

# **SAMPLE SYLLABUS**

## **ME257-Advanced Combustion**

Prof. J.-Y. Chen (F2010)

Lectures: M. W: 10-11:30 EH 1165

Office Hours: Thu Fr: 10-11:30

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### 1. Turbulent Combustion

- a. Review of turbulent flows<sup>(1,3,7,11,15)</sup>
- b. Theory of turbulent nonpremixed flames<sup>(1,3,4,6,8,12,15)</sup>
- c. Theory of turbulent premixed flames<sup>(1,3,4,6,8,12,15)</sup>
- d. Modeling of turbulent flames<sup>(5,6,8,12,15)</sup>

### Books and References:

- (1) Williams, F.A.: Combustion Theory (second edition) Addison-Wesley Publishing Company, 1985.
- (2) Van Dyke, M.: Perturbation Methods in Fluid Mechanics, The Parabolic Press, 1975.
- (3) Kuo, K.K.; Principles of Combustion, John Wiley & Sons, 1986.
- (4) Kuznetsov, V.R. and Sabelnikov, V.A.: Turbulence and Combustion, Hemisphere Publishing Corporation, 1990.
- (5) Reduced kinetic mechanisms and asymptotic approximations for methane-air flames : a topical volume / Edited by Mitchell D. Smooke, Berlin ; New York : Springer-Verlag, Lecture notes in physics ; 384, 1991.
- (6) Turbulent Reacting Flows Edited by P. A. Libby and F. A. Williams, Springer-Verlag, New York, 1981.
- (7) Tennekes, H. and Lumley, J.L., A First Course in Turbulence, Cambridge, Mass., MIT Press, 1972.
- (8) Paul Libby and Forman Williams edited, Turbulent Reacting Flows, Academic Press (1993).
- (9) Chemically Reacting Flow, Theory & Practice, R.J. Kee, M.E. Coltrin, P. Glarborg, John Wiley, New York, 2003.
- (10) Combustion: Physical and Chemical Fundamentals, Modeling and Simulation, Experiments, Pollutant Formation Springer J. Warnatz, U. Maas, R.W. Dibble 2006.
- (11) Turbulent Flows Stephen B. Pope Cambridge, 2000.
- (12) Turbulent Combustion, N. Peter, Cambridge University Press, 2000.
- (13) Theoretical and numerical combustion, ISBN 1-930217-10-2Thierry Poinsot (CNRS/Institut de Mécanique des Fluides de Toulouse) & Denis Veynante (CNRS/Ecole Centrale Paris)
- (14) Fox R O 2003 Computational models for turbulent reacting flows *Cambridge University Press*
- (15) An introduction to Turbulent Reacting Flows, R.S. Cant and E, Mastorakos, Imperial College Press, 2008.

Detailed topics:

## 1. Turbulent Combustion

### a) Introduction to Turbulent Flows

- Effect of turbulence on combustion
- General characteristics of turbulence
- Statistical description of turbulence
- Velocity, time, and length scales
- Energy and scalar spectrum

### b) Turbulent nonpremixed flames

- Review of 1-D diffusion flames
- Flamelet concept and Damhohler number
- Transformation to mixture fraction coordinate
- Opposed jet flames: steady and transient
- Regime diagram of nonpremixed turbulent flames
- Dissipation rate and its crucial role in nonpremixed flames
- Theory of fast chemistry and flamelet regime
- Theory of probability density function (PDF)
- Monte Carlo simulations of PDF transport equations
- Conditional Moment Closure (CMC)

### c) Turbulent premixed flames

- Flame stretch effects
- Regime diagram for turbulent premixed flames
- BLM Theory of turbulent premixed flames with 1-step chemistry
- Flame surface density approach

### d) Modeling of turbulent flames

- Direct Numerical simulations
- RANS, LES
- Models for turbulence-chemistry interactions

If time available, the following topics will be discussed

## 2) Optional topic: A special mathematical approach for analysis of flames.

Asymptotic Analysis of Combustion Phenomena

- a. Governing equations for one-dimensional flows<sup>(1)</sup>
- b. Introduction to asymptotic expansion<sup>(2)</sup>
- c. Asymptotic analysis for adiabatic premixed flames<sup>(1,5)</sup>
- d. Extension of activation asymptotic to flame extinction due to heat loss effect<sup>(1,3)</sup>.