AME 513b: Fundamentals and Applications of Combustion II
Units: 4
Spring 2020 — Monday & Wednesday 9:00 — 10:50 am

Location: OHE 100C

Instructor: Paul Ronney
Office: OHE 430J
Office Hours: Thursdays 1:00 - 4:00 pm
Contact Info: (213) 740-0490, ronney@usc.edu

Teaching Assistant: N/A
Office: N/A
Office Hours: N/A
Contact Info: N/A

IT Help: N/A
Hours of Service: N/A
Contact Info: N/A
Course Description

This course builds upon the fundamental knowledge students have acquired in AME 513a (Principles of Combustion) to learn how apply this knowledge to practical combustion problems. First the 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 - plasma assisted combustion, 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 project, namely a “White Paper” proposing an original research project based on the knowledge accrued during 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, as evidenced by the “White Paper” research proposal.

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) will be posted online in advance.
- 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.
- Some assignments will require the use of ANSYS simulation software, specifically the Computational Fluid Dynamics module (FLUENT) which includes heat transfer and chemical reaction. Viterbi has a site license with an adequate number of licenses for the entire class to use ANSYS simultaneously.

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.
White Paper

In the 2-page White Paper, students will identify a need for new research related to one of the topics discussed in class, justify this need, and propose a line of investigation to address the question(s) raised. An example of a White Paper is given at http://ronney.usc.edu/AME514/SampleWhitePaper.pdf.

Grading Breakdown

<table>
<thead>
<tr>
<th>Homework #</th>
<th>Description</th>
<th>% of total grade</th>
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<tbody>
<tr>
<td>1</td>
<td>Analytical methods in combustion</td>
<td>10</td>
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<tr>
<td>2</td>
<td>Aerothermodynamics of combustion - stretch effects, stability, extinction</td>
<td>10</td>
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<tr>
<td>3</td>
<td>Ignition and plasma-assisted combustion</td>
<td>10</td>
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<tr>
<td>4</td>
<td>Turbulent combustion</td>
<td>15</td>
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<tr>
<td>5</td>
<td>Detonations and applications</td>
<td>10</td>
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<tr>
<td>6</td>
<td>Catalytic combustion; microscale combustion and power generation</td>
<td>15</td>
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<tr>
<td>7</td>
<td>White paper</td>
<td>10</td>
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<tr>
<td>---</td>
<td>Final exam</td>
<td>20</td>
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</tbody>
</table>

Grading policy

- Grading will be on a curve, with the average course grade close to the Viterbi School average for graduate courses.
- The White Paper will be graded on the following basis:
  - Justification of the need for the research 30%
  - Originality of the proposed research 30%
  - Clarity of the presentation of the proposed concept 40%
- Late assignments will be marked down 10 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
    - Study with others for the final exam
  - 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
    - Work together during the final exam
  - 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 on a 100-point scale, 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 on paper in OHE 430N or 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.

**Course Schedule**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topics/Daily Activities</th>
<th>Readings and Homework</th>
<th>Deliverable/ Due Dates</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Analytical methods in combustion: integral methods</td>
<td>Week 1 lecture notes</td>
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<tr>
<td>2</td>
<td>Analytical methods in combustion: asymptotic methods</td>
<td>Week 2 lecture notes HW #1 assigned</td>
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<td>3</td>
<td>Aerothermodynamics of flames I: stretch effects</td>
<td>Week 3 lecture notes HW #1 due</td>
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<td>4</td>
<td>Aerothermodynamics of flames II: stability and extinction</td>
<td>Week 4 lecture notes HW #2 assigned</td>
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<tr>
<td>5</td>
<td>Aerothermodynamics of flames III: ignition</td>
<td>Week 5 lecture notes HW #2 due</td>
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<td>6</td>
<td>Plasma-assisted combustion</td>
<td>Week 6 lecture notes HW #3 assigned HW #7 (white paper) assigned</td>
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<tr>
<td>7</td>
<td>Turbulent flames I: combustion regimes, burning velocities of premixed flames</td>
<td>Week 7 lecture notes HW #3 due</td>
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<td>8</td>
<td>Turbulent flames II: edge flames, lifted jet flames, extinction</td>
<td>Week 8 lecture notes</td>
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<td>9</td>
<td>Turbulent flames III: experimental methods, modeling approaches</td>
<td>Week 9 lecture notes HW #4 assigned</td>
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<tr>
<td>10</td>
<td>Detonations I: structure, propagation rates, initiation and extinction limits</td>
<td>Week 10 lecture notes HW #4 due</td>
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<td>11</td>
<td>Detonations II: applications - accidental explosions, Detonative Propulsion Engines</td>
<td>Week 11 lecture notes HW #5 assigned</td>
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<td>12</td>
<td>Catalytic combustion</td>
<td>Week 12 lecture notes HW #5 due</td>
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<td>13</td>
<td>Microscale combustion I - heat recirculating reactors</td>
<td>Week 13 lecture notes</td>
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<td>14</td>
<td>Microscale combustion II - power-generating devices</td>
<td>Week 14 lecture notes HW #6 assigned</td>
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<tr>
<td>15</td>
<td>Emerging technologies and new directions in combustion research</td>
<td>Wk 15 lecture notes HW #6 &amp; 7 due</td>
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<tr>
<td><strong>FINAL</strong></td>
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<td>Final exam date: consult classes.usc.edu/</td>
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</table>
White Paper Description

This course considers recent developments and emerging technologies in reacting flows. Thus, it is only reasonable that you try to identify your own “niche” in one of these emerging areas. Prepare a “white paper” (basically a highly compressed, top-level, research proposal), structured as follows (e.g. one paragraph for each bullet item; some bullets may be combined into one paragraph):

- State what your topic is and why it is important
- State what is known about the subject
- Complain about what is lacking in the current state of knowledge
- Explain what you would do that would improve the state of knowledge (i.e. specifically what computer simulation or experiment or analysis you would perform)
- Describe how you would analyze or interpret the data once you had them
- Speculate as to what results you might obtain
- State how these results would advance the state of knowledge of the field
- List your references

There is no specific minimum or maximum page limit, but a guideline would be 2 – 3 pages. You may want to include a couple of key figures that would increase the page count. (In the real world white papers are almost never allowed to be more than 2 pages including figures.) Also in a “real” white paper you would also need to include a statement about budget and schedule but you don’t need to do that for this assignment. However, the target level for your white paper should be a project that could be conducted by a small group, e.g., not more than a faculty member, postdoc and 2 graduate students and not a Manhattan Project or Apollo type of proposal.

Project Timeline:

- Week 6: Identify White Paper topic and start background research
- Week 8: Propose White Paper topic to instructor
- Week 10: Receive feedback from instructor on White Paper topic; continue background research
- Week 13: Begin writing White Paper
- Week 15: White paper due

The White Paper will be graded on the following basis:

- Justification of the need for the research 30%
- Originality of the proposed research 35%
- Clarity of the presentation of the proposed concept 30%
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.