
Professor and Undergraduate Advisor



ALUMNI ASTRONAUTS

JAMES B. IRWIN (MS 1957, HSCD 1971)
Astronaut support crew for Apollo 10, 12 and 15

JACK R. LOUSMA (1959, HSCD 1973)
Astronaut support crews for the Apollo 9, 10, and 13 missions

JAMES A. MCDIVITT (1959, HSCD 1965)
Gemini and Apollo programs. Command Pilot during the Gemini 4 flight

EDWARD WHITE (MS 1959, HSCD 1971)
First US space-walk on the Gemini 4 mission and served as back-up for Gemini 7

ALFRED WORDEN (MSE 1963, HSCD 1971)
Command module pilot for the Apollo 15 lunar mission in 1971



Edward White, Gemini 4, 1965



Prof. John Shaw

ADVISING

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Undergraduate Advisor

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Linda Weiss



#1
Public Aero Dept.
According to U.S.
News & World Report

303
Current Enrollment

10:1
Student-to-Faculty Ratio

COMMUNITY
Our students come from
25 states and 18 countries

PROGRAM DESCRIPTION

Here at the University of Michigan, students in Aerospace Engineering begin with a set of courses that provide an exceptional background in all the fundamental aspects of the field. These span the entire spectrum of aerospace technologies, from aerodynamics and propulsion (collectively referred to as “gas dynamics”) to structural mechanics, flight dynamics and controls.

GAS DYNAMICS COURSES

Treat fluid and gas flow around bodies and through turbojet engines and rocket nozzles. Also involved is the study of large- and small-scale air motion in the atmosphere and its relationship to environmental and noise problems.

STRUCTURAL MECHANICS COURSES

Aircraft and spacecraft structures must be lightweight and endure significant loads in extreme environmental conditions while protecting the payload (passengers, instrumentation) and providing aerodynamic shape. Our courses address how to analyze and design such lightweight structures and how to size them for different loading conditions.

FLIGHT DYNAMICS AND CONTROL SYSTEMS COURSES

Dynamic behavior of vehicles and systems as a whole, their stability and controllability both by human pilots and autonomous systems. These courses cover everything from the fundamentals to the design and construction of aircraft, spacecraft and other vehicular systems and subsystems. Integration of all this material takes place in the senior design course, which gives students an appreciation of the interrelation of the various areas of study in the design of an overall system. Students can select either aircraft or spacecraft design.

WHEN DO I APPLY?

GENERAL ADMISSIONS



First-year students are not admitted directly to the Aerospace Engineering Department but to the University of Michigan and the College of Engineering. Students declare a major, typically in their second or third semester at Michigan. Students declaring Aerospace Engineering as their major are assigned a faculty advisor in the department.

Information on admission for first-year students, transfer students and international students is available at admissions.umich.edu and engin.umich.edu/college/admissions/undergrad



Class of 2014

TAILOR YOUR DEGREE

The Aerospace Engineering program offers considerable flexibility. Students tailor the program to their own interests by choosing electives from advanced aerospace courses or from courses in a wide range of other technical areas. These include the following applications:

- Aerodynamics
- Helicopters
- Air vehicle systems
- Rocket and spacecraft propulsion
- Orbital dynamics and satellite control
- Materials and advanced composites
- Computer and information systems for aerospace vehicles



2 BACHELOR'S IN 1 BACHELOR'S AND MASTER'S IN 5

Students can also choose a combined degree program that offers them two bachelor's degrees, with the second often being in a related field such as mechanical engineering. There's even a combined program you can choose that leads to both a bachelor's and a master's degree in just five years.

43%

Students from outside of Michigan

30

Median ACT Score

1350

Median SAT Score

3.9

Median HSGPA

ACT with math and verbal (critical reading) scores added, possible 36.
SAT with math and verbal (critical reading) scores added, possible 1600.

COURSES

Course outcomes and objectives contain complete information about the course, including prerequisites, course topics, objectives and outcomes are available online at engin.umich.edu/aero. This information can be used to compare courses between institutions, identifying appropriate matches for study abroad semesters or transfer credit.

