AEROSPACE ENGINEERING SCIENCES - MASTER OF SCIENCE (MS)

CU Boulder's Department of Aerospace Engineering Sciences (AES) is internationally recognized for its research and education leadership in aerospace engineering, Earth and space sciences. Its world-renowned engineers and scientists tackle challenges in aerospace technology and science, focusing on Astrodynamics and Satellite Navigation Systems (ASN); Autonomous Systems (AUT); Bioastronautics (BIO), Fluids, Structures and Materials (FSM); and Remote Sensing, Earth and Space Science (RSESS).

With more than 50 faculty members and over 550 MS and PhD students, our graduate programs prepare aerospace engineering students to meet the needs of our 21st-century society through the understanding, conception, design and application of aerial and spacecraft systems.

In the MS program we focus on hands-on, experiential learning, technical and organizational expertise, and end-to-end mission and systems perspectives via course-based degree options.

Research opportunities for MS students are very limited and are not funded. Students interested in completing an MS thesis are encouraged to take a few of our courses before deciding to pursue that route.

For more information, visit the department's Prospective Graduate Students (https://www.colorado.edu/aerospace/prospective-students/graduates/) webpage and our Graduate Student Handbook (https://www.colorado.edu/aerospace/current-students/graduates/curriculum/graduate-student-handbooks/).

Requirements

Program Requirements

Students must complete a total of 30 credit hours, equivalent to 10 classes, with a grade of B- or better and a cumulative GPA of at least 3.00. Of these 30 credits, at least 24 credit hours must be completed at the 5000 level or above, and at least 18 of those credits must be in Aerospace Engineering (ASEN) courses, and one approved math course. (Note: EMEN 5405 Fundamentals of Systems Engineering counts as an ASEN class. Seminar credits, even those earned in other disciplines, do not count toward the MS degree.)

Up to 6 credits can be taken at the 4000 level in approved engineering, math and science departments (ECEN, CVEN, MCEN, CHEN, CSCI, ATOC, ASTR, PHYS, MCDB, APPM, MATH, STAT, CHEM, IPHY, GEOL, ENVD). ASEN courses level 4000 or below do not count towards AES graduate degrees.

Focus Area-Defined Courses

Some focus areas offer the option to take additional courses to satisfy the non-thesis option. This will represent at least an additional six credit hours with respect to the minimum requirement to obtain a MS with that focus area.

Code	Title	Credit Hours
Required Math Course:		
Choose one:		*3*
ASEN 5044	Statistical Estimation for Dynamical Systems [1]	
ASEN 5227	Mathematics for Aerospace Engineering Sciences 1	
ASEN 5307	Engineering Data Analysis Methods	
ASEN 5327	Experimental Design and Statistical Methods	
ASEN 5417	Numerical Methods in Engineering and Science	
ASEN 5519	Special Topics (Multi-Object Filtering Theory)	
ASEN 6412	Uncertainty Quantification	
CSCI 5636	Numerical Solution of Partial Differential Equations	
ECEN 5612	Random Processes for Engineers	
ECEN 5632	Theory and Application of Digital Filtering	
ECEN 5652	Detection and Extraction of Signals from Noise	
EMEN 5005	Introduction to Applied Statistical Methods	
4000, 5000, 6000, or 7000 level APPM course		
4000, 5000, 6000, or 7000 level MATH course		
4000, 5000, 6000, or 7000 level STAT course		
Choose one of the following:		
Thesis Option		
The MS thesis must consist of original and independent research conducted by the graduate student under the supervision of the faculty advisor. The thesis topic must be related to the major field.		
ASEN 6950	Master's Thesis	
Non-Thesis Option (Select One)		
ASEN 5018 & ASEN 6028	Graduate Projects I and Graduate Projects II (6 credits)	
Required courses leading to an approved certificate (or completion of the dual ASEN/EMP degree)		
Course-only option (FSM and AUT)		

[1] Can be used to meet only one ASEN curriculum-specific requirement, i.e. math or ASN core. This restriction does not apply to certificate requirements.

Please visit our Graduate Student Handbook (https://www.colorado.edu/aerospace/current-students/graduates/curriculum/graduate-student-handbooks/) for focus area requirements and coursework offerings.

Time Limit

All degree requirements must be completed within four years of the date of commencing coursework. Most students complete the degree in approximately two years.

