REFERENCE TEXTBOOKS

MATERIAL AND ENERGY BALANCE:

- **Elementary Principles of Chemical Processes,** 4th Edition - Richard M. Felder, Ronald W. Rousseau, Lisa G. Bullard

THERMODYNAMICS:

- **Introduction to Chemical Engineering Thermodynamics (**8th Edition) - J.M. Smith, Hendrick Van Ness, Michael Abbott, and Mark Swihart *(primary)*
- **Fundamental of Chemical Engineering Thermodynamics** - Themis Matsoukas
- **Engineering and Chemical Thermodynamics, 2nd Edition** - Milo D. Koretsky

TRANSPORT:

- **Transport Phenomena (**revised 2nd Edition) - R. Bryon Bird, Warren E. Stewart, Edwin N. Lightfoot *(primary)*
- **Fundamentals of Momentum, Heat and Mass Transfer (**6th Edition) - James Welty, Gregory L. Rorrer, David G. Foster
- **Munson, Young and Okiishi's Fundamentals of Fluid Mechanics (**8th Edition) - Philip Gerhart, Andrew Gerhart, John Hochstein
- **Fox and McDonald's Introduction to Fluid Mechanics (**9th Edition) - Philip Pritchard, John Mitchel
- **Fundamentals of heat and Mass Transfer (**8th Edition) - Theodore L. Bergman, Adrienne S. Lavine

KINETICS AND REACTOR DESIGN:

- **Elements of Chemical Reaction Engineering** (5th Edition) - H. Scott Fogler

SEMESTER 1

COURSE 1: MATERIAL AND ENERGY BALANCES - THERMODYNAMICS - TRANSPORT

Material Balances	**Energy Balances**
Fundamental of Material Balances - Chapter 4 FRB	Energy and Energy Balances - Chapter 7 FRB
4.2 - Conservation of Mass	7.1 & 7.2 - Forms of Energy & 1st Law of Thermodynamics
4.1 - Process Classification	7.3 - Energy Balances on Closed Systems
4.3 - Degrees of Freedom	7.4 - Flow Work, Shaft Work and Specific Properties
4.3 - Flowsheet Labeling and Basis Calculation (note, 4 lectures above fall under one “bullet” on the navigation panel)	7.4 & 7.6: - Energy Balances on Open Systems at Steady State
4.5 - Recycle and Bypass	7.5 - Tables of Thermodynamics Data
4.4 - Balances on Multiple Unit Processes	7.7 - Mechanical Energy Balance
4.6 - Chemical Reaction Stoichiometry	Energy Balances on Non-Reactive Processes - Chapter 8 FRB
4.7 - Balances on Reactive Processes	8.1 - Elements of Energy Balance Calculation
4.7 - Independence and Different DOF Analysis (note, both 4.7 items fall under one “bullet” in navigation)	8.2 & 8.3 - Changes in Pressure and Temperature
4.8 - Combustion	8.4 - Phase Change Operation
4.6 - Chemical Equilibrium	8.5 - Mixing and Solutions
4.6 - Yield, Selectivity, and Conversion	Energy Balances on Reactive Processes - Chapter 9 FRB
Single Phase Systems and Volumetric Properties of Pure Fluid - Chapter 5 FRB & Chapter 3 SVAS	9.1 - Heats of Reaction
3.2 - PVT Behavior of Pure substance (Van Ness)	9.2 - Measurement and Calculation of Heat of Reaction
5.2 - Ideal Gases	9.3 & 9.4 - Heats of Formation and Heats of Combustion
5.3 - Equation of State for Non-Ideal gases	9.5 - Energy Balances on Reactive Processes
5.4 - Compressibility Factor Equation of State	
Multi-Phase Systems - Chapter 6 FRB	
6.1 - Single Component Phase Equilibrium	
6.2 - The Gibbs Phase Rule	
6.3 - Gas-Liquid System: One Condensable Component	
6.4 - Multi-Component Gas-Liquid Systems	
6.5 – Calculation of Dew Point and Bubble Point Temperatures	

SEMESTER 1, CONTINUED

THERMODYNAMICS	TRANSPORT
The Second Law of Thermodynamics - Chapter 5 SVAS	**Momentum Transport**
5.1 - Statement of Second Law	Fluid Mechanics, Basics and Definitions - Chapter 1 & 2 BSL
5.3 - Carnot Engine with Ideal-Gas-State Working Fluid	Introduction to Fluid Mechanics
5.4 - Entropy	1.1 - Newton's Law of Viscosity
5.6 - Entropy Balance for Open Systems	Differential Equations of Fluid Mechanics
5.2 & 9.2- Heat Engines, Heat Pumps, and Refrigeration	2.1 – Shell Momentum Balance
Thermodynamic Properties of Fluids - Chapter 6 SVAS	(Example) 2.2 – Flow of a Falling Film
6.1 - Fundamental Property Relations	(Example) 2.3 – Flow Through a Circular Tube
6.2 - Residual Properties	(Example) 2.4 – Flow Through an Annulus
6.4 - Generalized Property Correlation for Gases	The Equations of Change For Isothermal Systems - Chapter 3 BSL
6.5 - Two-Phase Systems	3.1 - The Equation of Continuity
Application of Thermodynamics to Flow Processes - Chapter 7 - 8 SVAS	3.2 - The Equation of Motion - Shell Momentum Balance
7.1 - Nozzles, Throttling Process	3.5 - Navier-Stokes Equation
7.2 - Turbines (Expanders)	(Example) - Flow of a Falling Film
7.3 - Compression Process - Compressors	(Example) - Flow Through a Circular Tube
7.3 - Compression Process - Pumps	(Example) - Flow Through an Annulus
8.1 - The Steam Power Plant - Rankine Cycle	

