AME 436 – Energy and Propulsion - Spring 2013

Instructor: Prof. Paul D. Ronney
Office: Olin Hall 430J, 740-0490, ronney@usc.edu
Office hours: Thursdays 1:00 pm to 4:00 pm; other times by appointment

Teaching Assistant:
Thada Suksila (suksila@usc.edu)
Office hours: Fridays 9:00 am – 12:00 noon, VHE 202

Grader:
Daniel Yan (yi.yan0423@gmail.com) (for correspondence)
ame436@yahoo.com (to submit homework)

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

Final: Wednesday, May 8, 7:00 - 9:00 pm.

Web page: http://ronney.usc.edu/AME436S13/

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

Possibly useful supplemental materials:

- Heywood, J. B., Internal Combustion Engine Fundamentals, McGraw-Hill, 1988 (http://catalogs.mhhe.com/mhhe/viewProductDetails.do?isbn=007028637X)
- Mattingly, J. D., Elements of Propulsion: Gas Turbines and Rockets, AIAA Education Series, 2006 (https://www.aiaa.org/PubDetail.aspx?id=12218)
- Farokhi, S., Aircraft Propulsion, Wiley, 2009 (http://www.wiley.com/WileyCDA/WileyTitle/productCd-0470459220.html)
- Turns, S., An Introduction to Combustion, 3rd Ed., McGraw-Hill, 2012 (http://catalogs.mhhe.com/mhhe/viewProductDetails.do?isbn=0073380199)

Grading:

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

- Exams will be open book and notes
- Homework problems will be assigned Fridays 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.

- 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, you lose.
- 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.

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. Understand the differences between the basic types of internal combustion engines (premixed-charge reciprocating, non-premixed charge reciprocating, turbojet, turbofan, etc.)
2. Understand the advantages and disadvantages of internal combustion engines compared to alternatives such as steam, electric and solar power
3. Calculate flame temperature for an idealized fuel-air mixture (constant specific heats, no dissociation, etc.)
4. Understand qualitatively how ideal flame temperatures are affected by non-ideal factors such as variable specific heats, dissociation, heat losses, etc.
5. Understand the difference between the following four types of combustion processes: laminar premixed flames, turbulent premixed flames, homogeneous reaction (knock) and non-premixed spray or droplet flames
6. Understand the basics of how NO, CO, unburned hydrocarbons and soot emissions are formed in engines and how they are minimized.
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 a 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. Estimate how these non-ideal processes affect engine design and performance.
12. Understand the basic performance and design considerations of hypersonic propulsion systems and how they are analyzed.

AME 436 Tentative schedule

Week	Date	Subject(s)	Lecture	Optional readings	HW
Introduction					
1	1/16	Engine types; alternatives to airbreathing combustion engines; review of basic thermodynamics	PDR	Heywood 1, Mattingly 1	
Chemical thermodynamics and combustion					
2	1/23	Fuels, chemical thermodynamics	PDR	Heywood 3, 4; Turns 2	
3	1/30	Chemical thermodynamics	PDR		1A
4	2/6	Basics of combustion	PDR	Turns 4, 5, 8, 9, 10	1D
5	2/13	Pollutant formation		Heywood 11; Turns 15	2A
Unsteady-flow engines					
6	2/20	Basic operating principles, design and performance parameters	PDR	Heywood 2	2D
7	2/27	Midterm #1 – covering material from weeks 1 – 5	MT1	Heywood 5.1 – 5.3	
		Using P-V and T-s diagrams	PDR		
8	3/6	Ideal cycle analysis	PDR	Heywood 5.4 – 5.7	3A
9	3/13	Non-ideal cycle analysis	PDR	Heywood 5.8	3D, 4A
	3/20	**Spring break**	XXX	XXX	
10	3/27	Combustion in engines: knock; ignition, misfire; emissions	PDR	Heywood 9, 10	4D
Steady-flow engines					
11	4/3	Thrust and aircraft range; compressible flow	PDR	Mattingly 4	
12	4/10	Midterm #2 – covering material from weeks 6 – 10	MT2	Mattingly 3	5A
		Compressible flow (continued)	PDR		
13	4/17	Ideal performance of turbojets	PDR	Mattingly 5.1 – 5.8	5D
14	4/23	Turbofans, ramjets, scramjets	PDR	Mattingly 5.9 – 5.11	6A
15	4/30	Non-ideal performance; Hypersonic propulsion	PDR	Mattingly 6, 7	6D, 7A
	5/8		FIN		7D

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.

Legend:

PDR	PDR lectures
PT	Pre-taped lecture (PDR out of town) (Pre-taping times to be announced).
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
7. Hypersonic propulsion, practice problems for final exam