ASEN 2804 – Spring 2024

Aerospace Vehicle Design Laboratory

Lab: M/W 8:30 – 10:20 am (Section 001 / Room Aero 141 - PILOT)
M/W 10:35 am – 12:25 pm (Section 002 / Room Aero 141 - PILOT)

T/TH 8:30 – 10:20 am (Section 003 / Room Aero 141 - PILOT)
T/TH 10:35 am – 12:25 pm (Section 004 / Room Aero 141 - PILOT)

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Teaching Assistants/Fellows:

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Lab Assistants: Alyx Ellington
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Class Canvas Website:

Texts (Optional): Anderson, **Introduction to Flight**, 8th or 9th ed. (hardcopy or electronic version)
Sellers, **Understanding Space: An Introduction to Astronautics**, 3rd or 4th ed.

Pre/Co-requisites: (PR) ASEN 1320; (PR or CR); ASEN 2704, 2012

Required Equipment / Software

- Access to a computer or laptop
- Computational / Programming Software
    - Many assignments will require access to a computer and basic programming skills. Computer programming skills are a prerequisite for this class, e.g. GEEN 1300, ASEN 1320/CSCI 1300. We will not teach computer programming, although we will make an effort to formulate the assignments to emphasize proper computing skills.
    - MATLAB is highly recommended but not required. You can download a free MATLAB license for your personal computer from CU at https://oit.colorado.edu/software-hardware/software-downloads-and-licensing/matlab. You can also use MATLAB Online for this course at https://matlab.mathworks.com/.
    - Use of Excel, Pyton, or any other programming language is allowed; however, you must consider ease of integration across your team members as some consistency across your team is required.
- Any CAD software of your choice

Course Material Costs: This course does not require the purchase of a textbook; however, material fees for the fabrication of your vehicle are required. The lab will provide basic fabrication materials and tools to build your prototype vehicle at no cost; however, all students are expected to contribute an additional $5 towards their team fabrication budget for this course to augment the provided materials with any additional fabrication needs not provided. Total in-pocket expenses by students is capped at up to $5 and cannot be exceeded by any team or individual regardless of willingness to spend more to ensure all teams operate on the same constrained budget. Materials provided by the course do not count against your budget costs.

Course Objectives: To introduce the mindset, theory and methods for the engineering design of aerospace vehicles. Specific learning objectives are:

1. **Gain experience as a member of an engineering team on an applied, multi-disciplinary aerospace engineering design problem**
    a. Exercise engineering judgement in an open-ended, complex engineering design problem
    b. Exercise engineering agility in developing design solutions under conditions of uncertainty
    c. Gain exposure to problems that arise from integration of sub-components / sub-disciplines in an aerospace system.
    d. Gain exposure to project management methods and experience working in engineering teams.
2. **Demonstrate the ability to apply lower division engineering knowledge towards integrated aerospace vehicle design**
    a. Demonstrate ability to integrate lower division engineering conceptual knowledge towards meeting engineering design requirements.

a. Development & assessment of engineering models to support vehicle design leveraging prior course knowledge.
b. Conduct experimentation and/or benchmarking to validate components of engineering models used in design.
c. Identify key design parameters and conduct parametric sizing and sensitivity analysis to optimize your design for requirements.
d. Discuss concept of uncertainty in models and understand why first-order models are useful.

3. **Analyze performance of an aerospace system**
    a. Develop technical skills in hands on rapid prototyping for the purpose of conceptual design risk and uncertainty mitigation.
    b. Compile, condition, and analyze experimental data.
4. **Develop effective technical communication and team skills necessary for both intra-team coordination as well as formal technical reviews.**

Course Structure: This course is meant to serve as an integrator of your lower division engineering knowledge through a multidisciplinary team-based engineering design project. Canvas will be used to communicate the course schedule, send out announcements, and to provide general information about course assignments. We reserve the right to make changes to the weekly course schedule based on occurring events that require different dispositions. We will give sufficient advance notice through announcements in class and posting on the web. Changes to this syllabus and assignments-table may be announced at any time during class periods. We will post the current syllabus and assignments-table on Canvas.

