Aerospace and Space Systems Engineering

OUR MISSION

The MS in Aerospace and Space Systems Engineering (AESE) at Lehigh University is an interdisciplinary hybrid Master's program that is led by the Department of Mechanical Engineering & Mechanics and includes strong collaborations with Electrical and Computer Engineering, Industrial Systems Engineering, Material Science & Engineering, Physics and Earth and Environmental Sciences. Students with undergraduate backgrounds in the disciplines listed above can pursue the MS in Aerospace & Space Systems Engineering. The AESE program also offers 12 credit graduate certificates in Aerodynamics, Aerospace Systems, & Space Systems Engineering.

OUR FACULTY

A complete listing can be found on our website (https://aerospace.lehigh.edu/faculty-staff/).

MASTERS DEGREE PROGRAM

The MS in Aerospace & Space Systems Engineering requires 30 credit hours of graduate work. Audit courses may not be used towards the degree. Master's degrees must satisfy the University course distribution requirements, as outlined in the P.C. Rossin College of Engineering & Applied Science (RCEAS) Graduate Student Handbook (https://engineering.lehigh.edu/academics/graduate/student-handbook/). The minimum program for all Masters degrees includes:

- At least two full semesters of advanced work
- At least 30 credits
- At least 24 credits of 300- and 400- level courses
- At least 18 credits of 400- level courses
- At least 18 credits in a major field
- At least 15 credits of 400- level courses in the major field

MASTER OF SCIENCE IN AEROSPACE AND SPACE SYSTEMS ENGINEERING

The **MS in Aerospace & Space Systems Engineering** at Lehigh University is an interdisciplinary hybrid Master's program that is led by the Department of Mechanical Engineering & Mechanics and includes strong collaborations with Electrical and Computer Engineering, Industrial Systems Engineering, Material Science & Engineering, Physics and Earth and Environmental Sciences. Students with undergraduate backgrounds in the disciplines listed above can pursue this MS program.

Master of Science

The Program for the Master of Science degree must be comprised of a minimum of 30 credit hours distributed as follows:

Required Core Course in Aerospace & Space Systems Engineering (9 credits)

AESE 401	Introduction to Modern Aerospace Engineering	3

and two courses from the following:

AESE 402	Advanced Astrodynamics	3
AESE 403	Space Propulsion Systems	3
AESE 404	Guidance, Navigation and Control	3
AESE 406	Data Fusion and State Estimation	3
AESE 407	Hypersonic Flows	3
MECH 426	Advanced Aerodynamics	3

Depth Requirement: Choose one concentration area and take three courses (9 credits)

Three courses are to be selected from one concentration area that may be aligned with the student's parent discipline. Courses may be at the 300 and 400 level but cannot include AESE 460 (Project) or AESE 490 (Thesis). Only one course may be at the 300 level.

Breadth Requirement: (12 credits)

Four courses at the 300 and 400 level selected from outside the depth concentration. Students can also mix and match but cannot choose courses from the concentration area they use for their depth requirement.

Concentration Areas:

(Aerodynamics)

AESE 407	Hypersonic Flows	3
ME 424	Unsteady and Turbulent Flow	3
ME 430	Advanced Fluid Mechanics	3
ME 431	Advanced Gas Dynamics	3
MECH 426	Advanced Aerodynamics	3
MECH 427	Unsteady Flows	3

(Aerospace Systems)

AESE 402	Advanced Astrodynamics	3
AESE 404	Guidance, Navigation and Control	3
AESE 406	Data Fusion and State Estimation	3
ME 356	Astrodynamics	3
ME 433	Linear Systems and Control	3
ME 436	Systems Identification	3
ME 454	Aeroelastic Flight Dynamics	3

(Space Systems Engineering)

AESE 403	Space Propulsion Systems	3
AESE 404	Guidance, Navigation and Control	3
AESE 405	Launch Vehicle Engineering	3
AESE 408	Advanced Aerospace Vehicle Design	3
ISE 432	Product Quality	3

