AEROSPACE ENGINEERING SCIENCES

The aerospace program is organized around focus areas in astrodynamics and satellite navigation systems, bioastronautics, remote sensing, Earth and space sciences and aerospace engineering systems, including fluid dynamics and propulsion, automatic control, structures and mechanics of materials.

The Ann and HJ Smead Department of Aerospace Engineering Sciences (http://www.colorado.edu/aerospace) at the University of Colorado Boulder is one of the top aerospace engineering departments in the nation. Aerospace engineers work on Earth and in space not only to extend frontiers, but also to better understand and preserve our terrestrial environment. Few fields offer as many exciting and diverse career opportunities: becoming an astronaut (15 graduates to date have become astronauts), designing the next generation of aircraft and spacecraft, monitoring our global habitat via remote sensing from space, *in situ* sensing with unmanned vehicles and helping to develop environmentally clean energy and transportation systems.

Aerospace graduate students often formulate degree plans on the basis of their interests and needs. Portions of the program are designed to promote our students' engineering and professional development.

Graduate students are admitted into a specific focus area that provides research advising and financial support, and sets specialized admission and program requirements with recommendations for course work within and outside the department.

The four focus areas are:

- Aerospace Engineering Systems
  - Structures and mechanics of materials
  - Automatic control
  - Fluid dynamics and propulsion
- Astrodynamics and Satellite Navigation Systems
- Bioastronautics
- Remote Sensing, Earth and Space Sciences

Each focus area has defined the required characteristics of its successful graduates at the MS and PhD level, and defined the required and elective courses that support its educational program.

Aerospace-related research centers in the College include the Colorado Center for Astrodynamics Research, the Center for Aerospace Structures, the Research and Engineering Center for Unmanned Vehicles, and BioServe Space Technologies. Other research centers within the University that are involved in space-related research activities are the Center for the Study of Earth from Space, the Center for Astrophysics and Space Astronomy, the Laboratory for Atmospheric and Space Physics, JILA and the Cooperative Institute for Research in Environmental Sciences.

Course code for this program is ASEN.

Master's Degrees

- Aerospace Engineering Sciences - Master of Science (MS) (catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/aerospace-engineering-sciences/aerospace-engineering-sciences-master-science-ms)
- Aerospace Engineering Sciences - Professional Master of Science (MSAES) (catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/aerospace-engineering-sciences/aerospace-engineering-sciences-professional-master-science-msaes)

Doctoral Degree

- Aerospace Engineering Sciences - Doctor of Philosophy (PhD) (catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/aerospace-engineering-sciences/aerospace-engineering-sciences-doctor-philosophy-phd)

Certificates

- Astrodynamics and Satellite Navigation Systems - Graduate Certificate (catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/aerospace-engineering-sciences/astrodynamics-satellite-navigation-systems-graduate-certificate)
- Remote Sensing - Graduate Certificate (catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/aerospace-engineering-sciences/remote-sensing-graduate-certificate)
- Satellite Systems Design - Graduate Certificate (catalog.colorado.edu/graduate/colleges-schools/interdisciplinary-programs/satellite-system-design-certificate)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Ahmed, Nisar Razzi (https://experts.colorado.edu/display/fisid_153237)
Assistant Professor; PhD, Cornell University

Akos, Dennis M. (https://experts.colorado.edu/display/fisid_131119)
Professor, Associate Chair; PhD, Ohio University

Anderson, Allison P. (https://experts.colorado.edu/display/fisid_156275)
Assistant Professor; PhD, Massachusetts Institute of Technology

Argrow, Brian M. (https://experts.colorado.edu/display/fisid_102860)
Professor, Chair; PhD, University of Oklahoma

Axelrad, Penina (https://experts.colorado.edu/display/fisid_100792)
Professor, Chair; PhD, Stanford University

Biringen, Sedat (https://experts.colorado.edu/display/fisid_105974)
Professor; DSc, Universite Libre de Bruxelles (Belgium)

Bosanac, Natasha (https://experts.colorado.edu/display/fisid_158199)
Assistant Professor; PhD, Purdue University

Brasseur, James Gordon (https://experts.colorado.edu/display/fisid_156801)
Research Professor; PhD, Stanford University

Braun, Bobby (https://experts.colorado.edu/display/fisid_158523)
Professor; PhD, Stanford University

Chow, Chuen-Yen
Professor Emeritus

Chu, Xinzhao (https://experts.colorado.edu/display/fisid_141893)
Professor; PhD, Peking University (China)

Clark, Torin K. (https://experts.colorado.edu/display/fisid_155959)
Assistant Professor; PhD, Massachusetts Institute of Technology

Correll, Nikolaus J. (https://experts.colorado.edu/display/fisid_147555)
Associate Professor; PhD, Ecole Polytech Federale de Lausanne (Switzerland)

Culp, Robert D.
Professor Emeritus

Doostan, Alireza (https://experts.colorado.edu/display/fisid_147382)
Associate Professor; PhD, Johns Hopkins University