Course Delivery: All labs will be conducted in-person only. Due to the emphasis on team learning objectives of the course and the critical nature of good team communication, students are expected to attend all scheduled lab periods in person, and attendance will be a part of a student's individual grade determination. Lab sections and instruction will NOT be recorded.

Team Structure: The team size will be 6-8 students depending on section enrollment. Team structure will be determined by each team; however, each team will designate a lead and deputy project manager to support coordination of the team efforts and communication with the instructional team.

The Project Management Team (lead and deputy) will have the following authorities and responsibilities:

- Authorities:
    - Establish & coordinate team schedule (within the context of the overall course project timeline)
    - Establish taskings for individual team members to support the completion of team assignments
- Responsible for:
    - Coordinate/Lead the integrated conceptual design process
    - Ensure task load is distributed fairly across team
    - Facilitate leveling of knowledge across team members on all task concepts and identification of critical inter-dependencies
    - Communicate team issues with instructional team and relay guidance from instructional team to team members

Project Managers and Deputy Project Managers may receive a bonus to their grades based on how effectively they do their PM duties based on instructional team observations and peer feedback on their performance due to the added responsibilities of the position. PM Bonus will be additive only (i.e. you may not get the bonus, but it will not reduce your overall grade).

Evaluation & Assessments: As a project-based course, most of the assignments are team-based and collaboration is encouraged within your team to achieve most tasks. However, there are some individual responsibilities that will be evaluated on an individual basis for this course. The breakout of individual vs team evaluation points is as follows:

- **Individual Grades and Weights**

Attendance in lab	10%
Wood / Composite Shop Training Completion (Online & Hands On)	2%
Individual Design Configuration (Individual design configuration portion of Milestone 1)	5%
Peer Evaluation 1	5%
Peer Evaluation 2	8%
Peer Evaluation 3	10%
Macroethics Bonus (Optional)	2%
INDIVIDUAL TOTAL (not including bonus points)	40%

- **Team Grades and Weights**

Milestone 1: Modeling & Initial Vehicle Design Results	20%
• Aerodynamic Force Modeling Progress Check	5%
• Thrust and Flight Dynamics Modeling Progress Check	5%
Milestone 2: Conceptual Design Review Presentation (CDR)	20%
• Sizing and Trade Study Progress Check	5%
• CDR Draft Slides Progress Check	2%
• Flight Test Airworthiness Check & Flight Test	3%
TEAM TOTAL	60%

- Please verify all your scores and grades on Canvas within 2 weeks after they are posted; requests to change a score need to be made within this period.
- We reserve the right to make minor changes to this distribution of weights based on variations in assignments.
- A "C-" is considered passing for this course. Minor adjustments may be made in the determination of final letter grades and with grade cut lines shown below, but there is no "curving" in this course. This course uses the standard grading percentage cutlines:

Letter Grade	Range
A	100% to 94%
A-	< 94% to 90%
B+	< 90% to 87%

B	< 87% to 83%
B-	< 83% to 80%
C+	< 80% to 77%
C	< 77% to 73%
C-	< 73% to 70%
D+	< 70% to 67%
D	< 67% to 63%
D-	< 63% to 60%
F	< 60% to 0%

- 70% is the maximum for which the C- cutline will be set but may be set lower after instructor review of the course (never higher). Students should not assume this baseline will be lowered for final grades.
- Collaboration assignments designated as individual effort, using another student's work as your own, or allowing another student to use your work as their own is considered academic misconduct and will not be tolerated. If you are caught in any of these activities, you will be reported to the Honor Council and be subject to an academic penalty.
- Regrade requests must be submitted to the professors within 2 weeks of the grade posting to Canvas. Regrade requests are only considered if you believe there was an error in the grading per the written rubric. Regrade requests are not to argue against the grading rubric, as we carefully design this for each quiz.