Astrodynamics and Satellite Navigation Systems (ASN) (https://www.colorado.edu/aerospace/current-students/graduates/curriculum/astrodynamics-satellite-navigation-systems/)

Requirements of the MS degree in the Astrodynamics and Satellite Navigation Systems focus area are:

- Three ASN Core Classes
- One ASEN MS Course or Required course from an outside (non-ASN) AES Focus Area. The outside course is any course not listed under the ASN curriculum.

Code	Title	Credit Hours
Core Courses		**9**
Choose three:		
ASEN 5010	Spacecraft Attitude Dynamics and Control	
ASEN 5044	Statistical Estimation for Dynamical Systems	
ASEN 5050	Space Flight Dynamics	
or ASEN 5052	Analytical Astrodynamics	
ASEN 5090	Introduction to Global Navigation Satellite Systems	
Additional Course		
Choose one ASEN MS Course or Required course from an outside (non-ASN) AES focus area		3
Elective Courses Offered by ASN Focus Area		
ASEN 6008	Interplanetary Mission Design	
ASEN 6010	Advanced Spacecraft Dynamics and Control	
ASEN 6014	Spacecraft Formation Flying	
ASEN 6015	Space Vehicle Guidance and Control	
ASEN 6020	Optimal Trajectories	
ASEN 6060	Advanced Astrodynamics	
ASEN 6070	Satellite Geodesy	
ASEN 6080	Statistical Orbit Determination	
ASEN 6090	Advanced Global Navigation Satellite Systems: Software and Applications	
ASEN 6091	Global Navigation Satellite System (GNSS) Receiver Architecture	
ASEN 6519	Special Topics (Celestial Mechanics & Advanced Astrodynamics)	
ASEN 6519	Special Topics (GNSS for Remote Sensing)	
ASEN 6519	Special Topics (Multi-Object Detection, Tracking, and Characterization)	

Autonomous Systems (AUT) (https://www.colorado.edu/aerospace/current-students/graduates/curriculum/autonomous-systems/)

Students are required to take one course from three of the following topic areas:

Code	Title	Credit Hours
Autonomous Decision-Making		
ASEN 5254	Algorithmic Motion Planning	
ASEN 5519	Special Topics (Decision-Making Under Uncertainty)	
Control Theory		
ASEN 5014	Linear Control Systems	
ASEN 6024	Nonlinear Control Systems	
Dynamics and Modelling of Vehicles		
ASEN 5519	Special Topics (Small UAS Dynamics and Control)	
ASEN 6519	Special Topics (System Identification for Control)	
Estimation and Sensor Fusion		
ASEN 5044	Statistical Estimation for Dynamical Systems	
Programming for Embedded Systems		
ASEN 5067	Microavionics: Introduction to PIC Microcontrollers for Aerospace Systems	
CSCI 5302	Advanced Robotics	
ECEN 5613	Embedded System Design	
ECEN 5813	Principles of Embedded Software	
MCEN 5115	Mechatronics and Robotics I	
Elective Courses Offered by AUT Focus Area		
ASEN 5114	Automatic Control Systems	
ASEN 5519	Special Topics (Aerobotics)	
ASEN 5519	Special Topics (Machine Learning for Aerospace)	
ASEN 6519	Special Topics (Cooperative Control)	
ASEN 6519	Special Topics (Hybrid Control Systems)	
ASEN 6519	Special Topics (Stochastic Verification and Synthesis)	

Bioastronautics (BIO) (https://www.colorado.edu/aerospace/current-students/graduates/curriculum/bioastronautics/)

Students are required to take two Core courses and one course from each of the following areas:

Code	Title	Credit Hours
Core Courses		**6**
ASEN 5016	Space Life Sciences	3
ASEN 5158	Space Habitat Design	3
Choose one:		*3*
ASEN 5226	Medicine in Space and Surface Environments	
ASEN 6116	Spacecraft Life Support Systems	
ASEN 6216	Human Operation of Aerospace Vehicles	
ASEN 6316	Extravehicular Activity	
Choose one:		*3*
ASEN 5010	Spacecraft Attitude Dynamics and Control	
ASEN 5012	Mechanics of Aerospace Structures	
ASEN 5014	Linear Control Systems	
ASEN 5044	Statistical Estimation for Dynamical Systems	
ASEN 5050	Space Flight Dynamics	
or ASEN 5052	Analytical Astrodynamics	
ASEN 5090	Introduction to Global Navigation Satellite Systems	
ASEN 5335	Aerospace Environment	
Elective Courses Offered by BIO Focus Area		
ASEN 5226	Medicine in Space and Surface Environments	