Emery, William J.
Professor Emeritus

Evans, John A. (https://experts.colorado.edu/display/fisid_152970)
Assistant Professor; PhD, University of Texas at Austin

Farnsworth, John A. (https://experts.colorado.edu/display/fisid_153255)
Assistant Professor; PhD, Rensselaer Polytechnic Institute

Felippa, Carlos A. (https://experts.colorado.edu/display/fisid_105701)
Professor; PhD, University of California, Berkeley

Forbes, Jeffrey M.
Professor Emeritus

Frew, Eric W. (https://experts.colorado.edu/display/fisid_134685)
Professor; PhD, Stanford University

Gates, Harvey
Associate Professor Adjunct; PhD, University of Denver

Gerren, Donna Sue (https://experts.colorado.edu/display/fisid_108563)
Teaching Professor; PhD, University of Kansas

Heckman, Christoffer (https://experts.colorado.edu/display/fisid_155294)
Assistant Professor; PhD, Cornell University

Hieb, Rick
Scholar in Residence; MS, University of Colorado

Hodgkinson, Robert
Instructor; MS, University of Colorado Boulder

Holzinger, Marcus J.
Associate Professor; PhD, University of Colorado Boulder

Hussein, Mahmoud Ismail (https://experts.colorado.edu/display/fisid_144300)
Associate Professor; PhD, University of Michigan Ann Arbor

Jackson, Jelliffe
Instructor; PhD, University of Florida

Jansen, Kenneth E. (https://experts.colorado.edu/display/fisid_147360)
Professor; PhD, Stanford University

Jones, Brandon A. (https://experts.colorado.edu/display/fisid_149418)
Assistant Professor Adjunct; PhD, University of Colorado

Kantha, Lakshmi H. (https://experts.colorado.edu/display/fisid_100231)
Professor; PhD, Massachusetts Institute of Technology

Klaus, David M. (https://experts.colorado.edu/display/fisid_107103)
Professor, Associate Chair; PhD, University of Colorado Boulder

Knipp, Delores Jane (https://experts.colorado.edu/display/fisid_147655)
Research Professor; PhD, University of California, Los Angeles

Koster, Jean N.
Professor Emeritus

Lahijanian, Morteza Mehdi (https://experts.colorado.edu/display/fisid_164179)
Assistant Professor; PhD, Boston University

Larson, Kristine M.
Professor Emerita

Lawrence, Dale A. (https://experts.colorado.edu/display/fisid_104057)
Professor; PhD, Cornell University

Leben, Robert R.
Research Professor Emeritus

Li, Xinlin (https://experts.colorado.edu/display/fisid_100016)
Professor; PhD, Dartmouth College

Liu, Hanli
Associate Professor Adjunct; PhD, University of Michigan

López Jiménez, Francisco (https://experts.colorado.edu/display/fisid_157867)
Assistant Professor; PhD, California Institute of Technology

Mah, John
Instructor; MS, Stanford University

Marshall, David B. (https://experts.colorado.edu/display/fisid_158629)
Research Professor; PhD, Monash University (Australia)

Marshall, Robert Andrew (https://experts.colorado.edu/display/fisid_155957)
Assistant Professor; PhD, Stanford University

Maslanik, James
Research Professor Emeritus

Matsuo, Tomoko (https://experts.colorado.edu/display/fisid_145041)
Assistant Professor; PhD, SUNY at Stony Brook

Maute, Kurt (https://experts.colorado.edu/display/fisid_113875)
Professor; PhD, University of Stuttgart (Germany)

McGrath, Michael T. (https://experts.colorado.edu/display/fisid_100133)
Professor Adjunct; BS, University of Colorado Boulder

McMahon, Jay Warren (https://experts.colorado.edu/display/fisid_150062)
Assistant Professor; PhD, University of Colorado Boulder

Morton, Jade
Professor; PhD, Pennsylvania State University

Nabity, James A. (https://experts.colorado.edu/display/fisid_153102)
Associate Professor; PhD, University of Colorado Boulder

Neogi, Sanghamitra (https://experts.colorado.edu/display/fisid_156773)
Assistant Professor; PhD, Pennsylvania State University

Nerem, R. Steven (https://experts.colorado.edu/display/fisid_118478)
Professor; PhD, University of Texas at Austin

Palo, Scott E. (https://experts.colorado.edu/display/fisid_109033)
Professor; PhD, University of Colorado Boulder

Park, Kwang-Chun
Professor Emeritus

Schaub, Hanspeter (https://experts.colorado.edu/display/fisid_143818)
Professor, Associate Chair; PhD, Texas A&M University

Scheeres, Daniel J. (https://experts.colorado.edu/display/fisid_145035)
Distinguished Professor; PhD, University of Michigan Ann Arbor

Schwartz, Trudy L. (https://experts.colorado.edu/display/fisid_108607)
Senior Instructor; MS, University of Colorado Boulder

Scott, Hank
Lecturer; MA, University of Queensland

Singer, Howard Joseph (https://experts.colorado.edu/display/fisid_154257)
Professor Adjunct; PhD, University of California, Los Angeles