Final Exam: There is no final exam for this course.

Office Hours / Team Mentors: Office hours will be conducted by appointment with the instructor outside of lab periods; however, many opportunities will exist to receive help during scheduled lab periods. Additionally, each student team will be assigned a team mentor from the teaching assistant/teaching fellow instructional team who will be their primary mentor throughout the lab course. This mentor will also advise the course instructor on team performance as feedback into evaluations.

Evaluated Outcomes

The Department of Aerospace Engineering Sciences has adopted a policy of assigning grades according to evaluated outcomes (Ox) in each course. Each assignment designed and graded to assess some combination of several or a few of the following outcomes:

O1 Professional context and expectations (ethics, economics, etc.)
O2 Historical perspective and vision
O3 Multidisciplinary, system perspective
O4 Written, oral, graphical communication ability
O5 Knowledge of key scientific/engineering concepts
O6 Ability to define and conduct experiments, use instrumentation
O7 Ability to learn independently, find information

O8 Ability to work in teams
O9 Ability to design systems
O10 Ability to formulate and solve problems
O11 Ability to use and program computers

Evaluation of these outcomes allows an assessment of your performance and provides a major portion of the process we use for continuous assessment and improvement of the entire AES undergraduate curriculum. The model for these outcomes derives from several sources including the "Desired Attributes of an Engineer" as defined by The Boeing Company, and "curriculum reviews" from major aerospace corporations including The Boeing Co., Lockheed Martin Corp. and Ball Aerospace Corp. These inputs were combined with the AES faculty vision of the desired attributes of an aerospace engineer and the requirements of the Accreditation Board for Engineering and Technology (ABET) to produce this list of evaluated outcomes. Each assignment is designed and graded to assess some combination of these outcomes.

The following is excerpted from one of the guiding papers on the inclusion of design curriculum in aerospace undergraduate education and source of inspiration in the development of this course.

Source: John McMasters and Lee Matsch. "Desired attributes of an engineering graduate - An industry perspective," AIAA 1996-2241. Advanced Measurement and Ground Testing Conference. June 1996.

CAREER DEVELOPMENT ELEMENTS

	FUNCTION	TECHNICAL COMPETENCE	LEARNING & CURIOSITY	PRACTICE	INTEGRITY	OWNERSHIP
LEADER (25 YEARS OUT)	Leader - Industry - Technical - Research - Academic - Society Highly Valued	Breadth & Depth Catalyst for change Driver of new technologies Definer of new tools Enabler of communications	Causes discovery Causes synergy Non-engineering field knowledge	Reduces complex issues to manageable tasks Discerns & innovates the most valuable initiatives Eliminates problems	Honest Gives credit Assumes responsibility	Stimulates organization-wide pride in work Enables break-throughs Instills loyalty
ESTABLISHED POSITION (10 YEARS OUT)	Marketing & sales Product engineer Technical specialist Project engineer Educator Interdisciplinary engineer	Depth Solves analytical problems Project specific applications Specific tools expertise Expert in communications	Personal contributions Deep and broad investigations Serendipitous discoveries	Understands what is possible Successfully drive to pragmatic results Anticipates problems & opportunities	Ditto	Team builder Sustained contributor Loyalty that builds integrity
ENTRY LEVEL (BS DEGREED)	Design engineer Analyst Test engineer Field engineer Process engineer Mfg. engineer Grad student	Breadth Classical physical laws Design applications Tool competence Communication skills evident	Extracurricular activities Exposure to diversity "Street smart" Self initiated discovery	Makes sound assumptions Can get linearized results to real problems Not intimidated by engineering problems	Ditto	Takes pride in work Takes on responsibility to contribute Loyalty

