ASEN 4013 -- Foundations of Propulsion – Fall 2021 – MWF 9:40-10:30 am – Aero 120

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Tuesdays, 9:00 am – 10:30 pm, AERO N353
Thursdays, 11:00 am – 12:30 pm, AERO N353

Web Page: This course uses CANVAS and Slack.

Overview: Basic one-dimensional flows: isentropic; area change; heat addition. Overall performance characteristics of propellers, ramjets, turbojets, turbofans, rockets. Performance analysis of inlets and exhaust nozzles, compressors, burners, and turbines. Rocket flight performance, single and multi-stage chemical rockets, liquid, and solid propellants.

Course Material: Lecture notes and relevant supplementary material will be posted to Canvas. These materials are sufficient for completing all homework assignments and exams. The textbook is an additional, recommended reference.

Recommended Textbook: J. D. Mattingly and K. M. Boyer, *Elements of Propulsion: Gas Turbines and Rockets*, AIAA, 2nd Edition, 2016.

Supplementary Textbooks: P. G. Hill and C. R. Peterson, *Mechanics and Thermodynamics of Propulsion*, Addison Wesley, 2nd Edition, 1992.

J. D. Anderson, Jr., *Fundamentals of Aerodynamics*, McGraw-Hill, 1991. [PDF file available online]

T. A. Ward, *Aerospace Propulsion Systems*, John Wiley & Sons (Asia) Pte Ltd, 2010.

A. M. Kuethe and C.-Y. Chow, *Foundations of Aerodynamics: Bases of Aerodynamic Design 5th Edition*, Wiley, 1997.

Approximate Course Outline:

Introduction

I. Thermodynamics of Gases
- properties of gases
- gas mixtures
- thermodynamic systems

II. Aerodynamics
- quasi one-dimensional flow with area change
- shock waves and expansions
- converging/diverging nozzle flows
- quasi one-dimensional flow with heat addition

III. Air-Breathing Engines
- thrust, efficiency, and range
- turbojets
- turbofans
- turboprops, propfans
- ramjets, scramjets

IV. Engine Component Analysis
- engine-aircraft matching
- inlets – supersonic, subsonic
- combustors, afterburners
- axial flow compressors
- axial flow turbines

V. Rocket Propulsion
- thrust and efficiency
- multi-staging
- chemical rocket propulsion
- liquid propellant rockets
- solid propellant rockets

Grading:

20% Problem Sets (8)
20% Exam 1 (50 min) – During regular lecture time
20% Exam 2 (50 min) – During regular lecture time
40% Exam 3 (2 hrs) – During scheduled Final Exam time (not comprehensive)

Grades will be assigned to indicate a student's level of competency in the course material. Accordingly, adjustments may be made in the assignment of final grades to reflect students' performance with respect to the current and historical average of the class. It is anticipated that the average grade (regardless of the absolute score) will be approximately a B-. The final grade

indicates your achievement in the course according to AES Department standards based on experience, interactions with industry, government laboratories, others in academia, and according to the criteria established by the ABET accreditation board.

Problem Sets:

- The purpose of the problem sets is to aid the student in learning by working on problems related to the course material.
- Eight problem sets of equal weights will be assigned. It is anticipated that Problem Sets 7&8 will be due at the same time.
- Students must scan (or photograph) their problem sets and submit them through Canvas by 5:00 pm on their due dates. **Late problem sets will not be accepted.** Insufficiently legible work will not be graded and a score of zero will be recorded. Questions about the problem sets should first be directed to the TA or a TF as soon as the questions arise.
- Problem set solutions will be posted on Canvas. For questions regarding the grading of a problem set, students should first discuss the issue with the TA or a TF, who will then decide whether the issue needs to be escalated to Prof. Minton.
- Collaboration is permitted on problem sets, but efforts are individual. **Every student is expected to turn in his/her own individual problem set for grading.** This means that students may discuss the means and methods for solving problems and even compare answers, but they are not free to copy someone's work or find solutions on the internet or in a solutions manual. Copying material from any resource and submitting it as one's own work may be considered plagiarism and an Honor Code violation.
- Use of MATLAB is permitted, but not always desirable. MATLAB code will not suffice for problem set solutions without prior permission. Work shall be written in "human" readable format (we will not try to decipher a student's code), and sufficient work must be shown to indicate to a grader that the student understands how the problem is solved. All graphs (including MATLAB graphs) should be legible and have meaningful axes and legends.
- Keep in mind that the more you think about the problems yourself, the more you will learn, and the easier it will be to succeed on exams.

Exams:

- Exams 1 and 2 will be given in the regular classroom (AERO 120) during the normal class time (9:40-10:30 am) on the scheduled exam days. Exam 3 will be given in the regular classroom (AERO 120) during the time scheduled by the Registrar for the final exam for this course (Wednesday, December 15, 7:30-10:00 pm). None of the exams will be cumulative. Exam 3 will be planned as a 2-hr exam, but students will be allowed the full 2.5-hour final exam time to complete the exam.
- Each student will be allowed to bring note sheets to the exams according to the following restrictions. For Exams 1 and 2: a single sheet of paper (8½ × 11 inches or A4) with any notes that the student writes in his/her own hand (notes may be written on both sides of this sheet of paper). For Exam 3, two such note sheets will be permitted. The note sheets shall be turned in with the student's completed exam and will be returned when the graded exam is returned.
- A hand ("scientific") calculator is permitted during an exam. With the exception of note sheets, as described above, all other materials (e.g., textbooks, notebooks) will not be

permitted during the exams. Electronic devices are not permitted during exams and must be turned off and put away during the exam – electronic devices include, but are not limited to: mobile phones, computers, tablets, Kindles, smart watches, and AR headsets. If a student's electronic device is audible at any time during an exam, then that student shall be obliged to turn in his/her exam and exit the room immediately.