200 LEVEL COURSES

- AEROSP 201. Introduction to Aerospace Engineering
- AEROSP 205. Introduction to Aerospace Engineering Systems
- AEROSP 215 Introduction to Solid Mechanics and Aerospace Structures
- AEROSP 225 Introduction to Gas Dynamics
- AEROSP 285. Aerospace Engineering Seminar

300 LEVEL COURSES

- AEROSP 305. Aerospace Engineering Laboratory I
- AEROSP 315. Aircraft and Spacecraft Structures
- AEROSP 325. Aerodynamics
- AEROSP 335. Aircraft and Spacecraft Propulsion
- AEROSP 347. Space Flight Mechanics
- AEROSP 348. Aircraft Dynamics and Control
- AEROSP 384. Introduction to Solid Modeling and CAD

400 LEVEL COURSES

- AEROSP 405. Aerospace Laboratory II
- AEROSP 416 (NAVARCH 416). Theory of Plates and Shells
- AEROSP 445. Flight Dynamics of Aerospace Vehicles
- AEROSP 481. Aircraft Design
- AEROSP 483. Space System Design
- AEROSP 484. Computer Aided Design

500 LEVEL COURSES

- AEROSP 510. Finite Elements in Mechanical and Structural Analysis I
- AEROSP 511. Finite Elements in Mechanical and Structural Analysis II
- AEROSP 513. Foundations of Solid and Structural Mechanics I
- AEROSP 516. Mechanics of Fibrous Composites
- AEROSP 524. Aerodynamics II
- AEROSP 526. Hypersonic Aerothermodynamics
- AEROSP 530. Gas-Turbine Propulsion
- AEROSP 535. Rocket Propulsion
- AEROSP 536. Electric Propulsion
- AEROSP 540 (MECHENG 540). Intermediate Dynamics
- AEROSP 544. Aeroelasticity
- AEROSP 545. Aeromechanics of Rotary Wing Vehicles

OVERALL DEGREE BREAKDOWN

Classification	No. of Credit
Subjects required by all programs	55
Related Technical Core Subjects	12
Aerospace Science Subjects	29
Aerospace Engineering Subjects	16
Electives	16
Total	128

8-TERM SAMPLE SCHEDULE

TERM 1

Course	No. of Credits
MATH 115, 116, 215, and 216	4
ENGR 100, Intro to Engr	4
CHEM 125/126 and 130, or 210 and 211	5
<u>Intellectual Breadth</u>	<u>4</u>
Total	17

TERM 2

Course	No. of Credits
MATH 115, 116, 215, and 216	4
ENGR 101, Intro to Computers or ENGR 151, Accel Intro to Computers	4
Physics 140 with Lab 141; Physics 240 with Lab 241	5
<u>Intellectual Breadth</u>	<u>4</u>
Total	17

TERM 3

Course	No. of Credits
MATH 115, 116, 215, and 216	4
Physics 140 with Lab 141; Physics 240 with Lab 241	5
AEROSP 201, Intro to Aerospace Engineering	3
AEROSP 205, Intro to Aerospace Engr Systems	3
<u>AEROSP 285, Aero Engineering Seminar</u>	<u>1</u>
Total	16

TERM 4

Course	No. of Credits
MATH 115, 116, 215, and 216	4
MECH ENG 240, Intro to Dynamics and Vibrations	4
AEROSP 215, Intro to Solid Mechanics and Aerospace Structures	4
<u>AEROSP 225, Intro to Gas Dynamics</u>	<u>4</u>
Total	16

TERM 5

Course	No. of Credits
EECS 314, Cct Analysis and Electronics	4
AEROSP 315, Aircraft and Spacecraft Structures	4
AEROSP 335, Aircraft and Spacecraft Propulsion	4
<u>AEROSP 347, Space Flight Mechanics</u>	<u>3</u>
Total	15

TERM 6

Course	No. of Credits
AEROSP 325, Aerodynamics	4
AEROSP 348, Aircraft Dynamics and Control	3
AEROSP 305, Aerospace Engr Lab I	4
<u>General Electives</u>	<u>5</u>
Total	16

TERM 7

Course	No. of Credits
Intellectual Breadth	4
MATSCIE 220, Intro to Materials	4
AEROSP 405, Aerospace Engr Lab II	4
<u>Technical Electives</u>	<u>4</u>
Total	16

TERM 8

Course	No. of Credits
Intellectual Breadth	4
AEROSP 481, Aircraft Design or Aero 483, Space System Design	4
Technical Electives	3
<u>General Electives</u>	<u>4</u>
Total	15



DEGREE PROGRAM OUTCOMES

After the completion of the Aerospace Engineering undergraduate program, graduates will demonstrate:

- An ability to apply knowledge of mathematics, science and engineering;
- An ability to design and conduct experiments as well as 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;
- 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 the techniques, skills and modern engineering tools necessary for engineering practice;
- A knowledge of aerodynamics, aerospace materials, structures, propulsion, flight mechanics, orbital mechanics, software, and stability and control; and,
- Competence in the integration of aerospace science and engineering topics and their application in aerospace vehicle design.