Spalart, Philippe
Professor Adjoint; PhD, Stanford University

Sternovsky, Zoltan (https://experts.colorado.edu/display/fisid_115211)
Associate Professor; PhD, Charles University (Czech Republic)

Stodieck, Louis S. (https://experts.colorado.edu/display/fisid_105272)
Research Professor; PhD, University of Colorado Boulder

Thayer, Jeffrey P. (https://experts.colorado.edu/display/fisid_134469)
Professor; PhD, University of Michigan Ann Arbor

Voss, James S. (https://experts.colorado.edu/display/fisid_140891)
Scholar in Residence; MS, University of Colorado Boulder

Williams, Christopher (https://experts.colorado.edu/display/fisid_105765)
Research Professor; PhD, University of Colorado Boulder

Wingate, Kathryn
Instructor; PhD, University of Colorado Boulder

Courses

ASEN 5007 (3) Introduction to Finite Elements
Introduces finite element methods used for solving linear problems in structural and continuum mechanics. Covers modeling, mathematical formulation, and computer implementation.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite matrix algebra.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 5010 (3) Spacecraft Attitude Dynamics and Control
Includes rigid body kinematics and spacecraft attitude descriptions, torque-free attitude dynamics, static attitude determination, motion and stability due to gravity gradient torque and spinning craft, passive and active methods of attitude control, nonlinear regulator and attitude tracking feedback controlaws.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 3200 or equivalent or instructor consent required.
Additional Information: Departmental Category: Astrodynamics and Orbital Mechanics

ASEN 5012 (3) Mechanics of Aerospace Structures
Applies fundamental concepts of continuum mechanics, theory of elasticity and energy methods to the analysis of structures.
Equivalent - Duplicate Degree Credit Not Granted: MCEN 5023
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisites APPM 2360 and ASEN 2001 and ASEN 2003 and ASEN 3112 or equivalent or instructor consent required.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 5014 (3) Linear Control Systems
Introduces the theory of linear systems, including vector spaces, linear equations, structure of linear operators, state space descriptions of dynamic systems, and state feedback control methods.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 3200 or equivalent or instructor consent required.
Additional Information: Departmental Category: Systems and Control

ASEN 5016 (3) Space Life Sciences
Familiarizes students with factors affecting living organisms in the reduced-gravity environment of space flight. Covers basic life support requirements, human physiological adaptations, and cellular-level gravity dependent processes with emphasis on technical writing and research proposal preparation.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Bioastronautics and Microgravity Science

ASEN 5018 (3-6) Graduate Projects I
Exposes MS and PhD students to project management and systems engineering disciplines while working a complex aerospace engineering project as part of a project team. The project team may perform some or all of the following project activities during this first semester of the two-semester course sequence: requirements, definition, design and design review, build, test, and verification.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 4138 or ASEN 5148 or ASEN 5158 or instructor consent required.

ASEN 5022 (3) Dynamics of Aerospace Structures
Applies concepts covered in undergraduate dynamics, structures and mathematics to the dynamics of aerospace structural components, including methods of dynamic analysis, vibrational characteristics, vibration measurements and dynamic stability.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5012 or ASEN 5227 or MATH 2130 or APPM 3310 or equivalent or instructor consent required.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 5034 (3) Stochastic Methods for Systems Engineering
Development of stochastic models used in aerospace and other systems engineering and optimization problems. Review of probability theory, stochastic models used in decision theory, random processes, queuing theory, information theory, reliability and quality control. Computer solutions required.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 5044 (3) Statistical Estimation for Dynamical Systems
Introduces theory and methods of statistical estimation for general linear and nonlinear dynamical systems, with emphasis on aerospace engineering applications. Major topics include: review of applied probability and statistics; optimal parameter and dynamic state estimation; theory and design of Kalman filters for linear systems; extended/unscented Kalman filters and general Bayesian filters for non-linear systems.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Systems and Control

ASEN 5047 (3) Probability and Statistics for Aerospace Engineering Sciences
Considers probability concepts and theory for better design and control of aerospace engineering systems. Includes descriptive and inferential statistical methods for experimental analysis. Covers discrete and continuous random variable distributions, estimators, confidence intervals, regression, analysis of variance, hypothesis testing, nonparametric statistics, random processes and quality control, including software models of same.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Computational and Analytic Methods

ASEN 5050 (3) Space Flight Dynamics
Includes celestial mechanics, space navigation, and orbit determination; trajectory design and mission analysis trajectory requirements; and orbital transfer and rendezvous.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 3200 or equivalent or instructor consent required.
Additional Information: Departmental Category: Astrodynamics and Orbital Mechanics

ASEN 5051 (3) Fluid Mechanics
Highlights physical properties of gases and liquids; kinematics of flow fields; and equations describing viscous, heat-conducting Newtonian fluids. Emphasizes exact solutions and rational approximations for low and high speed dissipative flows, surface and internal waves, acoustics, stability, and potential flows.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Aerodynamics and Fluid Mechanics

