Applied Combustion

AE/ME 525 | **Course Outline** | **Spring Semester 2000**

Lecturer: Joseph Majdalani, Ph.D.

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Office Hours: 2:00~4:00 p.m., MWF, Haggerty Hall, Rm. 251.

Lecture Times: MW 7:10-8:25 PM
Section No.: 1701.

Lecture Location: EN272.
Course Call No.: 52066/88906.

Prerequisites: Thermodynamics (*MEEN 104*) and Mechanics of Fluids (*ENME 151*)

Textbook: Stephen R. Turns, An Introduction to Combustion: Concepts and Applications, Second Edition, McGraw Hill, 1996.

Scope of Textbook: Targeted at senior and first year graduate level courses in combustion, this text covers more material than can be covered in a single semester course, but at a level that is easily comprehended by undergraduate students.

References:

1. Gary L. Borman & Kenneth W. Ragland, Combustion Engineering, McGraw Hill, 1998.
2. Irvin Glassman, Combustion, Third Edition, Academic Press, 1996.
3. Kenneth Kuan-yun Kuo, Principles of Combustion, Wiley, 1986.
4. A. Murty Kanury, Introduction to Combustion Phenomena, Fourth Edition, Gordan & Breach Science, New York, 1985.
5. F. A. Williams, Combustion Theory, Second Edition, Benjamin Cummings Publishing Co., 1985.
6. Amable Linan & Forman A. Williams, Fundamental Aspects of Combustion, Oxford, 1993.
7. N. A. Chigier & and H. H. Chiu, Mechanics and Combustion of Droplets and Sprays, Begell House, New York, 1995.
8. F. J. Weinburg, Advanced Combustion Methods, Academic Press, New York, 1986.
9. R. A. Strehlow, Combustion Fundamentals, McGraw Hill, 1984.
10. D. B. Spalding, Combustion and Mass Transfer, Pergamon Press, 1979.
11. R. M. Fristrom, Flame Structure and Processes, Oxford, 1995.
12. Colin R. Ferguson, Internal Combustion Engines: Applied Thermosciences, Wiley, 1986.
13. Willard W. Pulkrabek, Engineering Fundamentals of the IC Engine, Prentice Hall, 1997.
14. John B. Heywood, Internal Combustion Engine Fundamentals, McGraw Hill, 1988.

15. V. Ganesan, Internal Combustion Engines, McGraw Hill, 1994.
16. Arthur H. Lefebvre, Gas Turbine Combustion, Second Edition, Taylor and Francis, 1999.
17. William W. Bathie, Fundamentals of Gas Turbines, Second Edition, Wiley, 1995.
18. David G. Wilson, & Theododios Korakianitis, Design of High-Efficiency Turbomachinery and Gas Turbines, Second Edition, Prentice Hall, 1998

Combustion Related Links:

voyager5.sdsu.edu/index.html
www.wssci.org/
www.cis.yale.edu/engineer/Comb_Studies.html
www.en.com/users/crle/industrialmarketing/eog/basic.htm
www.seas.columbia.edu/~sa233/
users.telerama.com/~combust/
www.erc.wisc.edu/
www.ca.sandia.gov/CRF/index_4.html
www.combdyn.com/
odie.seas.ucla.edu/

Combustion Elements: The science of combustion involves complex interactions among many constituent disciplines, including thermodynamics, chemical kinetics, fluid mechanics, heat and mass transfer, material structure and behavior.

Combustion Topics:

Thermodynamics
- Equation of State
- First and Second Laws
- Gibbs-Dalton Law and its Implications

Thermochemistry –First Law of Thermodynamics Applied to Chemically Reacting Flows
- Enthalpies of Formation, Reaction and Combustion
- Thermochemical Laws
- Heat of Reaction

Equilibrium –Second Law of Thermodynamics Applied to Chemically Reacting Flows
- Free Energy
- Chemical Equilibrium
- Adiabatic Flame Temperature

Conservation Equations
- Mass, Momentum, Energy and Species

Chemical Kinetics
- Collision Theory
- Chain Reactions

Diffusion Flames
- Shvab-Zeldovich Formulation
- Conservation Conditions at the Interface
- Droplet Burning
- Boundary Layer Combustion
- Flame Propagation

Premixed Gas Flames
- Ignition
- Extinction Flammability Limits

Scope: This course covers the fundamentals of combustion systems, fire and explosion phenomena. Topics covered will be chosen from the following themes: thermochemistry, chemical kinetics, laminar flame propagation, detonations and explosions, flammability and ignition, spray combustion, and the use of computer techniques in combustion problems.

