**ChBE 3210**
**Transport Phenomena II**
**Fall 2012**

## General Course Information

**Instructors:**
Dr. Sven Behrens: sbehrens@gatech.edu
Office: Bunger-Henry 409
Phone: (404) 894-3166
Office hours: Monday 2:00-3:00 in ES&T 2354 and Tuesday 11:00-12:30 in ES&T 2229.

**Teaching Assistants:**
Elaine Tang: elaine.tang@gatech.edu
Cell: (404) 825-8995
Office Hours: Tuesday 2:00-3:30 in ES&T 2320.

**Course Prerequisite:**
ChBE 2110 (Thermodynamics I), ChBE 3200 (Transport Phenomena I), and Math 2403 (Diff. Eqns.)

**Class times and place:**
MWF 10 AM, Room L1125 ES&T

**Course Objectives:**
This course builds on heat transfer concepts developed in ChBE 3200 and introduces basic concepts of 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:**
Upon satisfactory completion of this course, students will be able to:

1. Analyze situations involving convective heat transfer in external and internal flow, for both forced and natural convection processes.
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.
3. Solve steady-state problems in counter-diffusion and uni-molal, uni-directional diffusion using Fick's first law.
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.
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.
6. Develop microscopic and macroscopic mass and energy balances, and solve them for a number of systems.
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).

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

**Office Hours:**
Dr. Behrens' office hours will be coordinated with participants in the Wednesday, August 22 class. Drop-ins and appointments by email are also welcome. Long emails with questions are time-consuming to answer, so please stop by instead and I will be better able to assist you.

**Course updates and resources:**
Syllabus, class info, homework solutions, additional examples, last year's exams/solutions, and class updates will be on the T-square course page. It is your responsibility to check that website often. Grades will also be posted on that website.

**Homework:**
Homework assignments are due *in class* on the date indicated on the assignment. Most of the time solutions will be posted on the class website on the day the homework is due. Late homework assignments (after the class is over) will not be accepted.

Students are encouraged to work in groups, but each student must submit an *original* homework. Copying from other students, solution manuals, or other sources is viewed as academic misconduct and will be dealt with according to institute policies. Homework solutions must be in accordance with the provided guidelines. In case of significant violations or illegible/unclear assignments, the homework will not be graded.

**Exams:**
In addition to the final exam, two exams will be given on **Thursday, 10/04 and Thursday, 11/15 at 6-8 pm in ES&T L1205.** No make-up exams will be offered. Only certified medical emergencies or an equivalent will be accepted for missing exams. No exam grade will be dropped. A student missing an exam should contact the instructors as early as possible and preferably before the exam. Exams will be cumulative.

The use of wireless devices is prohibited on the exams or the final. Programmable calculators are allowed, but relevant content must be erased from the memory. The exams and the final will have a closed book and an open book section.

**Pop quizzes:**
There will be 5-6 announced quizzes throughout the semester. No make-up quizzes will be given.

**Course grade breakdown:**
Exam I 20%
Exam II 25%
Final exam 30%
Pop quizzes 10%
Homework 15%

**Academic Misconduct:**
Students in this class are expected to abide by the Georgia Tech Honor Code at all times. All work turned in for grading must be original. Collaboration with other students in the class on the homework and projects are allowed but must be acknowledged on the assignments. References: the complete text of the Honor Code and other resources are available at http://www.honor.gatech.edu/.