ASEN 5053 (3) Rocket Propulsion
An in depth presentation of the theory, analysis, and design of rocket propulsion systems. Liquid and solid propellant systems are emphasized with an introduction to advanced propulsion concepts. Nozzle and fluid flow relationships are reviewed for background.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Thermodynamics and Propulsion

ASEN 5063 (3) Aircraft Propulsion
Designed to teach the theory, analysis and design of engines used for aircraft propulsion. Will deal with engine selection, engine performance, analysis and design of various components of modern aircraft engines, with emphasis on recent developments such as the geared turbofan.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 4013 or equivalent or instructor consent required.
Additional Information: Departmental Category: Thermodynamics and Propulsion

ASEN 5090 (3) Introduction to Global Navigation Satellite Systems
Global Navigation Satellite Systems (GNSS) are important tools for navigation, science, and engineering. Introduces GNSS hardware, signal structure, algorithms, error sources, and modeling techniques. Programming experience is required.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Global Positioning Systems

ASEN 5098 (3) System Engr and Design
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 5111 (3) Introduction to Aeroelasticity
Introduces static and dynamic aeroelasticity of airfoils and wings. Covers the classical aeroelasticity theory and introduces computational methods for aeroelastic problems.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisites ASEN 3111 or MATH 2130 or APPM 3310 and MATH 3430 or equivalent or instructor consent required.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 5114 (3) Automatic Control Systems
Methods of analysis and design of feedback control for dynamic systems. Covers nyquist, bode and linear quadratic methods based on frequency domain and state space models. Laboratory experiments provide exposure to computation for simulation and real time control, and typical control system sensors and actuators.
Equivalent - Duplicate Degree Credit Not Granted: ASEN 4114
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisites ASEN 3128 and ASEN 3200 or equivalent or instructor consent required.
Additional Information: Departmental Category: Systems and Control

ASEN 5122 (3) Control of Aerospace Structures 1
Introduces the basic problems in dynamic modeling and active control of large spacecraft and satellites. Includes system descriptions, model reduction, controller design, and closed-loop stability analysis.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 3200 or equivalent or instructor consent required.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 5148 (3) Spacecraft Design
Integrates the design elements and fundamental analyses necessary to complete the conceptual (Phase A) design of an unmanned spacecraft. Lecture and discussion explore mission design, propulsion, power, structure, thermal, attitude control, communication, command, and data handling and attitude control systems. The role of project management and systems engineering are examined. Resource estimating and lessons learned in satellite programs are reviewed.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 5151 (3) High Speed Aerodynamics
Provides aerodynamic theory applicable to the high speed flight of subsonic, transonic, and supersonic aircraft, and hypersonic vehicles. Topics include linear theory of subsonic and supersonic speeds, the nonlinear theories of transonic and hypersonic speeds, and compressible boundary layers.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Aerodynamics and Fluid Mechanics

ASEN 5158 (3) Space Habitat Design
Utilizes systems engineering methods for designing a spacecraft intended for human occupancy and provides a working knowledge of the technologies used to sustain life. Emphasis is placed on deriving functional requirements from stated mission objectives, developing integrated vehicle schematics, and comparing design options by trade study.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 5168 (3) Remote Sensing Instrumentation Design
Reviews and makes a detailed analysis of satellite instrumentation techniques and systems to understand the components, limitations, and overall capabilities. Emphasis on optical systems with in-depth treatment of conventional radiometry. Introduces both passive and microwave methods.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 5188 (3) Fundamentals of Systems Engineering
Examines the disciplined processes of designing and managing complex systems over their life cycle. Requirements engineering, reliability, logistics, team leadership, testing and evaluation, maintainability and other disciplines are examined with focus on the system engineering of small spacecraft.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 5210 (1) Remote Sensing Seminar
Covers subjects pertinent to remote sensing of the Earth, including oceanography, meteorology, vegetation monitoring, and geology. Emphasizes techniques for extracting geophysical information from satellite data. Course requirement for Remote Sensing Certificate. Formerly ASEN 6210.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Remote Sensing

ASEN 5212 (3) Composite Structures and Materials
Develops the macromechanical and micromechanical theory of the elastic behavior and failure of composite laminates. Applies basic theory to a broad range of practical problems including the buckling and vibration of composite plates, columns, and shells.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 5215 (3) Descriptive Physical Oceanography
Introduces descriptive and dynamical physical oceanography, focusing on the nature and dynamics of ocean currents and their role in the distribution of heat and other aspects of ocean physics related to the Earth's climate. Dynamical material limited to mathematical descriptions of oceanic physical systems.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5215
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Atmospheric, Oceanic, and Space Sciences