Objective: To provide a sound fundamental understanding of the physics of combustion phenomena, and to apply this knowledge to various applications in order to understand how the devices have been designed to recover useful work from the energy release while abating the associated pollutant emissions.

Motivation: There is a tremendous need for undergraduate students interested in the thermal sciences to have a basic knowledge of combustion science and its applications. This course is the first to present the essential theory and background material that is helpful for understanding the more complex literature on combustion, in a format that is teaching rather than reference oriented. The theory is reinforced by examples, review questions and problems.

1999-2000 Catalog Data: Topics in Thermofluids Science and Engineering: … chemical kinetics and combustion.

Contents:
1. Introduction.
2. Combustion and Thermochemistry.
3. Introduction to Mass Transfer.
4. Chemical Kinetics.
5. Some Important Chemical Mechanisms.
6. Coupling Chemical and Thermal Analyses of Reacting Systems.
7. Simplified Conservation Equations for Reacting Flows.
8. Laminar Premixed Flames.
9. Laminar Diffusion Flames - Burning Jets.
10. Laminar Diffusion Flames-Droplet Burning.
11. Introduction to Turbulent Flows.
12. Turbulent Premixed Flames.
13. Turbulent Non-Premixed Flames.

Text Appendices: A) Selected Thermodynamic Properties of Gases Comprising C-H-O-N System. B) Selected Properties of Hydrocarbon Fuels. C) Selected Properties of Air, Nitrogen, and Oxygen. D) Binary Diffusive at One Atmosphere. E) Generalized Newton's Method for the Solution of Nonlinear Equations.

Homework Assignments: Homework assignments will be made in class. Late homework will only be accepted with an acceptable excuse. The homework will be graded on both correctness and style. Failure to present one’s work in a concise, easy to follow manner is likely to result in deductions.

Grade Distribution: A) Homework: 20%. B) Exams: 2@25%. C) Final: 30%.

Applied Combustion

Lecture		Date	Topics (tentative)		Text
1	January	17	Martin Luther King Day	*Week 1*	HOLIDAY
2		19	Introduction		Chapter 1
3		24	Combustion and Thermochemistry	*Week 2*	Chapter 2
4		26	Combustion and Thermochemistry		
5		31	Combustion and Thermochemistry	*Week 3*	
6	February	2	Introduction to Mass Transfer		Chapter 3
7		7	Introduction to Mass Transfer	*Week 4*	
8		9	Introduction to Mass Transfer		
9		14	Chemical Kinetics	*Week 5*	Chapter 4
10		16	Chemical Kinetics		
11		21	Chemical Kinetics	*Week 6*	
12		23	Important Mechanical Mechanisms		Chapter 5
13		28	Important Mechanical Mechanisms	*Week 7*	
14	March	1	Important Mechanical Mechanisms		
15		13	Thermochemical Reactors	*Week 8*	Chapter 6
16		15	Thermochemical Reactors		
17		20	Thermochemical Reactors	*Week 9*	
18		22	Conservation Equations		Chapter 7
19		27	Conservation Equations	*Week 10*	
20		29	Conservation Equations		
21	April	3	Laminar Premixed Flames	*Week 11*	Chapter 8
22		5	Laminar Premixed Flames		
23		10	Laminar Premixed Flames	*Week 12*	
24		12	Laminar Diffusion Flames		Chapter 9
25		17	Laminar Diffusion Flames	*Week 13*	
26		19	Laminar Diffusion Flames		
27		24	EASTER	*Week 14*	HOLIDAY
28		26	Introduction to Turbulent Flows		Chapter 11
29	May	1	Introduction to Turbulent Flows	*Week 15*	
30		3	Introduction to Turbulent Flows		
		10	FINAL EXAM 8:00-10:00 PM		Wednesday