AME 436 – Energy and Propulsion - Spring 2023

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Office hours: Tuesdays 1:00 – 3:00 pm & Wednesdays 2:00 – 3:00 pm
In-person: OHE 406; Zoom: https://usc.zoom.us/j/91281665343

Course producer / grader: Mark McDermott, markmcde@usc.edu
Office hours: to be determined

Lecture: 6:40 – 9:20 PM Thursdays, OHE 122

Final: Thursday, May 4, 7:00 - 9:00 pm.

Website: https://courses.uscden.net/d2l/home/25080 (for syllabus, lecture notes, assignments)
Piazza page https://piazza.com/usc/spring2023/ame436 (for discussions)

Required texts:
None; course will be taught primarily from lecture notes

Possibly useful supplemental materials:

- Heywood, J. B., Internal Combustion Engine Fundamentals, 2nd Ed., McGraw-Hill, 2018, ISBN-13: 9781260116106
  https://www.mheducation.com/highered/product/1260116107.html4
  Useful as the "industry standard" reference, but difficult to use as a textbook.
- Mattingly, J. D. and Boyer, K. M., Elements of Propulsion: Gas Turbines and Rockets, 2nd Ed., AIAA Education Series, 2016, ISBN-13: 9781624103711
  https://arc.aiaa.org/doi/book/10.2514/4.103711
  Detailed, algebra-heavy analysis of gas turbine cycles similar to the class presentation
- Turns, S. and Haworth, D. C., An Introduction to Combustion: Concepts and Applications, 4nd Ed., McGraw-Hill, 2021, ISBN-13: 9781260477696
  https://www.mheducation.com/highered/product/introduction-combustion-concepts-applications-turns-haworth/M9781260477696.html
  A good introduction to combustion that goes far beyond what is covered in this class.

Grading:

Midterm exams (2)	20% each
Final exam	30%
Homework	30%

- Exams will be open book and notes
- Homework problems will usually be assigned Wednesdays and due the following Friday at 4:30 P.M. **Late homework will be marked down 10 points (out of 100 total) per working day late.** The fact that it was "someone else's fault" (e.g., your roommate overslept or forgot to turn it in, your computer crashed, the printer ran out of ink, etc.) doesn't matter.

Since everyone has some valid reason for missing or doing poorly on at least one homework assignment, your lowest homework score will be eliminated. Requests for extensions will be considered in special circumstances (attendance at student conferences, participation in athletic events, etc.) **but only if requested at least 3 days before the homework is due.**

- Since there will be 6 homework assignments (approximately one every two weeks), each assignment will be about twice as long as those in a class with weekly assignments.
- The deadline for disputing grading of homework or exams is **two weeks from the day the graded material is returned.** So, if you pick up your graded material three weeks after it's available, that's too late to "file a claim."
- To request reconsideration of a homework grade for any reason, send an email to the grader at ame436s23@gmail.com. Attach a picture of the disputed part along with an explanation as to why you believe the grade should be changed. Send a separate email for each problem you believe needs reconsideration. If you and the grader can't reach an agreement, PDR will make the final decision.
- Electronic versions of homework and exam solutions will not be posted. Hard copies will be available for on-campus students; DEN students will have solutions sent to their individual DEN mailboxes.
- There will be no "extra credit" assignments. If extra credit is offered to one student, I have to offer it to every student, in which case it becomes just another assignment and the number of assignments is already enough for the course.
- Grading policy
    - The average course grade will be close to the Viterbi School average of about 3.3/4.0, perhaps a bit higher if I decide in the end that this class is better than average, or a bit lower if... well you get the idea. But it's very unlikely that the average grade will be above 3.4 or below 3.2.
    - I'll adjust the weighting of the two midterms separately so that getting an average grade on either will give you the same number of points toward your total course points. The same consideration applies to the final exam, though the final is weighted 1.5 times higher than each midterm.
    - I try hard not to give any grade below C, since you need to maintain a C average to stay here, so if I give you a grade below C that implicitly means I believe you effectively failed the course. Rarely do I have to give below a C to someone who did all the work. The major source of low grades is students not doing the homework and thus losing 30% of their grade. Viterbi students as a group are extremely competitive in the sense that the standard deviation of scores is small, so losing 30% of your total score would typically move one from the A range to the C range.