ASEN 5327	Experimental Design and Statistical Methods
ASEN 5849	Independent Study (for MS students)
ASEN 6116	Spacecraft Life Support Systems
ASEN 6216	Human Operation of Aerospace Vehicles
ASEN 6316	Extravehicular Activity
ASEN 6849	Independent Study (for PhD 'pre/non-thesis' topic)

Fluids, Structures and Materials (FSM) (https://www.colorado.edu/aerospace/academics/graduates/curriculum/fluids-structures-and-materials/)

Requirements of the MS degree in the Fluids, Structures and Materials (FSM) focus area are:

- Two Core Classes in your chosen track, and one Core course in the other FSM track.
- Two electives from the FSM focus area, with at least one in your chosen track. (See Graduate Handbook for detailed listing.)
- Attending 50% of the “Fluid, Structures and Materials” seminars each semester.

Code	Title	Credit Hours
Core Courses		
Fluids Sub-Track		
ASEN 5051	Fundamentals of Fluid Dynamics	
ASEN 5151	Fundamentals of Gas Dynamics	
ASEN 5519	Special Topics (Molecular Thermodynamics and Kinetics)	
Structures and Materials Sub-Track		
ASEN 5007	Introduction to Finite Elements	
ASEN 5012	Mechanics of Aerospace Structures	
ASEN 5022	Dynamics of Aerospace Structures	
Elective Courses Approved by FSM Focus Area		
Fluids		
ASEN 5121	Boundary Layers and Convection	
ASEN 5321	Computational Fluid Dynamics Structured Grid	
ASEN 5519	Special Topics (Introduction to Hypersonics)	
ASEN 6011	Experimental Fluid Mechanics	
ASEN 6037/ MCEN 7221	Turbulent Flows	
ASEN 6061	Molecular Gas Dynamics and DSMC	
ASEN 6331/ MCEN 5231	Computational Fluid Dynamics	
ASEN 6519	Special Topics (Advanced Turbulence Simulation)	
ASEN 6519	Special Topics (Flow Control)	
ASEN 6519	Special Topics (Isogeometric Analysis)	
ASEN 6519	Special Topics (Mathematical Foundations of Finite Element Analysis)	
ASEN 6519	Special Topics (Stabilized and Multiscale Finite Element Methods)	
MCEN 5022	Classical Thermodynamics	
MCEN 5042	Heat Transfer	
MCEN 5151	Flow Visualization	
MCEN 5152	Introduction to Combustion	
MCEN 6001	Reacting Flows	
Structures and Materials		
ASEN 5111	Introduction to Aeroelasticity	
ASEN 5148	Spacecraft Design	
ASEN 5188	Fundamentals of Systems Engineering	
ASEN 5212	Composite Structures and Materials	
ASEN 5218	Large Space Structures Design	
ASEN 5519	Special Topics (Deployable and Lightweight Structures)	
ASEN 5519	Special Topics (Design Optimization in Aerospace Systems)	
ASEN 5519	Special Topics (Introduction to Phononics)	
ASEN 5519	Special Topics (Inverse Methods)	
ASEN 5519	Special Topics (Nonlinear Mechanical Vibration)	
ASEN 6107	Nonlinear Finite Element Methods	
ASEN 6367	Advanced Finite Element Methods for Plates, Shells, and Solids	
ASEN 6412	Uncertainty Quantification	
ASEN 6519	Special Topics (Isogeometric Analysis)	
ASEN 6519	Special Topics (Mathematical Foundations of Finite Element Analysis)	
ASEN 6519	Special Topics (Molecular Dynamics)	
CVEN 5161	Advanced Mechanics of Materials I	
CVEN 6161	Advanced Mechanics of Materials 2	
CVEN 7141	Plates and Shells	
CVEN 7511	Computational Finite Inelasticity and Multiphase Mechanics	
MCEN 5044	Mechanical Behavior of Materials	
MCEN 5228	Special Topics in Mechanical Engineering (Mechanics of Composite Materials)	
MCEN 5228	Special Topics in Mechanical Engineering (Mechanics of Soft Materials)	

Remote Sensing, Earth and Space Science (RSESS) (https://www.colorado.edu/aerospace/current-students/graduates/curriculum/remote-sensing-earth-space-sciences/)

Note that MS students using the Remote Sensing Certificate for their degree requirements in lieu of an MS thesis or two semester graduate projects may count a maximum of 2 of the 4 required RSESS focus area courses toward the certificate requirement.

