As the first aeronautics program in the nation and one of the most highly-ranked undergraduate and graduate aerospace engineering departments in the US, we provide a vibrant environment of intellectual challenge and excitement that is at the same time collegial and conducive to higher learning.

Our graduate program offers degrees at both master's and doctoral levels, with research topics associated with air and space vehicles, vehicle systems and associated technologies. Our graduate students perform cutting-edge research in subjects that are closely related to Aerospace Engineering, including adaptive control for aerospace applications; aeroelasticity; aerospace information systems; autonomous air vehicles; combustion and energy sciences; composite structures; computational fluid dynamics; computational solid mechanics; control of propulsion and plasma physics, electric propulsion and plasma physics; flapping-wing aerial vehicles; hypersonic vehicles; multidisciplinary design and optimization; rotorcraft aeromechanics; smart materials and structures, spacecraft dynamics, control, and systems engineering; structural health monitoring; turbulence and fluid mechanics; and wind energy.

A combination of fundamental and applied research topics is a hallmark of our graduate program. The unusual breadth, depth, and excellence of the graduate program are a reflection of that. Our research has in recent years been additionally complemented by new efforts that are addressing engineering systems and applications research. These extend well beyond the traditional boundaries of aerospace engineering sciences and include such contemporary topics as energy usage, environmental sustainability, homeland defense, and large-scale computing. The Ph.D. program is fully-funded through fellowships, teaching assistantships, and research assistantships.

Top students from around the U.S. and worldwide have long been attracted to do their graduate studies at Michigan. This is because of the breadth and quality of the research being done here across all major technical disciplines of the field, and because of the outstanding environment for learning and growth. Our large alumni base includes professors at prestigious universities, various level managers (including CEOs) in different aerospace corporations, government labs, etc. 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 and many return to speak with students and faculty.

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

Krzysztof Fidkowski
Associate Professor and Graduate Chair
GAS DYNAMICS
Gas dynamics is the study of 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, 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, plasmas, aerodynamics, 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 gas dynamics. Some particular strengths of Michigan’s research program in gas dynamics are listed on faculty members’ web pages.

STRUCTURES & MATERIALS
Structures & Materials is the study of the mechanical behavior of solids and structures. Aerospace structures differ from other structures due to the high demands for performance and weight. 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/structural 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 & Control 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.
**RESEARCH PROJECTS**

**MXL - THE MICHIGAN EXPLORATION LABORATORY**

MXL works to achieve a comprehensive blend of education, research, and entrepreneurship within the University of Michigan College of Engineering.

The collaborative MXL environment has yielded flight-proven achievements in high altitude ballooning and small satellite design, with even more innovations resulting from the analysis of completed missions.

Based in the Department of Aerospace Engineering, MXL brings together students from across a multitude of academic engineering disciplines in order to create a well-balanced science and engineering design and development team. By working with such a diversely populated team on real missions, students are afforded the opportunity to cultivate their own strengths and interests while learning key team-building and communication skills.

**GE TAPS**

The GE Taps combustor is a new feature of GenX engines on the Boeing 787 Dreamliner. It provides exceptionally low NOx emissions and improved fuel economy by incorporating revolutionary new concepts of Lean Premixed Prevaporized (LPP) combustion. This research work at Michigan utilizes a GE TAPS combustor in a high pressure vessel fitted with optical windows so that the flow field can be imaged. The work identifies fundamental reasons why LPP concepts reduce NOx and how pilot flames stabilize the main flame.

**STRUCTURES AND MATERIALS FOR EXTREME ENVIRONMENTS (SMEE)**

High performance composite materials are being incorporated into many aerospace structures, where their specific stiffnesses and strengths are advantageous. It is critical that these materials are proven in the extreme environments to which they will be subjected. Furthermore, it is vital that modeling techniques keep pace or exceed advances in the materials, so that engineering analysis can drive the design of structures that are enabled by these materials. Two areas of concern are ceramic matrix composites for aerospace engine structures and the performance of adhesively bonded joints. Current efforts have focused on the Discrete Cohesive Zone Model (DCZM), a technique, developed in the Department of Aerospace Engineering.

**CENTER FOR RADIATIVE SHOCK HYDRODYNAMICS (CRASH)**

The Center for Radiative Shock Hydrodynamics (CRASH) is advancing predictive science in the nationally important area of radiation hydrodynamics (RH) via a unified, multi-prong approach. To substantially improve the ability to do predictive simulations of high-energy density and astrophysical flows, Center researchers are:

- Developing a software framework for RH to serve as a testbed for development, verification and validation of RH modeling elements.
- Developing a system for hierarchically validating the software framework.
- Extending an existing experimental effort, centered on radiative shocks, to obtain data and quantify uncertainties in the experiments.
- Simulating these experiments and quantifying the accuracy of the simulations. Establishing a doctoral program for Predictive Science and Engineering.