INSTRUCTIONAL LABS

FIRST-YEAR LAB

This course introduces students to practical aerospace engineering processes by the means of design, build, test and operation of simple flight vehicles (e.g. lighter than air craft). Students will design Mars surveillance blimps or dirigibles and fabricate and fly a terrestrial model. Students will be exposed to multiple disciplines in both engineering and the sciences including Aerospace, Electrical, Materials and Atmospheric Physics. The class involves hands-on experiences covering nearly all aspects of a real mission including concept proposal, design fabrication, test, operations, analysis, documentation and presentation of results. There will be individual training on fundamental diagnostic instruments, sensors and computers tools. Specific experiments include multi-meters, power supplies, temperature and pressure sensors, thermal-vacuum testing, data acquisition, micro-controllers and radio controlled components. This section emphasizes individual hands on skills, oral and written communication and working effectively in a team environment. The course is supported by a dedicated design-build-test facility.

SECOND-YEAR LAB

This course introduces students to practical aerospace system engineering processes by the means of design, build, test and operation of a flight vehicle. Students will be exposed to a variety of technologies. These include computer aided design (CAD), computer aided manufacturing (CAM), computer numerically controlled (CNC) machining, composites, mechanisms, laboratory instrumentation, basic analog and digital electronics, microcontrollers and sensors. These lab activities culminate in a team design-build-test- compete project of a dual-mode radio controlled and autonomous hovercraft.

THIRD-YEAR LAB

First course of a two-semester sequence covering fundamentals of instrumentation and measurement and their application in engineering testing and experimentation. Includes principles of analog and digital data acquisition, analysis of discrete measurement data, statistical assessment of hypotheses, design of experiments and similarity scaling of data. Emphasized development of skills for written communication and for working effectively in a team environment.

SENIOR LAB

Second course of a two-semester sequence covering fundamentals of instrumentation and measurement and their application in engineering testing and experimentation. Focuses primarily on application of the fundamental principles learned in Aero 305 to more advanced test and measurement applications. Involves instructor-designed experiments and one major project conceived, designed, conducted, analyzed and reported by student teams. Emphasizes development of skills for written communication and for working effectively in a team environment.

Research Areas

Aerospace engineering at U-M tackles the three fundamental areas that drive advances in aircraft and spacecraft: gas dynamics, dynamics and controls, and structures and materials. Some of our projects relate to space systems, specifically electric propulsion and small satellites. Visit our website at engin.umich.edu/aero to see how these findings improve vehicles and other technologies.

FLIGHT DYNAMICS AND CONTROL



The field of flight dynamics and controls deals with the motion of flight vehicles in the atmosphere and in space, as well as dynamics, control and planning issues related to flight and space applications. The department has a long history of excellence in the areas of flight dynamics and control systems. It was one of the first engineering departments in the nation to offer courses in automatic control, flight dynamics and simulation.

The flight dynamics and control specialization has a strong aerospace emphasis as illustrated by current research on aircraft dynamics, flight planning, flight control and autonomous flight; dynamics and control of attitude systems; astrodynamics; guidance, navigation and associated flight systems; flexible aerospace vehicles; and acoustics and flow control. There is a strong multidisciplinary systems orientation that emphasizes linear and nonlinear systems, optimization, feedback control, optimal planning and decision-making, stochastic processes and estimation and computational and software aspects of flight systems.

This specialization covers theory, experiments and implementation issues, as well as the study of specific cutting edge aerospace vehicles.

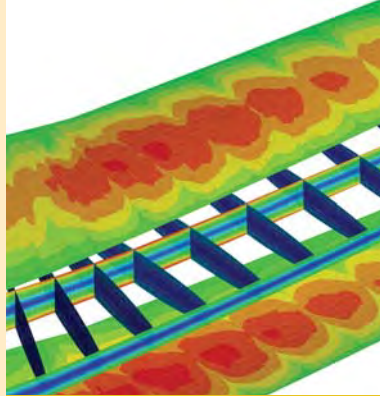
GAS DYNAMICS



Gas dynamics is the study of compressible flows: either around aerodynamic bodies (external flows, aerodynamics or fluid dynamics) or through engines (internal flows or propulsion). Gas dynamics is important for numerous aspects of aerospace engineering, such as airplane aerodynamics, helicopter aerodynamics, hypersonics, jet propulsion, rocket propulsion, advanced propulsion, properties of the space environment and many others.