ASEN 5218 (3) Large Space Structures Design
Develops the necessary structural analysis skills for conducting conceptual and preliminary designs of large space structures with a practical emphasis on structures considered by NASA over the past 20 years. Applies analysis skills to a broad range of space missions requiring large space structures, emphasizing low cost and practical design.
Equivalent - Duplicate Degree Credit Not Granted: ASEN 4218
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 5222 (3) Materials Science for Composite Manufacturing
Studies common matrix materials and the modificationsand improvements of properties which can be achieved by adding second phase reinforcements. Properties will be significantly affected by the design approach and by requirements, and by the procedure of adding reinforcements. Investigates polymer, ceramic and metallic materials. Explores manufacturing, fabrication and processing techniques. Evaluates future developments.
Equivalent - Duplicate Degree Credit Not Granted: ASEN 4222
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisites ASEN 3112 and ASEN 4012 or equivalent or instructor consent required.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 5227 (3) Mathematics for Aerospace Engineering Sciences 1
Provides an introduction to the methods and mathematics of advanced engineering analysis tailored to aerospace engineering applications. Topics include vector and tensor calculus, ordinary differential equations, and an introduction to the calculus of variations.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Computational and Analytic Methods

ASEN 5235 (3) Introduction to Atmospheric Radiative Transfer and Remote Sensing
Examines fundamentals of radiative transfer and remote sensing with primary emphasis on the Earth's atmosphere; emission, absorption and scattering by molecules and particles; multiple scattering; polarization; radiometry and photometry; principles of inversion theory; extinction- and emission-based passive remote sensing; principles of active remote sensing; lidar and radar; additional applications such as the greenhouse effect and Earth's radiative energy budget.
Equivalent - Duplicate Degree Credit Not Granted: ATOC 5235
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite one year of calculus-based physics and math up through differential equations.
Additional Information: Departmental Category: Remote Sensing

ASEN 5245 (3) Radar and Remote Sensing
Examines active techniques of remote sensing, with emphasis on radar fundamentals, radar wave propagation, scattering processes, and radar measurement techniques and design. Examines specific radar systems and applications, such as synthetic aperture radar phased arrays for atmosphere, space, land, and sea applications.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Remote Sensing

ASEN 5255 (3) Environmental Aerodynamics
A review of the properties and causes of hazards posed by the environment, ranging from atmospheric wind shear to tornadic flows. Involves a multidisciplinary approach combining analytical, numerical, scale modeling studies with extensive field measurements, wind energy and biophysical aerodynamics.
Equivalent - Duplicate Degree Credit Not Granted: ASEN 4255
Recommended: Prerequisite senior standing in aerospace engineering.
Additional Information: Departmental Category: Atmospheric, Oceanic, and Space Sciences

ASEN 5307 (3) Engineering Data Analysis Methods
Gives students broad exposure to a variety of traditional and modern statistical methods for filtering and analyzing data. Topics include estimation methods, principal component analyses and spectral analyses. Introduces these methods and provides practical experience with their use. Students carry out problem assignments.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Computational and Analytic Methods

ASEN 5315 (3) Ocean Modeling
Introduces students to basic principles behind, and the current practices in, ocean modeling. Discusses different prevailing approaches. Offers students hands-on experience with the use of supercomputers and work stations for model running and pre- and post-processing.
Recommended: Prerequisite graduate standing or instructor consent required.
Additional Information: Departmental Category: Atmospheric, Oceanic, and Space Sciences

ASEN 5321 (3) Computational Fluid Dynamics Structured Grid
Introduction to advanced computational methods for the solution of fluid mechanics problems on the computer with emphasis on nonlinear flow phenomena. Formerly ASEN 6327.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5417 or equivalent or instructor consent required.
Additional Information: Departmental Category: Aerodynamics and Fluid Mechanics

ASEN 5325 (3) Small Scale Processes in Geophysical Fluids
Provides an overview of mixing and wave processes in the oceans and the atmosphere. Topics include turbulent boundary layers in the lower atmosphere and the upper ocean, air-sea interactions, and surface and internal waves.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Atmospheric, Oceanic, and Space Sciences

ASEN 5331 (3) Computational Fluid Dynamics Unstructured Grid
Focuses on unstructured grid computational approaches to solve the Navier-Stokes equations. Assumes a basic knowledge of the solution of partial differential equations with numerical methods with focus finite element/volume methods (FEM/FVM but primarily FEM). These issues include: the discrete formulation, non-linear equation iterator, linear equation formation, boundary condition prescription and linear equation solution.
Requisites: Restricted to Engineering (ENGR) graduate students or Aerospace Engineering-Concurrent Degree (C-ASEN) students.
Additional Information: Departmental Category: Aerodynamics and Fluid Mechanics

ASEN 5335 (3) Aerospace Environment
Examines the components of the solar-terrestrial system and their interactions to provide an understanding of the re-entry and orbital environments within which aerospace vehicles operate. Includes the sun, solar wind, magnetospere, ionosphere, thermosphere, radiation belts, energetic particles, comparative environments (Mars, Venus, etc.), orbital debris, spacecraft charging, particle effects on systems, shielding, and satellite drag.
Recommended: Prerequisite senior or graduate standing in engineering or related physical sciences.
Additional Information: Departmental Category: Atmospheric, Oceanic, and Space Sciences