- Solutions to the exams will be posted on Canvas. For questions regarding the grading of an exam, students should first discuss the issue with the TA or a TF, who will then decide whether the issue needs to be escalated to Prof. Minton.
- Make-up exams will only be approved for students with a legitimate excuse. There are no unexcused make-up exams.
- A student who requires accommodations because of a disability shall submit an accommodation letter from Disability Services to the instructor in a timely manner (minimum of two weeks in advance of the first exam) so that the student's needs can be addressed.

Evaluated Outcomes:

The Department of Aerospace Engineering Sciences has adopted a policy of assigning grades according to "evaluated outcomes" in each course:

O1 Professional context and expectations (ethics, economics, business environment, etc.)
O2 Current and historical perspective
O3 Multidisciplinary, systems 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
O10 Ability to formulate and solve problems
O11 Ability to use and program computers

Evaluation of these outcomes allows an assessment of the student's performance and provides a major portion of the process that the faculty use for continuous assessment and improvement of the entire AES 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) toproduce this list of evaluated outcomes. Each assignment is designed and graded to assess some combination of several or a few of the outcomes.

Behavioral Expectations:

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings. This includes respectful and courteous behavior, as well as ensuring a quiet work atmosphere without noise distractions (e.g., talking and audible sounds from electronic devices). 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. Those who fail to adhere to behavioral standards may be subject to discipline. For more information, see the policies on classroom behavior and the Student Conduct and Conflict Resolution policies.

Requirements for COVID-19:

- As a matter of public health and safety due to the pandemic, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements, and all public health orders in place to reduce the risk of spreading infectious disease. Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to Student Conduct and Conflict Resolution. For more information, students are referred to the policy on classroom behavior and the Student Code of Conduct. If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the "Accommodation for Disabilities" statement in this syllabus.
- As of August 13, 2021, CU Boulder has returned to requiring masks in classrooms and laboratories regardless of vaccination status. This requirement is a temporary precaution during the delta surge to supplement CU Boulder's COVID-19 vaccine requirement. Exemptions include individuals who cannot medically tolerate a face covering, as well as those who are hearing-impaired or otherwise disabled or who are communicating with someone who is hearing-impaired or otherwise disabled and where the ability to see the mouth is essential to communication. Students who qualify for a mask-related accommodation should follow the steps in the "Accommodation for Disabilities" (see below). In addition, vaccinated instructional faculty who are engaged in an indoor instructional activity and are separated by at least 6 feet from the nearest person are exempt from wearing masks if they so choose.
- Students who have tested positive for COVID-19, have symptoms of COVID-19, or have had close contact with someone who has tested positive for or had symptoms of COVID-19 must stay home. In this class, a student who is sick or quarantined should obtain lectures and other course materials on Canvas and contact the instructor to discuss any potential need for special consideration on an exam. There will be no special consideration for problem sets. If a student has been sick or quarantined with COVID-19 during the course, then the instructor will take this into consideration when assigning the student's final grade.

Accommodation for Disabilities:

If a student qualifies for accommodations because of a disability, the student must submit his/her accommodation letter from Disability Services to the instructor in a timely manner so that the student's needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. For assistance, Disability Services may be contacted at 303-492-8671 or dsinfo@colorado.edu. A student with a temporary medical condition should 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 policy may include: plagiarism, 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 the Honor Code (honor@colorado.edu; 303-492-5550). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found on the Honor Code website.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation:

- CU Boulder is committed to fostering a positive and welcoming learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct (including sexual assault, exploitation, harassment, dating or domestic violence, and stalking), discrimination, and harassment by members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127 or cureport@colorado.edu. Information about the OIEC, university policies, reporting options, and the campus resources can be found on the OIEC website.
- Faculty and graduate instructors have a responsibility to inform OIEC when made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about their rights, support resources, and reporting options.

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. The instructor will make every effort to accommodate a student's religious obligations provided that the student gives notification well in advance of the scheduled conflict. In all but extraordinary cases, notification shall be provided at least two weeks in advance of the conflict to request special accommodations. See the campus policy regarding religious observances for full details.

ASEN 4013 – FALL 2021 SCHEDULE (subject to change with notification)

MONDAY	WEDNESDAY	FRIDAY
Aug. 23	Aug. 25	Aug. 27
Aug. 30	Sept. 1	Sept. 3
Sept. 6 LABOR DAY no class	Sept. 8 **Prob. Set 1 due, 5:00 pm**	Sept. 10
Sept. 13	Sept. 15	Sept. 17
Sept. 20	Sept. 22 **Prob. Set 2 due, 5:00 pm**	Sept. 24
Sept. 27	Sept. 29 **EXAM 1**	Oct. 1
Oct. 4	Oct. 6 **Prob. Set 3 due, 5:00 pm**	Oct. 8
Oct. 11	Oct. 13	Oct. 15
Oct. 18	Oct. 20 **Prob. Set 4 due, 5:00 pm**	Oct. 22
Oct. 25	Oct. 27 **EXAM 2**	Oct. 29
Nov. 1	Nov. 3 **Prob. Set 5 due, 5:00 pm**	Nov. 5
Nov. 8	Nov. 10	Nov. 12
Nov. 15	Nov. 17 **Prob. Set 6 due, 5:00 pm**	Nov. 19
Nov. 22 FALL BREAK no class	Nov. 24 FALL BREAK no class	Nov. 26 THANKSGIVING HOLIDAY no class
Nov. 29	Dec. 1	Dec. 3 **Prob. Sets 7/8 due, 5:00 pm**
Dec. 6	Dec. 8	Dec. 10 Reading Day no class
	Dec. 15 – Exam 3 7:30-10:00 pm	