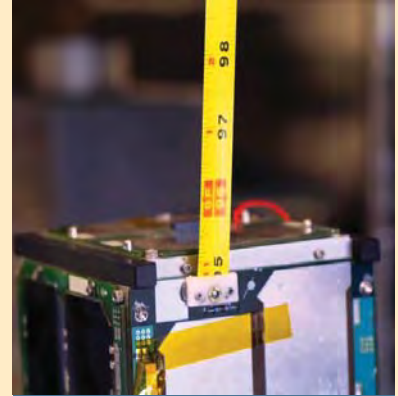
At Michigan, courses in the gas dynamics curriculum cover topics such as incompressible flow, compressible flow, viscous flow, turbulence, plasmadynamics, non-equilibrium and rarefied flows, jet and rocket propulsion, electric propulsion and computational fluid dynamics, among others. Research at Michigan covers a wide array of topics of current interest in gasdynamics.

STRUCTURAL MECHANICS AND MATERIALS



Structural mechanics is the study of the mechanical behavior of solids and structures. Aerospace structures differ from other structures due to their high demands for performance and lightweight. Modern aerospace structures typically require the use of composite materials, advanced multifunctional materials and thin-walled constructions. To obtain the level of performance required from flight structures, thorough knowledge of material limitations, structural stability and strength considerations are needed. Current research in the department emphasizes the characterization of advanced materials, material and structural stability, computational material/structure design, thermo-mechanical and electro-mechanical interactions, structural dynamics, multiscale modeling, multifunctional structures, morphing structures, aeroelasticity, structural health management and design optimization. This specialization covers theory, computations, experiments and implementation issues, as well as the study of specific cutting edge aerospace vehicles.

SPACE SYSTEMS



A subset of faculty members in Gas Dynamics and Dynamics and Controls develop spacecraft and advanced spacecraft subsystems such as propulsion and control systems. Experimental and computational studies center around spacecraft electric propulsion (EP) systems, such as Hall thrusters. Michigan is developing 10-W EP systems that are small enough to fit on a chip for cubesat propulsion, and 200-kW thrusters that are large enough to drive piloted missions to asteroids and Mars.

Cubesats in orbit around Earth are currently used to observe plasmas in the atmosphere that are known to disrupt satellite communication with Earth.



Design ► Build ► Fly

AIRCRAFT STUDENT PROJECT TEAMS

- **Human Powered Helicopter:** Design, build, and fly a human-powered helicopter
- **MAAV (Michigan Autonomous Aerial Vehicles):** Join this highly competitive interdisciplinary design team to compete in the annual International Aerial Robotics Competition (ARC)
- **M-Jet:** Get hands-on jet engine experience and learn the inner workings of a turbine engine
- **M-Fly Aero Design:** Apply what you know to special design projects outside of the classroom
- **Solar Drones Team:** Design, build and test unmanned-aerial vehicles

SPACE STUDENT PROJECT TEAMS

- **Mars Rover:** Contribute to research that builds and tests prototypes of manned rovers for use in a human mission to Mars
- **MASA (Michigan Aeronautical Science Association):** Design and fabricate rockets with new hybrid propulsion technologies and composite structures
- **MXL-Strato (Michigan Exploration Laboratory-Strato):** Develop novel flight vehicles and missions

Undergraduate Opportunities

SUMMER PROGRAM

SURE: SURE offers summer research internships to outstanding undergraduate students who have entered or completed their junior year by the time of their internship. Participants have the opportunity to conduct 10-12 weeks of full-time summer research with some of the country's leading faculty engineers.

FALL/WINTER PROGRAMS

UROP: The Undergraduate Research Opportunity Program (UROP) provides a structured research experience for credit or pay through a work-study program. Apply in the spring before your freshman or sophomore year.

SUGS: The Sequential Undergraduate/Graduate Study (SUGS) program is for top students in the University of Michigan aerospace engineering undergraduate program and leads to the MSE degree. SUGS students are able to double count up to nine credit hours and transfer up to six credit hours from their undergraduate program to their graduate program. Eligible students typically apply to the SUGS program in their senior year.