Code	Title	Credit Hours
Data or Numerical Analysis Methods Primary Courses		
Choose one:		3
ASEN 5307	Engineering Data Analysis Methods	
ASEN 6055	Data Assimilation & Inverse Methods for Earth & Geospace Observations	
ASEN 6337	Remote Sensing Data Analysis	

APPM 5350	Methods in Applied Mathematics: Fourier Series and Boundary Value Problems	
APPM 5570	Statistical Methods	
APPM 5580/ STAT 5610	Introduction to Statistical Learning	
ECEN 5612	Random Processes for Engineers	
ECEN 5632	Theory and Application of Digital Filtering	
ECEN 5652	Detection and Extraction of Signals from Noise	
STAT/MATH 5520	Introduction to Mathematical Statistics	
STAT/MATH 5540	Introduction to Time Series	
Instrumentation Fundamentals Primary Courses		
Choose one:		3
ASEN 5067	Microavionics: Introduction to PIC Microcontrollers for Aerospace Systems	
ASEN 5090	Introduction to Global Navigation Satellite Systems	
ASEN 5168	Remote Sensing Instrumentation Design	
ASEN 5245	Radar and Remote Sensing	
ASEN 5440	Mission Design and Development for Space Sciences	
ASEN 6050	Space Instrumentation	
ASEN 6265	Fundamentals of Spectroscopy for Optical Remote Sensing	
ASEN 6365	Lidar Remote Sensing	
Physical Sciences of Earth and Space Primary Courses		
Choose one:		3
ASEN/ATOC 5235	Introduction to Atmospheric Radiative Transfer and Remote Sensing	
ASEN 5335	Aerospace Environment	
ASEN 6519	Special Topics (Aerospace Environment: Upper Atmospheres)	
ASTR 5300	Introduction to Magnetospheres	
ATOC 5050	Atmospheric Thermodynamics and Dynamics	
ATOC 5051	Introduction to Physical Oceanography	
ATOC 5060	Dynamics of the Atmosphere and Oceans	
PHYS 5141	Astrophysical and Space Plasmas	
PHYS 5150	Introductory Plasma Physics	
Astrodynamics and Satellite Navigation Systems		
Choose one:		3
ASEN 5014	Linear Control Systems	
ASEN 5044	Statistical Estimation for Dynamical Systems	
ASEN 5050	Space Flight Dynamics	
or ASEN 5052	Analytical Astrodynamics	
ASEN 5051	Fundamentals of Fluid Dynamics	
ASEN 5148	Spacecraft Design	
ASEN 6070	Satellite Geodesy	
Total Credit Hours		**12**

Dual Degree Program

MS in Aerospace Engineering Sciences and ME in Engineering Management

Students may complement their aerospace engineering master's degree with a Master of Engineering (ME) in Engineering Management. To complete the Aerospace Engineering and Engineering Management dual degree program, students must be admitted to Aerospace Engineering first, and apply to Engineering Management afterwards.

Requirements

The dual degree consists of 45 credits: 24 credits based on Aerospace Engineering requirements and 21 based on Engineering Management requirements, as detailed below.

For more information, visit the Engineering Management Program's MS Aerospace Engineering Sciences & ME Engineering Management (http://www.colorado.edu/emp/programs/graduate-program/dual-degree-program/ms-aerospace-engineering-sciences-me-engineering/) webpage.

Aerospace Engineering

At least 24 credits at the 5000 level or above:

- At least 18 credits in Aerospace Engineering (ASEN) courses. (Note: EMEN 5405 Fundamentals of Systems Engineering counts as an ASEN class).
- One approved math course (3 credits)
- Professional MS students do not follow focus area-specific requirements and do not require the completion of a certificate, graduate projects or MS thesis
- Traditional MS students:
  - Completion of an approved certificate, graduate projects (6 credits) or MS thesis (6 MS thesis credits)
  - Fulfill focus area-specific requirements

Review our Graduate Student Handbook (https://www.colorado.edu/aerospace/current-students/graduates/curriculum/graduate-student-handbooks/) for details on focus area requirements, GPA and grade minimums, and other information.

Engineering Management

Students must complete at least 21 credits. Visit the Engineering Management website (https://www.colorado.edu/emp/current-students/graduate-programs/dual-graduate-degree/) for details.