AME 513b: Fundamentals and Applications of Combustion II

Units: 4
Spring 2022 — Tuesday & Thursday 2:00 — 3:50 pm

Location: OHE 100B

Instructor: Carlos Pantano
Office: OHE 430L
Office Hours: by appointment (zoom)
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Teaching Assistant: N/A
Office:
Office Hours:
Contact Info:

Course Description

This course builds upon the fundamental knowledge students have acquired in AME 513a (Principles of Combustion) to learn how to apply this knowledge to practical combustion problems. After a review and extension of some of the material presented in AME 513a, students are introduced to analytical methods in combustion research, then these methods are applied to several core combustion phenomena - stretch effects, stability, ignition and extinction of flames. These principles are then used to develop understanding of several key combustion phenomena - turbulence effects on combustion, detonations, and finally electrical power generation and propulsion at small scales. The course concludes with a discussion of emerging technologies and future needs in combustion research. Course assignments include traditional problem sets, critical reviews of student-chosen classic papers in the fields covered, and a capstone-like team project consisting in the improvement of an already existing calculation tool (implemented as a google spreadsheet) for the modeling of high-speed propulsion. This collaborative project integrates the material leanred in the course.

Learning Objectives and Outcomes

It is expected that after completing this course, students will be able to apply fundamental and applied knowledge they have acquired to both fundamental research topics and practical combustion systems. Of particular importance is that the students be able to critically assess existing research and identify knowledge gaps in the current state-of-the-art.

Prerequisite(s): AME 513a (Fundamentals and Applications of Combustion I)
Co-Requisite(s): none
Concurrent Enrollment: none
Recommended Preparation: Review knowledge of combustion obtained in AME 513a.

Course Notes

- Grading Type: Letter grade
- Weekly lecture material (PowerPoint slides and journal articles).
- All lectures will be posted on the USC Distance Education Network website (https://courses.uscden.net/d2l/login).
- This course will use the Piazza platform (http://www.piazza.com/) for online discussion. Please submit all questions related to homework assignments, logistics and the final exam through Piazza (rather than directly to the instructor) so that other students can benefit from the answers. You can submit questions anonymously if you so desire. If you are not automatically enrolled in Piazza, please contact the instructor.
- Videoconferencing is available during office hours for DEN students using the BlueJeans platform (https://viterbigrad.usc.edu/technical-support/bluejeans/). Please contact the instructor if interested.

Required Readings and Supplementary Materials

Lectures will be delivered via weekly PowerPoint presentations, supplemented by readings of review articles and seminal research papers on the topics covered. No textbook will be required, however, a recommended general combustion textbook is S. R. Turns, An Introduction to Combustion, 3rd Ed.: http://mheducation.com/highered/product/introduction-combustion-concepts-applications-turns/M0073380199.html

Description and Assessment of Assignments

Each homework assignment will consist several analytical/computational problems on the topics covered during the assignment period plus a report/review on a scientific paper chosen from an approved list.

Project

Students will help improve an existing (partially functional) google spreadsheet to model the functioning of a hypersonic propulsion engine: Hypersonic Engine. (access to it will be given after the course starts)

Grading Breakdown

Homework #	Description	% of total grade
1	Extension of AME 513a: chemical kinetics, nonpremixed flames	10
2	Analytical methods in combustion	10
3	Aerothermodynamics of combustion - extinction, ignition, stability	10
4	Turbulent combustion	10
5	Detonations and applications	10
6	Catalytic combustion; microscale combustion and power generation	10
7	Team Project	40

Grading policy

- Grading will be on a curve, with the average course grade close to the Viterbi School average for graduate courses.
- The Project will be graded on the following basis:
    - Completion of the assigned submodule 50%
    - Proposed enhancements 20%
    - Successful integration with other modules 30%
- Late assignments will be marked down 20 points (out of 100 total) per working day late.
- Each assignment and the final exam will be weighted separately so that receiving an average grade on any assignment will give the student the same number of points toward the total course points.
- Statement on academic integrity
    - For AME 513b you may
        - Work with others to find solutions to homework assignments
        - Work with others for project integration (but not for your submodule)
    - For AME 513b 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
    - Violators will be reported to the Office of Committee for Student Judicial Affairs and Community Standards (http://www.usc.edu/student-affairs/SJACS/) (for undergraduate students) or the Viterbi Academic Integrity System (for graduate students; see https://policy.usc.edu/scampus-part-b/, section 13.10).