SEMESTER 2

COURSE 2: THERMODYNAMICS - TRANSPORT - KINETICS AND REACTOR DESIGN

TRANSPORT	THERMODYNAMICS
Heat Transfer	The Framework of Solution Thermodynamics - Chapter 10 SVAS
Thermal Conductivity and Energy Transport - Chapter 9 BSL	10.1 & 10.2 - Fundamental Relation and The Chemical Potential
9.1 - Fourier's Law of Heat Conduction (Molecular Energy Transport)	10.2 - Chemical Equilibrium
9.2 - Temperature and Pressure Dependence of Thermal Conductivity	10.3 - Partial Properties
Heat Transport by Convection: Forced and Free	10.4 - The Ideal-Gas-State Mixture Model
Heat Transport by Radiation - 16.4	10.5 - Fugacity and Fugacity Coefficient: Pure Species
Shell Energy Balances and Temperature Distributions - Chapter 10 BSL	10.5 - Vapor/Liquid Equilibrium for Pure Species
10.1 - Shell Energy Balances; Boundary Conditions	10.6 - Fugacity and Fugacity Coefficient: Species in Solution
Important Dimensionless Groups	10.7 - Generalized Correlation For Fugacity Coefficient
Mass Transfer	10.8 - The Ideal Solution Model
Diffusivity and the Mechanisms of Mass Transport - Chapter 17 BSL	10.9 - Excess Properties
17.1 - Fick's Law of Binary Diffusion (Molecular Mass Transport)	Mixing Processes - Chapter 11 SVAS
17.2 - Temperature and Pressure Dependence of Diffusivities	11.1 - Property Changes of Mixing
17.7 - Mass and Molar Concentrations and Average Velocities	Phase Equilibrium: Introduction - Chapter 12 SVAS
17.7 - Molecular and Convective Mass and Molar Fluxes	12.2 - The Phase Rule - Duhem's Theory
17.8 - Summary of Mass and Molar Fluxes	12.3 - VLE: Qualitative Behavior - Part 1
Concentration Distributions in Solids and in Laminar Flow - Chapter 18 BSL	12.3 - VLE: Qualitative Behavior - Part 2
18.1 - Shell Mass Balances; Boundary Conditions	Thermodynamic Formulation for VLE - Chapter 13 SVAS
18.2 - Diffusion Through a Stagnant Gas Film	13.1 - Excess Gibbs Energy and Activity Coefficients
18.3 - Diffusion with a Heterogeneous Chemical Reaction	13.2 - The Gamma/Phi Formulation of VLE
18.4 - Diffusion with a Homogeneous Chemical Reaction	13.3 - Raoult's Law, Bubble Point/Dew Point Calculations
	13.3 - Modified Raoult's Law, & Henry's Law
	13.8 - Flash Calculations

SEMESTER 2, CONTINUED

KINETICS AND REACTOR DESIGN	
Mole Balances - Chapter 1 Fogler	Isothermal Reactor Design: Moles and Molar Flow Rates - Chapter 6 Fogler
1.1 - The Rate of Reaction	6.2 - Mole Balances on CSTR, PFR, PBR and Batch Reactors
1.2 - The General Mole Balance Equation 1.3 - Batch Reactors	
1.4 - Continuous-Flow Reactors(CSTR, Tubular, PBR)	
Conversion And Reactor Sizing - Chapter 2 Fogler	
2.1 - Definition of Conversion	
2.2 - Batch Reactor Design Equation	
2.3 - Design Equations For Flow Reactors (CSTR, Tubular, Packed Bed)	
2.5 - Reactors in Series (CSTR, PFR, Combination)	
Rate Laws - Chapter 3 Fogler	
3.1 - Basic Definitions	
3.2 - The Reaction Order and Rate Law	
3.2 - Non-Elementary Rate Laws	
3.3 - Reaction Rate Constant	
3.4 - Reactor Sizing And Design Summary	
Stoichiometry - Chapter 4 Fogler	
4.1 - Batch Systems	
4.2 - Flow Systems	
Isothermal Reactor Design: Conversion - Chapter 5 Fogler	
5.1 - Design Structure For Isothermal Reactors	
5.2 - Batch Reactors	
5.3 - Single CSTR	
5.3 - CSTR in Series	
5.4 - Tubular Reactors	