ASEN 5347 (3) Math Methods in Dynamics
Two-part graduate-level course on dynamics. Covers both flexible and rigid multibody analytical dynamics and finite element method for dynamics. Emphasizes formulations that naturally lead to easy computer implementation and stability, linearization, and modern rotational kinematics. Department consent required.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 5417 (3) Numerical Methods in Engineering and Science
Provides computational skills and basic knowledge of numerical methods for advanced courses in engineering/scientific computation using Fortran, C, or Matlab.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite APPM 2360 or equivalent or instructor consent required.
Additional Information: Departmental Category: Computational and Analytic Methods

ASEN 5426 (3) Neural Systems and Physiological Control
A biophysical exploration of human physiology from the standpoints of control systems and neural information processing. Topics include: neural control of movement and cardiovascular performance, tissue growth and repair, carcinogenesis, and physiological responses to microgravity.
Equivalent - Duplicate Degree Credit Not Granted: ASEN 4426 and ECEN 4821 and ECEN 5821
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Bioastronautics and Microgravity Science

ASEN 5440 (3) Mission Design and Development for Space Sciences
Brings science and engineering students together to develop the multidisciplinary skills required to create a successful proposal to develop a NASA-funded small space mission. Goals: 1) develop the proposal science objectives based on scientific community priorities and NASA Announcement of Opportunity. 2) Understand how science requirements lead to the design of instrumentation. 3) Understand practical aspects of mission development.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 5780
Grading Basis: Letter Grade
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 5506 (1-2) Bioastronautics Seminar
Focuses on current topics related to space habitat systems design and research aimed at understanding the effects of spaceflight on living organisms ranging from humans down to microbes. Literature analysis and scientific presentations are expected. Emphasis is on biophysical mechanisms, comprehensive models, and related technology development.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Bioastronautics and Microgravity Science

ASEN 5519 (1-3) Selected Topics
Reflects upon specialized aspects of aerospace engineering sciences. Course content is indicated in the online Class Search.
Repeatable: Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite varies.
Additional Information: Departmental Category: Specialized Courses

ASEN 5849 (1-6) Independent Study
Study of special projects.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Specialized Courses

ASEN 5940 (3-6) Engineering Research Internship
Grants credit to foreign visiting graduate students for conducting research within the Aerospace Engineering Sciences department. Credits can be transferred to the student's home institution. CU-Boulder students may also receive credit for conducting research outside of the university, either overseas or in the US.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Specialized Courses

ASEN 6008 (3) Interplanetary Mission Design
Exploration of principles and methods related to the design and construction of trajectories for interplanetary mission design. Some topics covered include: two-and three-body motion, gravity assists, maneuver computation, navigation, numerical integration, and construction of orbits. The main focus is on simple ballistic mission designs, such as Galileo or Cassini, however, libration point trajectories will also be covered.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5050 or instructor consent required.
Additional Information: Departmental Category: Astrodynamics and Orbital Mechanics

ASEN 6009 (1-2) Special Topics Seminar
Presents research and developments in each department's focus areas.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Specialized Courses

ASEN 6010 (3) Advanced Spacecraft Dynamics and Control
Studies the dynamic modeling and control of spacecraft containing multiple momentum exchange devices, and/or flexible spacecraft components. Will develop nonlinear feedback control algorithms, explore singularity avoidance strategies. The second half of the course derives analytical methods (D'Alembert's equations, Lagrange's equations, Boltzmann Hamel equations) to model a hybrid rigid/flexible spacecraft system.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Requires prerequisite course of ASEN 5010 (minimum grade D-).
Additional Information: Departmental Category: Astrodynamics and Orbital Mechanics

ASEN 6013 (3) High Speed Propulsion
Covers air-breathing and rocket propulsion cycles, their relative performance trade-offs, and how they fit within the context of a vehicle system. Specific emphasis will be placed on fundamental cycle analyses, component level design, and propulsion/airframe integration for rockets, turbojets, ramjets, scramjets, combined cycles, and other advanced propulsion concepts.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 4013 or equivalent or instructor consent required.
Additional Information: Departmental Category: Thermodynamics and Propulsion

ASEN 6014 (3) Spacecraft Formation Flying
Studies the dynamic modeling and control of spacecraft formations orbiting about a planet. Investigate linear and nonlinear relative motion descriptions, rectilinear and curvilinear coordinates, orbit element difference based descriptions, J2-invariant relative orbits, as well as Lyapunov-based relative motion control strategies.
Repeatable: Repeatable for up to 6.00 total credit hours.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5050 or instructor consent required.
Additional Information: Departmental Category: Systems and Control

ASEN 6020 (3) Optimal Trajectories
Introduces the theory and practice of trajectory optimization. The general theory behind optimization and optimal control will be introduced with an emphasis on the properties of optimal trajectories. The main application will be to space trajectories, but other applications will also be considered.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisites ASEN 5050 and ASEN 5014 or instructor consent required.
Additional Information: Departmental Category: Astrodynamics and Orbital Mechanics

ASEN 6021 (3) Viscous Flow
Studies low Reynolds number flows, including incompressible and compressible laminar boundary layer theory; similarity theory; and separation, transition, and turbulent boundary layers.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5051 or equivalent or instructor consent required.
Additional Information: Departmental Category: Aerodynamics and Fluid Mechanics