Collaboration policy:

- You may
    - Work with others to find solutions to homework assignments
    - Study with others for exams
- You may NOT
    - Copy homework assignments from others – even if you work together, you must prepare and turn in assignments that were created by you only

    - Work together during exams
- **Violators will be reported to the Office of Academic Integrity (see https://academicintegrity.usc.edu/)**

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the USC Student Handbook. All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Violation	USC - Recommended Sanction for Undergraduates*	AME - Recommended Sanction for Undergraduates and Graduates
Copying answers from other students on any course work.**	F for course.	First offense: F on assignment. Second offense: F for course.
One person allowing another to cheat from his/her exam or assignment.	F for course for both persons.	If assignment: First offense: F on assignment. Second offense: F for course. If exam: F for course.
Possessing or using material during exam (crib sheets, notes, books, etc.) which is not expressly permitted by the instructor.	F for course.	First offense: F on exam. Second offense: F for course.
Continuing to write after exam has ended.	F for course.	F on exam
Taking exam from room and later claiming that the instructor lost it.	F for course and recommendation for further disciplinary action (possible suspension).	F for course
Changing answers after exam has been returned.	F for course and recommendation for further disciplinary action (possible suspension).	F for course
Fraudulent possession of exam prior to administration.	F for course and recommendation for suspension.	F for course
Obtaining a copy of an exam or answer key prior to administration.	Suspension or expulsion from the university; F for course.	F for course
Having someone else complete course work for oneself.	Suspension or expulsion from the university for both students; F for course.	F for course
Plagiarism — Submitting other's work as one's own or giving an improper citation.	F for course.	First offense: F on assignment. Second offense: F for course.
Submission of purchased term papers or papers done by others.	F for course and recommendation for further disciplinary action (possible suspension).	F for course
Submission of the same assignment to more than one instructor, where no previous approval has been given.	F for both courses.	F for both courses
Unauthorized collaboration on an assignment.	F for the course for both students.	First offense: F on assignment. Second offense: F for course.
Falsification of information in admission applications (including supporting documentation).	Revocation of university admission without opportunity to reapply.	Revocation of university admission without opportunity to reapply.
Documentary falsification (e.g., petitions and supporting materials; medical documentation.)	Suspension or expulsion from the university; F for course when related to a specific course.	Suspension or expulsion from the university; F for course when related to a specific course.
Plagiarism in a graduate thesis or dissertation.	Expulsion from the university when discovered prior to graduation; revocation of degree when discovered subsequent to graduation.***	Expulsion from the university when discovered prior to graduation; revocation of degree when discovered subsequent to graduation.***

*Assuming first offense
**Exam, quiz, tests, assignments or other course work.
***Applies to graduate students

Suggestions for how to do well in this class (applies to almost any class, really):

1. **Come to lectures!** There IS a very good correlation between attendance and performance in the course. The lecture notes are a **supplement** to lectures, not a replacement. **Do not assume that you can learn everything by reading the lecture notes. If a topic is clarified or expanded upon in class but not in the lecture notes, it's fair game for homework and exam questions.** The fact that you "didn't know" something that was discussed in class is not an excuse. Also, exams will mirror lectures … obviously the stuff I discuss most in class is the stuff mostly likely to appear on exams.
2. **Read the lecture notes!** Everything on the homework and exams is covered in class and in the lecture notes.
3. **Pick up your graded homework and exams and their solutions.** It's remarkable that many students don't. How can you know what you did correctly or incorrectly without comparing your answers to the "correct" ones? And without such feedback, how can you do better on subsequent homeworks and exams?
4. **Tips for studying for and taking exams**
    1. Do the posted sample exams, homework and examples in lecture notes without looking at answers. Some students have a tendency to spend too much time on the first problem and try to get it "just right" before moving on to the next one. If you're particularly prone to that, after getting your graded exam back, try re-doing the exam backwards, i.e. last problem to first problem.
    2. Since electronic versions of the lecture notes are not allowed during exams, put hard copies of all the lecture notes into a 3-ring binder then (and here's the important part) create a system of tabs or some type of indexing (e.g. where key topics like "burning velocity" "T-s diagrams" "knock" etc. are located) so you can find things quickly. Just the process of doing this organization will force you to ask yourself, "What are the important topics in this course? Where can I find them in the notes?"
    3. Work both independently and as part of a group. As much as you may think otherwise, you really don't understand something until you have to explain it to someone else
    4. During the exam, budget your time and pick the low hanging fruit.

