AE 6766 Outline

This is a *tentative* outline of the material that will be covered and the appropriate chapter assignments from Turns. Class lectures will parallel and *expand upon* the coverage in the text (and items marked* have subjects with little or no coverage in the text book).

		Reading	# Hours
I.	**Introduction and Thermodynamics Review**	Chapter 2	1.5
	A. Overview		
	B. Equivalence Ratio		
	C. Chemical Equilibrium		
	1. Adiabatic Flame Temperature		
	2. Equilibrium Composition		
II.	**Chemical Kinetics**		8.5
	A. Introduction to Chemical Kinetics	Chapter 4	
	1. Review of Gas Kinetic Theory and Collision Rates		
	2. Chemical Kinetics Basics		
	a. Elementary vs. Overall (Global) Reactions and Reaction Rates		
	b. Rate Constants: Bimolecular Models, Collision Complex Activation Energy		
	B. Advanced Models		
	1. Activated Complex Theory for Bimolecular Reactions*		
	2. Unimolecular and Termolecular Mechanisms (Lindemann-Hinshelwood)		
	C. Analyzing Reaction Mechanisms		
	1. Reaction Mechanisms (example: Zeldovich NO)		
	2. Characteristic Reaction Times		
	3. Use of Analytic Approximations to Produce Reduced Mechanism: Partial Equilibrium and Steady-State Assumptions (example: Reduced Zeldovich*)		
	4. Introduction to Chain Branching Reactions		
	D. Important Combustion Reaction Mechanisms	Chapter 5	
	1. Explosions and Hydrogen Oxidation		
	a. Explosion Limits and Chain Branching		
	b. Hydrogen Oxidation and H_2-O_2 Explosion Limits		
	c. Relationship of Explosion Limits to Induction Delay*		
	2. CO and Hydrocarbon Fuel Oxidation		
	a. Carbon Monoxide Oxidation: dry and wet		
	b. CO/H_2 mixtures (syngas)		
	c. Hydrocarbon Oxidation		
	3. Nitrogen Oxidation (NOx)		
	a. Extended Zeldovich (thermal)		
	b. Intermediate N_2O and NNH		
	c. Prompt (Fenimore/HCN)		
	d. NO_2		
III.	**Coupled Chemical and Thermal Analysis**	Chapter 6	3.5
	A. Chemical Reactor Basics		
	1. Temperature-Energy Coupling to Reactions		
	2. Introduction to Chemical Reactors		
	B. Batch Reactors		
	1. Reactor equations		
	2. Example - Calculation of Autoignition/Induction Delay*		

C. Flow Reactors
   1. Plug Flow Reactors and Residence Time
   2. Well-Stirred Reactors
      Example: Ignition, Extinction and Combustor Blowout*

IV. Conservation (Transport) Equations for Multi-Component, Reacting Fluids — Chapter 7, 3 — 2

A. Introduction to Molecular Diffusion
B. Conservation Equations
C. Energy Eq. Simplifications and Lewis Number Similarity

V. Premixed Combustion: 1-d Combustion Waves — Chapter 16 — 2

A. Mixedness, 1-d Wave Propagation, Detonations/Deflagrations
B. Conservation Laws
C. The Rayleigh Line
D. The Rankine-Hugoniot Relation
E. Chapman-Jouget Points and Allowed Solutions

VI. Planar Detonations — Chapter 16 — 1

A. 1-D Structure - ZND Model
B. Chapman-Jouget Detonation Speed (D_{CJ})
C. 3-D (Cellular) Structure

VII. Laminar Premixed Flames (Deflagrations) — Chapter 8 — 8

A. Basic Flame Structure and Laminar Flame Speed Model
   1. Plane Laminar Flame Structure
   2. Conservation Equations (with diffusion)
   3. Flame Speed (S_L^o) Two-Zone Model
B. Flame Thickness/Speed Scaling and Detailed Flame Structure
   1. Flame Thickness (δ_f)
   2. Physical and Chemical Effects on S_L^o and δ_f: Scaling
   3. Detailed 1-d Flame Structure: Multistep Chemistry Results
C. Flame Stretch and Flame Speed Measurements*
   1. Stretched Flames and Convective-Diffusive Misalignment
   2. Lewis Numbers, Differential Diffusion and Impacts on S_L
   3. Flame Speed Measurement Techniques
D. Propagation Limits, Stability and Stabilization
   1. Quenching Distance
   2. Flammability Limits
   3. Flame Instabilities*
   4. Flame Extinction by Stretch*
   5. Flame Stabilization/Holding*

VIII. Ignition* — Chapter 8 — 1.5

A. Forced Ignition and Ignition Kernels
B. Ignition by Hot Surfaces
C. Ignition in Storage Vessels

IX. Laminar Nonpremixed Combustion — 6

A. Basics
   1. Diffusion Flame Overview
   2. Nonconvecting 1-d Flame and Flame Sheet Approximation

B. Laminar Axisymmetric Jet Flames — Chapter 9
   1. Nonreacting Laminar Jets
      a. Flowfield Description and Mixture Fraction
      b. Conservation Equations and Iso-density Solution
   2. Laminar Jet Flames
      a. Description
      b. Conservation Equations, Conserved Scalars, State Relations
      c. Comments on Solutions and Trends

C. Finite Rate Chemistry Effects
   1. Lifted Flames and Partially Premixed Combustion
   2. Counterflow Nonpremixed Flames
   3. Soot

D. Condensed Phase Combustion
   1. Overview and Regression Rate
   2. Liquid Droplet Flames — Chapter 10 (+ end of Chap. 3)
      a. Droplet Evaporation
         Evaporation Rate, Spalding Transfer #s., Droplet Lifetime
      b. Burning Droplets
         Evaporation Rate, Spalding Transfer #s, Flame Location, Ignition Delay

X. Introduction to Turbulent Combustion — 3

A. Introduction to Turbulence and Combustion Regimes — Chapter 11
   1. Characteristics of Turbulent Flows
   2. Turbulent Length and Time Scales
   3. Turbulent Reacting Flow Regimes

B. Premixed Turbulent Flames — Chapter 12
   1. Length and Velocity Ratios
   2. Turbulent Karlovitz Numbers and Flame Regimes (Borghi-Peters Diagram*)
   3. Turbulent Flame Speeds

C. Nonpremixed Turbulent Flames — Chapter 13
   1. Background
   2. Turbulent Jet Flames
      a. Flame Length
      b. Instantaneous Flame Structure
      c. Mixture Fraction Relations and Finite Rate Chemistry Effects
   3. Flamelet Modeling*
   4. Differentiating Premixed and Non-Premixed Combustion in Non-Premixed Combustors: Flame Index