ASEN 6024 (3) Nonlinear Control Systems
Introduces the analysis and control design methods for nonlinear systems, including Lyapunov and Describing Function methods.
Requisites: Requires prerequisite course of ASEN 5014 (minimum grade C). Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Systems and Control

ASEN 6028 (3) Graduate Projects II
Exposes MS and PhD students to leadership positions in project management and systems engineering while working a complex aerospace engineering project as part of a project team. The project team may perform some or all of the following project activities during this second semester of the two-semester course sequence: requirements definition, design and design review, build, test, and verification.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 4138 or ASEN 5148 or ASEN 5018 or ASEN 5158 or instructor consent required.
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 6037 (3) Turbulent Flows
Studies turbulent closure methods and computational procedures used to solve practical turbulent flows. Emphasizes multi-equation models used with time-averaged equations to calculate free-turbulent shear-flows and turbulent boundary layers. Employs spectral methods in direct and large-eddy simulation of turbulence. Formerly ASEN 6037.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5051 or equivalent or instructor consent required.
Additional Information: Departmental Category: Aerodynamics and Fluid Mechanics

ASEN 6050 (3) Space Instrumentation
Provides an overview of the relevant space environment and process, the types of instruments flown on recent mission and the science background of the measurement principles.
Equivalent - Duplicate Degree Credit Not Granted: ASTR 6050 and GEOL 6050
Requisites: Requires prerequisite course of ASEN 5335 (minimum grade D-).
Grading Basis: Letter Grade
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 6055 (3) Data Assimilation & Inverse Methods for Earth & Geospace Observations
Covers a selection of topics in probability theory, spatial statistics, estimation theory, numeric optimization, and geophysical nonlinear dynamics that form the foundation of commonly used data assimilation and inverse methods in the Earth and Space Sciences. Hands-on computational homework and projects provide opportunities to apply classroom curricula to realistic examples in the context of data assimilation.
Requisites: Requires prerequisite course of ASEN 5044 (minimum grade B-). Restricted to graduate students.
Grading Basis: Letter Grade

ASEN 6060 (3) Advanced Astrodynamics
Covers Lagrangian and Hamiltonian formalisms for astrodynamics problems, the computation and characterization of space trajectories in highly dynamic environments, computation of periodic orbits, stability analysis of orbital motion, and development of analytical theories for dynamics.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5050 or equivalent or instructor consent required.
Additional Information: Departmental Category: Astrodynamics and Orbital Mechanics

ASEN 6061 (3) Molecular Gas Dynamics and DSMC
Describes the composition and flow of gases on a microscopic level to examine the behavior of the molecules that make up a macroscopic flow system. Thermodynamic properties, transport phenomena, and the governing Boltzmann Equation are derived from molecular collision dynamics and the kinetic theory. The Direct Simulation Monte Carlo method is introduced with applications.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Aerodynamics and Fluid Mechanics

ASEN 6070 (3) Satellite Geodesy
Focuses on the measurement of the Earth's gravitational field, rotational characteristics, and shape using Earth and space-based tracking of artificial satellites. Particular emphasis on satellite altimetry and satellite gravity measurements.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 3200 or equivalent or instructor consent required.
Additional Information: Departmental Category: Astrodynamics and Orbital Mechanics

ASEN 6080 (3) Statistical Orbit Determination
Course on orbit and advanced estimation techniques. Emphasizes orthogonal transformation techniques such as Givens and Householder, square root filtering and smoothing and considers covariance analysis. Also nonlinear filters and dynamic model compensation techniques. Requires term project that involves the application of many of the techniques required for precise orbit determination.
Requisites: Requires prerequisite course of ASEN 5044 (minimum grade D-). Restricted to Aerospace Engineering (ASEN) graduate students or Aerospace Engineering-Concurrent Degree (C-ASEN) students.
Additional Information: Departmental Category: Astrodynamics and Orbital Mechanics

ASEN 6090 (3) Advanced Global Navigation Satellite Systems: Software and Applications
Focuses on high-precision applications of Global Navigation Satellite Systems (GNSS) and the software tools that are needed to achieve these precisions. Topics include precise orbital determination, reference frames, atmospheric delays, relativity, clock models, ambiguity resolution, and scientific applications.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5090 or instructor consent required.
Additional Information: Departmental Category: Global Positioning Systems

ASEN 6091 (3) Global Navigation Satellite System (GNSS) Receiver Architecture
Investigates the overall architecture of satellite navigation receivers: including both the analog radio frequency conditioning (antenna to the analog-to-digital converter) and the various signal processing algorithms. Such treatment of the operation of the receiver will provide insight into the trade-offs that go into GNSS as well as the more broad generic spread spectrum receiver design.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5090.
Additional Information: Departmental Category: Global Positioning Systems

ASEN 6107 (3) Nonlinear Finite Element Methods
Continuation of ASEN 5007. Covers the formulation and numerical solution of nonlinear static structural problems by finite element methods. Emphasizes the treatment of geometric nonlinearities and structural stability.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5007 or equivalent or instructor consent required.
Additional Information: Departmental Category: Specialized Courses