Aerospace Career Survey

(2004, 2008, 2012 Michigan Aerospace graduates)

What industry do you work in?

	Responses	Ratio
Aerospace and Defense	32	54%
Automotive	10	17%
Computer software and services	3	5%
Consulting	2	3%
Education	2	3%
Energy	1	2%
Start-up	1	2%
Government	2	3%
Legal	1	2%
Manufacturing	1	2%
Transportation	1	2%
Other	3	5%

Is your Job Engineering Related?

	Responses	Ratio
Yes	46	82%
No	10	18%

What is your job Function?

	Responses	Ratio
Analyst	1	2%
Business Development	2	4%
consulting	2	4%
Engineering	33	59%
Management	3	5%
Marketing	1	2%
Operations	3	5%
Project Management	2	4%
Research	2	4%
Teaching	1	2%
Other	4	7%

Career Opportunities

- Pilot Astronaut • Mission Specialist • Payload Specialist
- Astronomer • Chemist • Geologist • Meteorologist
- Oceanographer • Physicist • Computer Scientist • Mathematician • Statistician • Systems Analyst • Quality Control Inspector • Ground Radio Operator • Aerospace Model • Aircraft • Avionics • Electrical/Electronics Engineer • Fabrication • Materials • Pattern Maker and Molder



Aerospace Faculty, 2014

Aerospace Faculty

GAS DYNAMICS

- Prof. Luis Bernal
- Prof. Iain Boyd
- Asst. Prof. Karthik Duraisamy
- Prof. James Driscoll
- Asst. Prof. Mirko Gamba
- Assoc. Prof. Krzysztof Fidkowski
- Prof. Alec Gallimore
- Prof. Kenneth Powell
- Assoc. Prof. Venkat Raman
- Prof. Philip Roe
- Dr. J.P. Sheehan
- Dr. Timothy Smith
- Prof. Margaret Wooldridge (joint with ME)

DYNAMICS AND CONTROLS

- Assoc. Prof. Ella Atkins
- Prof. Dennis Bernstein
- Assoc. Prof. James Cutler
- Assoc. Prof. Anouck Girard
- Prof. Ilya Kolmanovsky
- Asst. Prof. Dimitra Panagou

SPACE SYSTEMS

- Prof. Iain Boyd
- Assoc. Prof. James Cutler
- Dr. Justin Edmondson
- Prof. Alec Gallimore
- Prof. Tamas Gombosi (joint with AOSS)
- Dr. J.P. Sheehan
- Prof. Thomas Zurbuchen (joint with AOSS)

STRUCTURES AND MATERIALS

- Prof. Daniel J. Inman (Dept. Chair)
- Prof. Carlos Cesnik
- Prof. Peretz Friedmann
- Assoc. Prof. Nakhiah Goulbourne
- Prof. Joaquim R.R.A. Martins
- Prof. John Shaw
- Assoc. Prof. Henry Sodano
- Assoc. Prof. Veera Sundararaghavan
- Assoc. Prof. Peter Washabaugh

Student Societies

AIAA American Institute of Aeronautics and Astronautics – Student Chapter

Neel Gandhi, President
www.umich.edu/~aiaa
neelg@umich.edu

SEDS Students for Exploration and Development of Space

Caue Borlina, President
caue@umich.edu
www.facebook.com/sedsatum

SGT Sigma Gamma Tau – Undergraduate Honors in Aerospace Engineering

Patrick Carrier, President
www.umsgt.org | Facebook [facebook.com/umsgt](https://www.facebook.com/umsgt)
pacarrie@umich.edu

Michigan Aviators

James Power, President
powerjam@umich.edu
www.michiganaviators.org

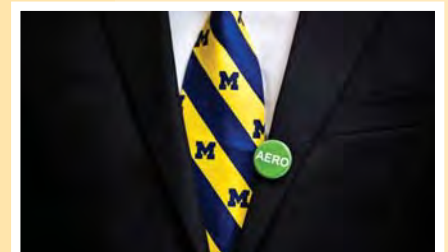
Michigan Mars Rover Team (MRover)

Scott Briggs, President
sdbrigg@umich.edu

Advisor: Lin Van Nieuwstadt
www.umrover.org

TBP Tau Beta Pi – CoE Graduate Student Engineering Honors Society

Cameron McBride, President
camarraahsmcbride@yahoo.com



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