AME 436 Tentative schedule

"Plans are nothing - planning is everything" - Dwight D. Eisenhower

Week	Date	Subject(s)	Lecture	Optional readings	HW
Introduction					
1	1/12	Engine types; alternatives to airbreathing combustion engines	PDR		
Chemical thermodynamics and combustion					
2	1/19	Fuels, chemical thermodynamics	PDR	Heywood 3, 4; Turns 2	
3	1/26	Chemical thermodynamics	PDR		1A
4	2/2	Basics of combustion	PDR	Turns 4, 5, 8, 9, 10	1D
5	2/9	Pollutant formation	PDR	Heywood 11; Turns 15	2A
Unsteady-flow engines					
6	2/16	Basic operating principles, design and performance parameters	PDR	Heywood 2	2D
7	2/23	Midterm #1 – covering material from weeks 1 – 5	MT1	Heywood 5.1 – 5.3	
		Using P-V and T-s diagrams	PDR		
8	3/2	Ideal cycle analysis	PDR	Heywood 5.4 – 5.7	3A
9	3/9	Non-ideal cycle analysis	PDR	Heywood 5.8	3D, 4A
	3/16	**Spring break**	XXX	XXX	
10	3/23	Combustion in engines: knock; ignition, misfire; emissions	PDR	Heywood 9, 10	4D
Steady-flow engines					
11	3/30	Thrust and aircraft range; compressible flow	PDR	Mattingly 4	
12	4/6	Midterm #2 – covering material from weeks 6 – 10	MT2	Mattingly 3	5A
		Compressible flow (continued)	PDR		
13	4/13	Ideal performance of turbojets and turbofans	PDR	Mattingly 5.1 – 5.8	5D
14	4/20	Non-ideal performance I	PDR	Mattingly 5.9 – 5.11	6A
15	4/27	Non-ideal performance II	PDR	Mattingly 6, 7	
	5/4		FIN		6D

The readings are optional, not required. You will not be responsible for material in these readings that is not covered in lectures or the lecture notes, however, you WILL be responsible for material covered in the lectures but not the lecture notes.

Legend:

PDR	PDR gives lecture
TA	TA gives lecture (PDR on travel)
MTn	Midterm exam #n
XXX	Break/end of semester
nA	Homework n assigned
nD	Homework n due

Homework topics:

1. Chemical thermodynamics
2. Combustion and emissions
3. Ideal cycle analysis
4. Unsteady flow engines
5. Thrust and compressible flow
6. Steady flow (propulsion) engines

Accreditation Board for Engineering and Technology (ABET) course objectives:

To introduce the student to the design and performance of automotive and aircraft engines including power output, efficiency and emissions.

ABET Course Outcomes: The student will be able to

1. Explain the differences between the basic types of internal combustion engines (premixed-charge reciprocating, non-premixed charge reciprocating, turbojet, turbofan, etc.)
2. Assess the advantages and disadvantages of internal combustion engines compared to alternatives such as steam, electric and solar power
3. Calculate flame temperature for idealized fuel-air mixtures (constant specific heats, no dissociation, etc.)
4. Describe qualitatively how ideal flame temperatures are affected by non-ideal factors such as variable specific heats, dissociation, heat losses, etc.
5. Explain the difference between laminar premixed flames, turbulent premixed flames, homogeneous reaction (knock) and non-premixed spray or droplet flames
6. Describe how NO, CO, unburned hydrocarbons and soot emissions are formed in engines, explain how they are minimized, and estimate how changes in engine operating conditions affect these emissions.
7. Analyze an ideal engine cycle (for either reciprocating or steady-flow engines) using P-v and T-s diagrams
8. Analyze the performance (indicated mean effective pressure, thrust specific fuel consumption, thermal efficiency, etc.) of an ideal Otto, Diesel, Brayton, etc. thermodynamic cycle.
9. Estimate the performance (indicated mean effective pressure, thrust specific fuel consumption, thermal efficiency, etc.) of an Otto, Diesel, Brayton, etc. thermodynamic cycle using a chemical thermodynamics computer program such as GASEQ.
10. Estimate the effect of non-ideal processes (throttling, slow burn, heat losses, knock, compressor/turbine losses, etc.) on an engine cycle using P-v and T-s diagrams
11. Explain how these non-ideal processes affect engine design and performance.