Electives:

(Electrical Engineering)

ECE 406	Autonomous Driving and Robotic Racing	0,3
or ECE 306	Autonomous Driving and Robotic Racing	
ECE 413	Power Electronics	3
or ECE 313	Power Electronics	
ECE 422	Introduction to Photovoltaic Energy Systems	3
or ECE 322	Introduction to Photovoltaic Energy Systems	
ECE 342	Communication Theory	3
ECE 414	Statistical Decision Making and Machine Learning Theory	3
ECE 443	RF Power Amplifiers for Wireless Communications	3

(Industrial Systems Engineering)

ISE 432	Product Quality	3
or ISE 332	Product Quality	
ISE 333	Introduction to Systems Engineering and Decision Analysis	3
ISE 434	Operational Excellence	3
or ISE 334	Operational Excellence	
ISE 335	Planning and Scheduling in Manufacturing and Services	3
ISE 436	Engineering Project Management	3
or ISE 336	Engineering Project Management	
ISE 482	Leadership Development	3
or ISE 382	Leadership Development	
ISE 447	Financial Optimization	3
or ISE 347	Financial Optimization	

(Materials Science & Engineering)

MAT 309	Composite Materials	3
or ME 309	Composite Materials	
MAT 332	Basics of Materials Science and Engineering	3
MAT 445	Additive Manufacturing and Powder Metallurgy	3
or MAT 345	Additive Manufacturing and Powder Metallurgy	
MAT 346	Physical Metallurgy of Welding	3
ME 402	Advanced Manufacturing Science	3

(Mechanical Engineering & Mechanics)

ME 322	Gas Dynamics [1]	3
ME 331	Advanced Fluid Mechanics [1]	3
ME 333	Propulsion Systems	3
ME 343	Control Systems	3
ME 354	Flight Dynamics [1]	3
ME 355	Spacecraft Systems Engineering	3
ME 356	Astrodynamics	3
ME 436	Systems Identification	3
MECH 326	Aerodynamics [1]	3
MECH 328	Aircraft Design Engineering	3
MECH 427	Unsteady Flows	3

1

Cannot receive credit for both 300- and 400- levels of the course.

(Physics)

ASTR 301	Introduction to Stellar Astrophysics	3
ASTR 302	Introduction to Galactic and Extragalactic Astrophysics	3
ASTR 332	High-Energy Astrophysics	3
or PHY 332	High-Energy Astrophysics	
ASTR 344	Cosmology	3
PHY 420	Mechanics	3
PHY 455	Physics of Nonlinear Phenomena	3

(Earth and Environmental Sciences)

EES 318	Geographic Analysis in EES	0-4
EES 325	Remote Sensing of Terrestrial and Aquatic Environments	0-4
EES 457	Advanced Remote Sensing of the Environment	3

(Project Management)

PMGT 409	Project Management Fundamentals	3
PMGT 410	Project Requirements and Scope Management	1
PMGT 411	Project Scheduling, Estimating & Budgeting	1
PMGT 412	Advanced Scheduling & Scheduling Tools	1
PMGT 413	Project Risk Management	1
PMGT 414	Managing Project Quality	1
PMGT 415	Project Procurement & Negotiation	1
PMGT 416	Decision Making and Ethics on Projects	1
PMGT 417	Project Leadership	1
PMGT 418	Facilitation and Teamwork for Projects	1
PMGT 419	Adaptive and Agile Project Management	1
PMGT 420	Managing Projects for Innovation	1
PMGT 421	Project Management Capstone	1-3

General Requirements for Master of Science

In meeting the requirements for the Master of Science degree, the student must satisfy the following common requirements, as outlined in the Engineering Graduate Student Handbook.