ASEN 6116 (3) Spacecraft Life Support Systems
Study the environmental control and the life support systems and technologies that keep people alive and healthy in spacecraft and habitats. Students will learn about thermal control systems, air revitalization processes, water reclamation and treatment, waste handling and the reuse of materials, and food and nutrition. Expect to develop analytical models from first principles and perform hands-on laboratory experiments. Formerly ASEN 5116.
Requisites: Requires prerequisite course of ASEN 5158 (minimum grade D-). Requires corequisite course of ASEN 5016. Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Grading Basis: Letter Grade
Additional Information: Departmental Category: Bioastronautics and Microgravity Science

ASEN 6220 (3) Topics in Remote Sensing
Covers infrared and microwave techniques for remote sensing, emphasizing oceanographic applications, fundamentals of electromagnetic radiation, remote sensing instrumentation (radars and radiometers), and conversion of sensory data to geophysical parameters, including sea surface topography, temperature, and atmospheric moisture.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Remote Sensing

ASEN 6265 (3) Fundamentals of Spectroscopy for Optical Remote Sensing
Provides a comprehensive overview of the fundamentals of quantum physics, atomic spectroscopy, molecular spectroscopy and laser spectroscopy. Exposes students to the spectroscopy applications in modern optical and laser remote sensing. Assists students to develop the fundamental knowledge and skills for independent learning.
Requisites: Restricted to Engineering (ENGR) graduate students or Aerospace Engineering-Concurrent Degree (C-ASEN) students.

ASEN 6337 (3) Remote Sensing Data Analysis
Covers some of the most commonly used machine learning techniques in remote sensing data analysis, specifically for clustering, classification, feature extraction and dimensionality reduction, and inverse methods used to retrieve geophysical information from remote sensing data. Hands-on computational homework and group and individual projects provide opportunities to apply classroom curricula to real remote sensing data.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Additional Information: Departmental Category: Remote Sensing

ASEN 6365 (3) Lidar Remote Sensing
Provides a comprehensive, yet easily understandable, up-to-date understanding of lidar principles, technologies and applications. Contains approaches for quantitative lidar simulation, lidar sensitivity and error analysis, lidar data retrieval, lidar system design and performance analysis. Gives students opportunities to see and operate real state-of-the-art lidar systems and make connections to lidar experts in the nation and world.
Requisites: Restricted to Engineering (ENGR) graduate students or Aerospace Engineering-Concurrent Degree (C-ASEN) students.
Additional Information: Departmental Category: Aerospace Design and System Engineering

ASEN 6367 (3) Advanced Finite Element Methods for Plates, Shells, and Solids
Continues ASEN 5007. Covers more advanced FEM applications to linear static problems in structural and continuum mechanics. Focuses on modeling, formulation and numerical solutions of problems modeled as plates, shells and solids. Includes an overview of advanced variational formulations.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite introductory graduate level course in FEM and familiarity with linear algebra.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 6412 (3) Uncertainty Quantification
This advanced topics course provides an exploration of techniques for representation and propagation of uncertainty in PDE/ODE-based systems.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisites APPM 5570 and ECEN 5612 (all minimum grade B) or equivalent courses with instructor consent.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 6427 (3) Advanced Computational Fluid Dynamics
Introduces computational techniques particularly applicable to high-speed gas flows that contain shocks. Complicated numerical methods are developed from relatively simple numerical modules.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5417 or equivalent or instructor consent required.
Additional Information: Departmental Category: Aerodynamics and Fluid Mechanics

ASEN 6517 (3) Computational Methods In Dynamics
Covers modeling, computational algorithms and their computer implementation for both linear and nonlinear dynamical systems. Topics covered include transient analysis, wave propagation, multiphysics analysis, and their significant engineering applications.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite ASEN 5022 or equivalent or instructor consent required.
Additional Information: Departmental Category: Structures, Materials, and Structural Dynamics

ASEN 6519 (1-3) Special Topics
Reflects upon specialized aspects of aerospace engineering sciences. Course content is indicated in the online Schedule Planner.
Repeatable: Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to College of Engineering (ENGR) graduate students or Aerospace Engineering Concurrent Degree (C-ASEN) majors only.
Recommended: Prerequisite varies.
Additional Information: Departmental Category: Specialized Courses

ASEN 6800 (3) Master of Engr Project
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Requisites: Restricted to graduate students only.
Additional Information: Departmental Category: Specialized Courses

ASEN 6849 (1-6) Independent Study
Studies special projects agreed upon by student and instructor.
Repeatable: Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.
Additional Information: Departmental Category: Specialized Courses

ASEN 6949 (1) Master's Candidate for Degree
Grading Basis: Pass/Fail
Additional Information: Departmental Category: Specialized Courses

ASEN 6950 (1-6) Master's Thesis
Additional Information: Departmental Category: Specialized Courses

ASEN 8990 (1-10) Doctoral Thesis
Additional Information: Departmental Category: Specialized Courses