DESIRED ATTRIBUTES OF AN ENGINEERING GRADUATE

- A good grasp of engineering science fundamentals.
  - Mathematics (including statistics)
  - Physical and life sciences
  - Information technology
- A good understanding of the design and manufacturing process (i.e., understand engineering).
- A basic understanding of the *context* in which engineering is practiced.
  - Economics and business practice
  - History
  - The environment
  - Customer and societal needs
- Possesses a multi-disciplinary, *system* perspective
- Good communication skills.
  - Written
  - Verbal
  - Graphic
  - Listening
- High ethical standards.
- An ability to think both critically and creatively - independently and cooperatively.
- Flexibility--An ability and the self-confidence to adapt to rapid/major change.
- Curiosity and a desire to learn - for life.
- A profound understanding of the importance of team work.

Note: This is a list of basic, durable *attributes* into which can be mapped specific *skills* reflecting the diversity of the overall engineering environment in which we in professional practice operate. In specifying desired attributes (i.e. desired outcomes of the *educational process*), we avoid specifying *how* a given university goes about meeting industry needs. Curriculum development is viewed as a university task to be done in cooperation with their "customers", and in recognition of their own local resources and constraints. Industry, as an important customer, must be an active partner in this process.

University Policies:

Classroom Behavior

Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy.

For more information, see the classroom behavior policy, the Student Code of Conduct, and the Office of Institutional Equity and Compliance.

Requirements for Infectious Diseases

Members of the CU Boulder community and visitors to campus must follow university, department, and building health and safety requirements and all public health orders to reduce the risk of spreading infectious diseases.

The CU Boulder campus is currently mask optional. However, if masks are again required in classrooms, students who fail to adhere to masking requirements will be asked to leave class. Students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct & Conflict Resolution. Students who require accommodation because a disability prevents them from fulfilling safety measures related to infectious disease will be asked to follow the steps in the "Accommodation for Disabilities" statement on this syllabus.

For those who feel ill and think you might have COVID-19 or if you have tested positive for COVID-19, please stay home and follow the further guidance of the Public Health Office. For those who have been in close contact with someone who has COVID-19 but do not have any symptoms and have not tested positive for COVID-19, you do not need to stay home.

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation

Disability Services determines accommodations based on documented disabilities in the academic environment. If you qualify for accommodations because of a disability, submit your accommodation letter from Disability Services to your faculty member in a timely manner so your needs can be addressed. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance.

If you have a temporary medical condition or required medical isolation for which you require accommodation, please notify the instructor immediately and we will coordinate efforts to mitigate the impact to the course and your project teammates. Also see Temporary Medical Conditions on the Disability Services website.

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include but are not limited to: plagiarism (including use of paper writing services or technology [such as essay bots]), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty.

All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: honor@colorado.edu, 303-492-5550. Students found responsible for violating the Honor Code will be assigned resolution outcomes from the Student Conduct & Conflict Resolution as well as be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits protected-class discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. These behaviors harm individuals and our community. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who believe they have been subjected to misconduct can contact OIEC at 303-492-2127 or email cureport@colorado.edu. Information about university policies, reporting options, and support resources can be found on the OIEC website.

Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of incidents related to these policies regardless of when or where something occurred. This is to ensure that individuals impacted receive an outreach from OIEC about their options for addressing a concern and the support resources available. To learn more about reporting and support resources for a variety of issues, visit Don't Ignore It.

Religious Holidays

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. **In this class, it is expected that you review the course schedule and identify any conflicts that may impact your ability to meet project timeline requirements due to religious observance within the first three weeks of class. This will allow for the instructor and your teammates to plan for mitigating the impacts.**

See the campus policy regarding religious observances for full details.

Mental Health and Wellness

The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS) located in C4C or call (303) 492-2277, 24/7.

Free and unlimited telehealth is also available through Academic Live Care. The Academic Live Care site also provides information about additional wellness services on campus that are available to students.