**X-HALE**

The Experimental HALE (X-HALE) aircraft is being developed as a low cost platform to obtain relevant nonlinear aeroelastic data to support validation of nonlinear aeroelastic code and also as future platform for control law studies. The aircraft should capture unique coupled nonlinear aeroelasticity/flight dynamics interactions in very flexible aircraft not easily obtained from wind tunnel tests. The main requirements are:

- Well-characterized structural, aerodynamics, propulsive vehicle properties
- Enough control authority to excite various flight conditions
- Capable of static deformations on the order of 30% tip deflection
- >30 minutes endurance

**GRE Scores**

- **Quantitative Math**: 164
- **Verbal**: 155
- **Writing**: 4
The University of Michigan Department of Aerospace Engineering can boast among its many resources 10 wind tunnels for instructional and research work. These tunnels are run by the Gas Dynamics Laboratories (GDL), which consists of a closely integrated group of professors, technicians and students within the Aerospace department. The function of this group is to conduct experimental and theoretical research, teach lecture and lab courses and to guide Ph.D. theses. The research interests of the group include a wide range of fluid dynamic, combustion and propulsion problems, much of which is based on wind tunnel experimentation. Below is a list of the wind tunnel facilities that the department offers.

• Subsonic Low Turbulence 5' x 7' Tunnel
• Variable Mach Number Supersonic Tunnel
• Edward A. Stalker 2' x 2' Subsonic Tunnel
• Subsonic 2' x 2' (Instructional) Tunnel
• Subsonic 6” Tunnels for Student Classroom Laboratories

The Aerospace Engineering Department is located in the François-Xavier Bagnoud (FXB) Building, a 100,000 square-foot complex that includes classrooms, teaching laboratories, and research labs as well as faculty and staff offices. The department also partially occupies four other research buildings: the wind tunnel building (20,000 sq ft), high-vacuum pumping station (4000 sq ft), power house (1000 sq ft), and the PEPL lab (5000 sq ft). Research facilities in our buildings include:

• a collection of wind tunnels that can test from micro air vehicles to models generating hundreds of pounds of lift and from very low-speed flight to above Mach 4 (Supersonic tunnels are in the wind tunnel building)
• a laboratory for plasmadynamics and electric propulsion, where full-scale tests can be run at millionths of a Torr (PEPL lab on Green Road)
• a composites laboratory with facility for mechanical testing of materials, vacuum and heating chambers for testing in controlled environments, high speed imaging of cracks and instrumentation for non-destructive evaluation
• a laboratory for autonomous aerospace systems
• Explosion resistant high bay research labs

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The University of Michigan Aerospace Engineering wind tunnel has been featured in special news reports to demonstrate tornadoes’ powerful winds

PhD

165
GRE Quantitative Math
Ph.D. Median Score

160
GRE Verbal
Ph.D. Median Score

4
GRE Writing
Ph.D. Median Score
APPLICATION DEADLINES

Applications are administered by the Rackham Graduate School: rackham.umich.edu/admissions

Applicants must meet Rackham requirements as well as those of Aerospace Engineering to be eligible.

FALL ADMISSION DEADLINES
December 15 for the Ph.D. program
January 15 for the SUGS and MSE programs

WINTER ADMISSION DEADLINE
October 1 for the Ph.D., SUGS and MSE programs

All application materials should arrive by these dates to be considered for admission. Applications that remain incomplete beyond the deadline will be at a competitive disadvantage during the evaluation process.

MOST COMMON FAQS - ANSWERED

1. Transcripts?
We require transcripts from ALL schools where bachelor’s, master’s, or professional degrees were awarded. Unofficial transcripts may be uploaded to the online application, but official transcripts must be sent to the Rackham Graduate School.

2. GPA?
We look for applicants who have demonstrated academic effort through a minimum GPA of 3.2 on a 4.0 scale.

3. GRE?
Graduate Record Examination General Test scores: We look for applicants who score a minimum of:
   a. Verbal & Quantitative combined score of 308
   b. Analytical Writing score of 4.0

4. Lower Scores?
The Admissions Review Committee looks at the complete application including academic performance, GRE (and TOEFL, if applicable) scores, research experience, letters of recommendation, and submitted statements. Applications are reviewed holistically and all materials are taken into consideration. You might consider applying to our program if you feel that the other portions of your application meet our requirements.

5. Engineering Background?
We encourage a wide range of prospective students to apply for our programs. The Admissions Review Committee does, however, prefer that applicants have at least some engineering background since the lack of this background often puts our students at a disadvantage during their graduate studies.

For GRE, TOEFL, and any other required external exams, the institution code is 1839.

DON’T HESITATE TO Contact Us!