Assignment Rubrics

Each assignment will be graded with more emphasis on knowing which equations / physical principles / assumptions / methods are applicable and relevant than on obtaining a specific numerical result. All work must be shown, and lengthy analysis or printouts of computer simulations may be attached as appendices.

Assignment Submission Policy

- Each homework assignment should be submitted electronically as a single PDF file via the course D2L DEN website (accessible through https://courses.uscden.net/d2l/login). Please make sure to append all pages into a single PDF document before submitting.
- Typed solutions are preferred but hand-written solutions are acceptable.
- Ensure that you provide legible and logically-organized solutions that explicitly include all necessary steps and assumptions (if any) made.

Grading Timeline

Assignments will generally be posted on Fridays, due the following Friday, and returned by the following class period.

Suggestions

- Download lectures from website before class
- Most lecture slide packages include
    - Outline
    - Beef
    - Summary
    - References
    - … so make use of these resources!
- Ask questions in class - the goal of the lecture is to maintain a 2-way "Socratic" dialogue on the subject of the lecture

Tentative Course Schedule

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

	Topics / Activities	Readings and Homework	Deliverable/ Due Dates
Week 1	Introduction and review of AME 513a	Week 1 lecture notes	
Week 2	Extension of AME 513a - chemical kinetics	Week 2 lecture notes	
Week 3	Extension of AME 513a - nonpremixed flames	Week 3 lecture notes HW #1 assigned	
Week 4	Analytical methods in combustion: integral methods	Week 4 lecture notes	HW #1 due
Week 5	Analytical methods in combustion: asymptotic methods	Week 5 lecture notes HW #2 assigned	
Week 6	Aerothermodynamics of flames I: extinction	Week 6 lecture notes HW #7 (white paper) assigned	HW #2 due
Week 7	Aerothermodynamics of flames II: ignition and stability	Week 7 lecture notes HW #3 assigned	
Week 8	Turbulent flames I: premixed flames	Week 8 lecture notes	HW #3 due
Week 9	Turbulent flames II: nonpremixed flames	Week 9 lecture notes HW #4 assigned	
Week 10	Detonations I: structure, propagation rates, initiation and extinction limits	Week 10 lecture notes	HW #4 due
Week 11	Detonations II: applications - accidental explosions, Detonatative Propulsion Engines	Week 11 lecture notes HW #5 assigned	Hypersonic tool assignements
Week 12	Microscale combustion I - heat recirculating reactors	Week 12 lecture notes	HW #5 due
Week 13	Microscale combustion II - power-generating devices	Week 13 lecture notes HW #6 assigned	
Week 14	Emerging technologies and new directions in combustion research - plasma-assisted combustion, material synthesis	Week 14 lecture notes	HW #6 due
Week 15	Hypersonic combustion Modeling Framework Integration	Week 15 lecture notes	
Final Exam			Final exam date: consult classes.usc.edu/

Project Description

This course considers recent developments and emerging technologies in reacting flows. In particular, we will focus on the application of the concepts learned in class to the development of a modeling tool to predict the performance of a hypersonic propulsion engine. This tool has been partially build in the previous year from a working Excel spreadsheet provided by Prof. Ronney (many thanks). The google spreasheet allows collaborative work among the team members and the integration and testing of the results. Different submodules of the tool (inlet, combustion chamber, diffuser, standard atmosphere model, etc) are in somewhat different states of development and they will be assignd to each student in the class. There are sufficient elements that each student will have his/her own module to work with. You can use the integration to test your implementation dynamically. This project provides an invaluable opportunity to participate and apply the knowledge build in class into a practical problem.

Project Timeline:

- Week 11: Assignement of submodules
- Week 12: Discussion of state of the modules and improvements/fixes
- Week 13: Progress Report
- Week 14: Integration
- Week 15: Live demonstration

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Student Health Counseling Services - (213) 740-7711 – 24/7 on call
engemannshc.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call
engemannshc.usc.edu/rsvp
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086
equity.usc.edu, titleix.usc.edu
Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421
studentaffairs.usc.edu/bias-assessment-response-support
Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
studentaffairs.usc.edu/ssa
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.
Diversity at USC - (213) 740-2101

diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.