1. All candidates for a Master's degree must submit the form entitled Program for Master's Degree (https://powerforms.docusign.net/8926a106-aaff-421b-99d5-0f460611b51b/?env=na3&acct=4522e8bc-42ec-46ec-af83-a167d8a26e3f&accountId=4522e8bc-42ec-46ec-af83-a167d8a26e3f)as soon as possible after accruing 15 credit hours of courses but no later than the semester before the student graduates. This form is eventually approved by the Registrar. The timing for completion of this form is critical, as it allows for corrections to a student's course plan if necessary.
2. The minimum program for all Masters degrees includes:
   • Not less than 30 credit hours of graduate work; audit credits may not be used toward the degree. Research or thesis registration counts as part of the 400-level course requirement.
   • Not less than 24 credit hours of 300- and 400-level coursework of which at least 18 hours is at the 400-level.
   • Not less than 18 credit hours in AESE program
   • Not less than 15 credit hours of 400-level coursework in AESE.
3. Eighteen (18) credit hours in the major field of Aerospace and Space Systems Engineering are required. These courses must be 300- and 400-level courses. The remaining twelve (12) credit hours may also be taken in Aerospace and Space Systems Engineering (300- and 400-level courses), or they may be taken in any other field in engineering in which courses for graduate credit are offered, subject to the approval of the student's advisor.
4. The Master’s degree is not granted unless the candidate has earned grades of B- or better in at least eighteen hours of the work in his/her program and in all 300-level courses. No course in which the grade earned is less than C- is credited towards the degree.
5. A student who receives more than four grades below B- in courses numbered 200 or higher becomes ineligible to qualify for the Master’s degree or to register for any other 400-level courses.

GRADUATE CERTIFICATES

The mission of this certificate program is to provide rigorous foundational and design-oriented training in disciplines central to the aerospace industry. The program equips students with the knowledge and skills needed to be competitive and successful in aerospace-related careers, with emphasis on fundamental science, systems design, and hardware integration.

Certification in Aerodynamics

The **Aerodynamics Certificate** focuses on the fundamental science of aerodynamics and its application to aircraft and spacecraft operating in atmospheric environments. Students develop an understanding of fluid dynamics, aerodynamic forces, and flow phenomena relevant to aerospace vehicle performance and design. Upon completion, students may apply the 12-credit certificate toward a Master of Science in Aerospace and Space Systems Engineering.

Students are required to choose four courses (12 credits) from the list below to complete the Certification in Aerodynamics:

AESE 407	Hypersonic Flows	3
ME 424	Unsteady and Turbulent Flow	3
ME 430	Advanced Fluid Mechanics	3
ME 431	Advanced Gas Dynamics	3
MECH 426	Advanced Aerodynamics	3
MECH 427	Unsteady Flows	3

certification in aerospace Systems

The **Aerospace Systems Certificate** focuses on the component-level design and analysis of aerospace vehicles, with particular emphasis on guidance, navigation, and control. Students develop expertise in the subsystems and control architectures that enable the operation and stability of aerospace vehicles. Upon completion, students may apply the 12-credit certificate toward a Master of Science in Aerospace and Space Systems Engineering.

Students are required to choose four courses (12 credits) from the list below to complete the Certification in Aerospace Systems:

AESE 402	Advanced Astrodynamics	3
AESE 404	Guidance, Navigation and Control	3
AESE 406	Data Fusion and State Estimation	3
ME 356	Astrodynamics	3
ME 433	Linear Systems and Control	3
ME 436	Systems Identification	3
ME 454	Aeroelastic Flight Dynamics	3

certification in space systems engineering

The **Space Systems Engineering Certificate** focuses on the overall design and integration of aerospace vehicles, including launch vehicles, spacecraft, and re-entry systems. Emphasis is placed on the integration of hardware within the mission design process and the systems-level considerations required for space missions. Upon completion, students may apply the 12-credit certificate toward a Master of Science in Aerospace and Space Systems Engineering.