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Flickr: Michigan Aero
Pinterest: Michigan Aero
Instagram: MichiganAero

On the cover: Alec Gallimore, Professor of Aerospace Engineering and Robert J. Vlasic Dean of Engineering, at work in his Plasmadynamics and Electric Propulsion Laboratory (PEPL). Gallimore is also the Richard F. and Eleanor A. Towner Professor and an Arthur F. Thurnau Professor.
# DYNAMICS & CONTROL

### Fundamental Courses
- AEROSP 540. Intermediate Dynamics
- AEROSP 550 (EECS 560, ME 564). Linear Systems Theory
- AEROSP 551. Nonlinear Systems and Control
- AEROSP 740. Aerospace Information Systems

### Elective Courses
- AEROSP 450. Flight Software Systems
- AEROSP 548. Astrodynamics
- AEROSP 566. Data Analysis and System Identification
- AEROSP 573. Dynamics and Control of Spacecraft
- AEROSP 575. Flight and Trajectory Optimization
- AEROSP 579. Control of Structures and Fluids
- AEROSP 580. Linear Feedback Control Systems
- AEROSP 581. Space Policy and Management
- AEROSP 582. Spacecraft Technology
- AEROSP 583. Space Systems Design and Management
- AEROSP 584. Avionics, Navigation and Guidance of Aerospace Vehicles

# GAS DYNAMICS FUNDAMENTAL COURSES

### Fundamental Courses
- AEROSP 520. Compressible Flow
- AEROSP 522. Viscous Flow
- AEROSP 523 (MECHENG 523). Computational Fluid Dynamics I
- AEROSP 525. Introduction to Turbulent Flows
- AEROSP 532. Molecular Gas Dynamics
- AEROSP 533 (ENSCEN 533). Combustion Processes

### Elective Courses
- AEROSP 423. Computational Methods for Aerospace Engineering
- AEROSP 521. Experimental Methods in Fluid Mechanics
- AEROSP 524. Aerodynamics II
- AEROSP 526. Hypersonic Aerothermodynamics
- AEROSP 530. Gas-Turbine Propulsion
- AEROSP 535. Rocket Propulsion
- AEROSP 536. Electric Propulsion
- AEROSP 544. Aeroelasticity
- AEROSP 623. Computational Fluid Dynamics II
- AEROSP 625. Advanced Topics in Turbulent Flow
- AEROSP 627. Advanced Gas Dynamics
- AEROSP 633. Advanced Combustion

# STRUCTURAL MECHANICS & MATERIALS

### Fundamental Courses
- AEROSP 510. Finite Elements I
- AEROSP 513. Solids and Structures I
- AEROSP 516. Mechanics of Composite Structures
- AEROSP 518. Elastic Stability
- AEROSP 543. Structural Dynamics

### Elective Courses
- AEROSP 495. Advanced Flight Structures
- NAME/AEROSP 416. Plates and Shells
- AEROSP 511. Finite Elements II
- AEROSP 514. Solids and Structures II
- AEROSP 544. Aeroelasticity
- AEROSP 545. Helicopter Aeromechanics
- MECHENG 505. Finite Element Methods in Mechanical Engineering
- MECHENG 512. Theory of Elasticity
- MECHENG 516. Thin Films and Layered Materials
- MECHENG 517. Mechanics of Polymers
- MECHENG 519. Theory of Plasticity
- AEROSP/MECHENG 540. Intermediate Dynamics
- MECHENG 605. Advanced Finite Element Methods in Mechanics
- AEROSP 618. Advanced Structural Stability
- AEROSP 714. Multidisciplinary Design and Optimization

# MATH REQUIREMENTS

- AEROSP 423. Computational Methods for Aerospace Engineering
- AEROSP 523. (ME 523) Computational Fluid Dynamics I
- AEROSP 623. Computational Fluid Dynamics II
- EECS 401. Probabilistic Methods in Engineering
- EECS 501. Probability and Random Processes
- EECS 502. Stochastic Processes
- EECS 560. (ME 564, AEROSP 550) Linear Systems Theory
- EECS 562. (AEROSP 551) Nonlinear Systems and Control
- Math 419. (EECS 400) Linear Spaces and Matrix Theory
- Math 451. Advanced Calculus I
- Math 452. Advanced Calculus II
- Math 454. Boundary Value Problems for Partial Differential Equations
- Math 471. Introduction to Numerical Methods
- Math 525. (STAT 525) Probability Theory
- Math 555. Introduction to Complex Variables
- Math 556. Methods of Applied Mathematics I
- Math 557. Methods of Applied Mathematics II
- Math 561. (IOE 510) Linear Programming I
- Math 562. Continuous Optimization Methods
- Math 602. Real Analysis II
- ME 501. Analytical Methods in Mechanics
- ME 502. Methods of Differential Equations in Mechanics
- NERS 571. Intermediate Plasma Physics I
- Physics 451, 452. Methods of Theoretical Physics
- ROB 501, Math for Robotics