**ChBE 3210, Fall 2012, Dr. Behrens - tentative course schedule**

| | | Date | Comment | #Hw due | Lecture content | Reading |
|---|---|---|---|---|---|---|
| Week 1 | lecture 1 | 20-Aug | | | convective heat transfer: fundamentals | Ch. 19.1 -19.5 |
| | lecture 2 | 22-Aug | | | convective heat transfer: dimensional analysis | |
| | lecture 3 | 24-Aug | | | convective heat transfer: boundary layer | |
| Week 2 | lecture 4 | 27-Aug | | | convective heat transfer: boundary layer | 19.5 - 19.7 |
| | lecture 5 | 29-Aug | | 1 | convective heat transfer: momentum analogy | |
| | lecture 6 | 31-Aug | | | convective heat transfer: turbulence | |
| Week 3 | Labor Day | 3-Sep | | | - | |
| | lecture 7 | 5-Sep | | 2 | correlations for natural convection | 20.1 - 20.3 |
| | lecture 8 | 7-Sep | | | correlations for forced convection | |
| Week 4 | lecture 9 | 10-Sep | | | boiling | 21.1 |
| | lecture 10 | 12-Sep | | 3 | condensation | 21.2 |
| | lecture 11 | 14-Sep | | | heat exchanger design | 22.1 - 22.3 |
| Week 5 | lecture 12 | 17-Sep | | | heat exchanger design | 22.4 |
| | lecture 13 | 19-Sep | | 4 | heat exchanger design | 22.5 |
| | lecture 14 | 21-Sep | | | mass transfer: fundamentals | 24.1 |
| Week 6 | lecture 15 | 24-Sep | | | mass transfer: diffusion | 24.2 |
| | lecture 16 | 26-Sep | | 5 | mass transfer: diffusion | |
| | lecture 17 | 28-Sep | | | mass transfer: convection | 24.3 |
| Week 7 | lecture 18 | 1-Oct | | | differential balances of mass transfer | 25.1 |
| | lecture 19 | 3-Oct | | | review, **Thursday Oct 4, 6 - 8 PM: EXAM 1** | |
| | lecture 20 | 5-Oct | | | differential balances of mass transfer | 25.2 |
| Week 8 | lecture 21 | 8-Oct | | | differential balances of mass transfer | 25.3 - 25.4 |
| | lecture 22 | 10-Oct | | 6 | steady state molecular diffusion | 26.1 - 3 |
| | drop day, lect 23 | 12-Oct | | | examples of 1-d steady state molecular diffusion | |
| Week 9 | Fall Break | 15-Oct | | | - | |
| | lecture 24 | 17-Oct | | 7 | steady state molecular diffusion with reaction | |
| | lecture 25 | 19-Oct | | | transient molecular diffusion | 27.1 - 27.2 |
| Week 10 | lecture 26 | 22-Oct | | | transient molecular diffusion | 27.3 - 27.4 |
| | lecture 27 | 24-Oct | | 8 | convective mass transfer: dimensional analysis | 28.1 - 28.3 |
| | lecture 28 | 26-Oct | | | convective mass transfer: boundary layer | 28.4 - 28.5 |
| Week 11 | lecture 29 | 29-Oct | | | convective mass transfer: momentum analogies | 28.6 - 28.7 |
| | lecture 30 | 31-Oct | | | simultaneous momentum, heat and mass transfer | 26.4 |
| | lecture 31 | 2-Nov | | 9 | simultaneous momentum, heat and mass transfer | 26.4 |
| Week 12 | lecture 32 | 5-Nov | | | interphase mass transfer: equilibrium | 29.1 |
| | lecture 33 | 7-Nov | | | interphase mass transfer | 29.2 |
| | lecture 34 | 9-Nov | | 10 | interphase mass transfer | |
| Week 13 | lecture 35 | 12-Nov | | | examples and review | |
| | lecture 36 | 14-Nov | | | review, **Thursday Nov 17, 6 - 8 PM: EXAM 2** | |
| | lecture 37 | 16-Nov | | 11 | mass transfer equipment | 31.1 |
| Week 14 | lecture 38 | 19-Nov | | | continuous contact towers | 31.3 - 31.5 |
| | lecture 39 | 21-Nov | | | unit operations: contact towers | |
| | Thanksgiving | 23-Nov | | 12 | - | |
| Week 15 | lecture 40 | 26-Nov | | | unit operations: stirred tanks | 31.2 |
| | lecture 41 | 28-Nov | | | mass transfer correlations: spheres and pipes | 30.1 - 30.2 |
| | lecture 42 | 30-Nov | | 13 | mass transfer correlations: columns, packed beds | 30.3 - 30.7 |
| Week 16 | lecture 43 | 3-Dec | | | mass transfer correlations: stirred tanks, towers | |
| | lecture 44 | 5-Dec | | | special topics: transdermal drug delivery | |
| | lecture 45, last class | 7-Dec | | | review | |
| | **Final exam** | **10-Dec** | 11:30 am - 2:20 pm | | | |

Reading refers to sections in ***Fundamentals of Momentum, Heat and Mass Transfer,*** **5th edition**, J.R. Welty, C.E. Wicks, R.E. Wilson and G. Rorrer, Wiley, (2008).