Students are required to choose four courses (12 credits) from the list below to complete the Certification in Space Systems Engineering:

AESE 403	Space Propulsion Systems	3
AESE 404	Guidance, Navigation and Control	3
AESE 405	Launch Vehicle Engineering	3
AESE 408	Advanced Aerospace Vehicle Design	3
ISE 432	Product Quality	3

Courses

AESE 401 Introduction to Modern Aerospace Engineering 3 Credits
A rigorous introduction to the fundamentals of aerospace engineering, tailored for graduate students with backgrounds in mechanical engineering, electrical engineering, or physics. Students will develop a strong foundation in aerodynamics, propulsion, flight mechanics, orbital mechanics, aircraft and spacecraft systems, and planetary environments. The course will emphasize both theoretical concepts and practical applications, utilizing real-world examples and case studies from the aerospace industry.

AESE 402 Advanced Astrodynamics 3 Credits
A project-based course that builds upon the knowledge and skills developed in an introductory course in astrodynamics. Topics include orbital perturbations, propagation, industry standard data formats, orbital debris, collision assessment and avoidance, constellation design, cislunar dynamics, and special topics in areas of current research.

AESE 403 Space Propulsion Systems 3 Credits
An introduction to rocket propulsion, covering fundamentals of solid rocket motors and liquid engines, including topics such as propellant thermochemistry, specific impulse calculations, liquid rocket engine cycles, and combustion stability. Advanced topics include airbreathing propulsion for launch vehicles and electric propulsion concepts for deep space vehicles.

AESE 404 Guidance, Navigation and Control 3 Credits
Provides an industry-focused introduction to autonomous vehicles and the guidance, navigation, and control (GN&C) engineering challenges they pose. Students will engage with theoretical and real-world examples for developing vehicles at varying levels of autonomy. Classical control theory will be complemented with approaches from the data-driven world of machine learning and artificial intelligence.

AESE 405 Launch Vehicle Engineering 3 Credits
A comprehensive course in the integrated design and engineering of today's launch vehicles, including structures, propulsion, materials, thermal and fluids management, and Guidance, Navigation, and Control. Multiple examples of current designs will be analyzed and a collaborate class project will focus on the design and analysis of a new launch vehicle.

AESE 406 Data Fusion and State Estimation 3 Credits
A comprehensive course in data fusion and Kalman Filtering for optimal state estimation of dynamic systems. Includes coverage of basic probability, dynamic system modeling, state space representation of dynamic systems, state estimation theory, least squares estimation, and discrete Kalman filter estimation. This course implements the theory through extensive modeling and simulation using Python and C++. A design project provides experience with practical design issues and tradeoffs.

AESE 407 Hypersonic Flows 3 Credits
An introduction to hypersonic aerodynamics, covering advanced concepts pertinent to highly compressible, reacting flows. Topics to include boundary layer and shockwave phenomena, viscous heat transfer, radiative heating, surface effects such as ablation and catalysis, and basics of rarefied flow. The course will focus on developing applied skills needed to solve real-world design problems for hypersonic flight, concluding with a final project.

AESE 408 Advanced Aerospace Vehicle Design 3 Credits
An overview of design methodology for next-generation aerospace vehicles such as satellites, reentry vehicles, hypersonic systems, and/or hybrid-electric aircraft concepts, focusing on the interdisciplinary analysis of structures, fluid mechanics, propulsion, and Guidance, Navigation, and Control. Case studies will be used to explore real-world vehicles and students will complete a systems-level design of a flight vehicle concept of their own choosing based on specified mission requirements.

AESE 460 Aerospace and Space Systems Engineering Project 1-6 Credits
Project work on some aspect of aerospace or space systems engineering in an area of student and faculty interest. Selection and direction of the project could involve interaction with local communities or industries. Consent of department required.
Repeat Status: Course may be repeated.

AESE 490 Thesis 1-6 Credits
Directed study leading to a thesis.
Repeat Status: Course may be repeated.