In special circumstances, and with the prior approval of the Graduate Chair, a student may elect other primarily mathematical courses offered by the departments of Mathematics, Statistics and/or Physics in support to a tailored program. The following courses cannot be used to satisfy the mathematics requirement: Math 404, Math 417, Math 448, and Math 450.
MASTER OF SCIENCE IN ENGINEERING

Admission for study towards the MSE degree requires the equivalent of a BSE at the University of Michigan. Solid undergraduate preparation in mathematics and engineering is essential. For the MSE degree, 30 credit hours of course work are required. Students have substantial flexibility in selecting courses to meet their individual needs.

The 30 credit hours must include at least five courses in aerospace engineering at the 500 level or higher (excluding directed study courses and seminars) and two approved courses in mathematics from the list (see right panel). Also, up to six credit hours of directed study (AEROSP 590) and three credit hours of AEROSP 585 seminar series may be elected. Students are encouraged to take advantage of directed study and become involved in research as part of their MSE experience. The MSE program does not include an option for a thesis per se; however, through AEROSP 590, students can perform research work in close supervision of a faculty member and investigate a problem of common interest, resulting in a paper of publishable quality, if they so choose. Students should become acquainted with the research work being performed in the Department and then contact faculty members with whom they find common research interest.

MASTER OF ENGINEERING DEGREE IN SPACE ENGINEERING

The successful integration of the scientific, engineering and management considerations in space systems requires highly capable professionals. In particular, managers at all levels must have a broad interdisciplinary background: they must be able to see branches, trees, and the entire forest at the same time. This program is open to engineers and scientists from all backgrounds, with aspirations of entering the aerospace workforce. This MEng program in Space Engineering combines strong emphasis on both theoretical and applied aspects with extensive hands-on experience at all levels. Designed to provide a broad interdisciplinary education in the scientific, engineering and management aspects of complex space systems, the program enhances disciplinary skills and provides insight and education in the systems engineering and management area. If you are interested in studying the scientific, engineering and management aspects of space engineering, this program allows you to structure the program to your specific area of interest. The program was developed jointly by Aerospace Engineering; Atmospheric, Oceanic & Space Sciences; and Electrical Engineering and Computer Science.

DOCTOR OF PHILOSOPHY

The doctoral degree and preliminary examination policies and procedures are intended to achieve the following four objectives:

1. Have a unified policy for the preliminary examination.
2. Allow students to pursue the traditional doctoral specializations in gas dynamics, structures and materials, and dynamics and control.
3. Allow students to pursue multi-disciplinary doctoral specialization in aerospace engineering approved and guided by a faculty adviser.
4. Successful completion of a preliminary examination is a key prerequisite in the pursuit of a doctoral degree in Aerospace Engineering. Taking the preliminary examination after the first year of graduate study is recommended.

Aerospace Engineering Doctoral Degree Requirements

The Ph.D. degree requires a sound background in aerospace engineering combined with good knowledge of applied mathematics and computational sciences. The Ph.D. dissertation requires that the student demonstrate ability to pursue and solve an original research problem, which implies ability to carry out independent research. A student who intends to work toward the Ph.D. degree must complete the following steps:

1. Pre-candidacy Status: A student must apply to the Graduate Committee of the Department of Aerospace Engineering for admission to pre-candidacy status in Aerospace Engineering.
2. Research Involvement: Each student in the doctoral degree program must initiate a research activity with a faculty member as an adviser in her/his first year of graduate study at U-M.
3. Preliminary Examination Requirement: Before advancing to Ph.D. candidacy, a student must demonstrate a high level of competency by successfully completing an oral preliminary examination in Aerospace Engineering. Each student must apply for the Preliminary Examination, with the endorsement of her/his research adviser.
4. Admission to Candidacy: The decision on admission to candidacy is based on Preliminary Examination performance, academic record in courses related to student’s research, and student’s ability to carry out independent research.
5. Additional Coursework: Courses selected to prepare for the Preliminary Examination do not alone constitute sufficient preparation for doctoral research. Each doctoral student is urged to select additional courses, beyond what is required for the Preliminary Examination.
6. Doctoral Research: Doctoral research is carried out under the supervision of a faculty advisor and a dissertation committee; the dissertation committee normally should be formed within one year after the student has achieved doctoral candidacy status.
7. Ph.D. Degree: The Ph.D. degree is awarded upon successful completion of a Ph.D. dissertation, a Ph.D. defense and the final post-defense. In order to complete the Ph.D. degree, the student must carry out original and publishable research, present the results in a written dissertation and defend the dissertation at a final oral defense.