

Spring 2012

## Course Syllabus

**Course Description:** This is an introductory course focused on theoretical aspects of Turbulent Combustion. A review of fundamental concepts of combustion and turbulent flows is performed. Characteristic scales and combustion diagrams are presented, and basic turbulent-combustion models for premixed and non-premixed combustion are discussed. Time permitting, fundamental concepts in spray combustion will be presented. Some emphasis is made to identify key physical processes in practical applications for propulsion and power generation.

**Prerequisite:** ME 361 Turbulence, ME 371 Combustion Fundamentals, or consent of instructor.

**Instructor:** Javier Urzay, Ph.D.

E-mail: [jurzay@stanford.edu](mailto:jurzay@stanford.edu)

Office: 206 CTR, Phone: 650 723 9601

Office Hours: Mondays 9:00 AM-11:00 AM.

**Lectures:** Tuesdays and Thursdays, 10:00 AM-11:15 AM at room 240-101.

**Reference Textbooks:** - N. Peters, "Turbulent combustion", Cambridge University Press, 2005.

- R.S. Cant & E. Mastorakos, "An introduction to turbulent reacting flows", Imperial College Press, 2008.

- F.A. Williams, "Combustion Theory", Benjamin Cummins, 1985.

Supplementary material shall be provided in class.

**Homeworks:** There will be 4 homework assignments. Homework will be assigned bi-weekly on Thursdays and collected on Tuesdays two weeks later at the beginning of the lecture, as detailed in the course schedule. No late homeworks will be accepted.

**Exams:** Midterm Exam: Tuesday, May 15, in class.

Final Exam: Tuesday, June 12, location TBA.

Both exams will consist of two parts: i) Short Questions (closed books, closed notes, no calculator), and ii) Problems (open book and open notes, calculator allowed).

**Grading Scheme:** 20% Homeworks + 35% Midterm Exam + 45% Final Exam.

**Academic Integrity:** The Stanford Honor Code will be followed.

<http://www.stanford.edu/dept/vpsa/judicialaffairs/guiding/honorcode.htm>

**Website:** [http://www.stanford.edu/~jurzay/ME\\_471](http://www.stanford.edu/~jurzay/ME_471)

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## OUTLINE

### *I. Review of fundamental aspects in combustion and turbulence:*

Conservation equations for reactive flows, chemical-reaction rates, detailed and reduced chemistry, asymptotic structures of flames, molecular diffusion, turbulent flows, Kolmogorov equilibrium theory, statistical description, Reynolds decomposition, closure problem, scalar dissipation and mixing, separation of scales in turbulent combustion, RANS LES and DNS in turbulent combustion.

### *II. Premixed turbulent combustion:*

Premixed burners, lean premixed combustion, characteristic scales, regime diagrams, intrinsic instabilities in propagating flames, effects of stretch and strain, turbulent-combustion modeling, turbulent transport in premixed flames, eddy break-up model, BML model, flame-surface density, level set, turbulent flame speed, flamelet limit, presumed PDF, thickened-flame model.

### *III. Non-premixed turbulent combustion:*

Non-premixed burners, anchoring of diffusion flames, characteristic scales, regime diagrams, conserved-scalar formulations, mixture fraction, Lewis-number effects, infinitely-fast chemistry limit, non-premixed turbulent combustion modeling, eddy dissipation, linear eddy model, laminar flamelets, flamelet progress-variable approach, presumed PDF.

### *IV. Spray-combustion fundamentals:*

Liquid-fueled burners, lean direct injection, droplet heating, droplet vaporization and droplet combustion, group combustion, characteristic scales and regime diagrams, Lagrangian and Eulerian approaches.

### **Reference Textbooks:**

Peters N.: "Turbulent Combustion".  
Cant R.S. & Mastorakos E: "Introduction to Turbulent Combustion".  
Williams F.A.: "Combustion Theory".

### **Instructor:**

Javier Urzay, Ph.D.  
[jurzay@stanford.edu](mailto:jurzay@stanford.edu)  
206 CTR Building,  
Stanford University.

