**ChBE 3210 Transport Phenomena II (required course)**

**Credit:** 3-0-3

**Prerequisite(s):** Thermodynamics I (ChBE 2130), minimum grade of "C**",** Transport Phenomena I (ChBE 3200), minimum grade "C", and Differential Equations (Math 2403), minimum grade of "C**"**

**Textbook:** *Fundamentals of Momentum, Heat and Mass Transfer,* 5th edition, J. R. Welty, C.E. Wicks, R. E. Wilson, G. Rorrer, John Wiley & Sons, Inc. (2008)

**Objectives:**

Fundamental principles and applications of heat and mass transfer. The analysis of chemical engineering processes and operations involving mass transfer.
This course builds on heat transfer concepts developed in ChBE 3200 and introduces basic concepts of heat and mass transfer: (i) theoretical basis for convective heat and mass transfer correlations, (ii) heat exchanger design, (iii) diffusion, interphase mass transport, and chemical reaction, and (iv) analysis of mass transfer equipment, such as packed beds and contact towers. Scaling, dimensional analysis, and design principles are emphasized.

**Learning Outcomes:**

By the end of this course, students will be able to:

1. Analyze situations involving convective heat transfer in external and internal flow. Both forced and natural convection processes are to be analyzed. (Student Outcomes: a, b, e, k)
2. Combine heat-transport resistances in series to obtain overall heat-transfer coefficients and apply these in a variety of design applications, including shell-and tube heat-exchangers. (Student Outcomes: a, c, k)
3. Solve steady-state problems in counter-diffusion and uni-molal, uni-directional diffusion using Fick's first law. (Student Outcomes: a, b, e, k)
4. Understand the theoretical basis of convective heat-transfer and mass-transfer, and to use the analogies between momentum, heat, and mass-transfer to interrelate rate constants.
   (Student Outcomes: a, b, k)
5. Use individual mass transfer coefficients to obtain overall mass transfer coefficients in multi-phase systems and to apply these in a variety of design applications. (Student Outcomes: a, b, e)
6. Develop microscopic and macroscopic mass and energy balances, and solve them for a number of systems. (Student Outcomes: a, b, k)

7. Design packed-columns for simultaneous heat- and mass-transfer (i.e., cooling towers, gas absorption, distillation etc.) in terms of number and height of transfer units (NTU & HTU). (Student Outcomes: a, c, k)

Topics Covered

1. Dimensional analysis
2. Convective heat transfer
   a. Blasius solution
   b. Boundary layer similarity
   c. Turbulence and momentum analogy
3. Heat transfer correlations
   a. Internal and external flows
   b. Empirical correlations
   c. Boiling and condensation
   d. Free convection
4. Heat Exchanger Design
   a. Overall heat transfer coefficients
   b. LMTD
   c. NTU-effectiveness method
5. Diffusion
   a. Molecular diffusion
   b. Knudsen and restricted diffusion
   c. Fick's law
   d. Unimolecular diffusion and counter-diffusion
6. Differential Mass Balances
   a. Steady and pseudo-steady state mass transfer
   b. Transient diffusion
   c. Mass transfer involving chemical reactions
7. Convective Mass Transport
   a. Mass transfer coefficients and correlations
   b. Analogies
   c. Simultaneous heat and mass transfer
   d. Penetration theory
   d. Interphase mass transport
8. Mass Transfer Equipment
   a. Stirred tanks
   b. Continuous contact towers
   c. Operating line equations
   d. Mass transfer capacity coefficients
9. Special topics: transdermal drug delivery, membrane separations

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Last Modified: February 15, 2014