ECH 4267 – Transport Phenomena II

Credits and Contact Hours

3 credit hours. 3 contact hours per week. Offered Spring Semester. B221, Tu Th 8-9:15

Instructor's or Course Coordinator's Name

Dr. Subramanian Ramakrishnan, Associate Professor
Room A162 College of Engineering
sramakrishnan@fsu.edu

Textbook(s) – title, author, and year

1. "Fundamentals of Momentum, Heat, and Mass Transfer", J.R. Welty, C.E. Wicks, R.E. Wilson, and G. Rorrer, John Wiley and Sons, 5th Edition.
2. "Schaum's Outline of Fluid Mechanics and Hydraulics", 4th edition, by C. Liu, G. Ranald, and J.B. Evett, 2013.
3. "Schaum's Outline of Heat Transfer", 2nd edition, by D. Pitts and L. Sissom, 2011.

Specific Course Information

a. Course Catalog Description
   - This is the second course of a two-semester sequence on transport phenomena. The aim of the course is to instill into ChE students critical analytical and mathematical skills for analyzing fundamental concepts in transport phenomena (including fluid mechanics, heat transfer, and mass transfer) and to apply these concepts to the solution of problems relevant to chemical and biomedical engineering. The focus is on the microscopic description of momentum, energy and mass transfer to obtain balance equations and to utilize information obtained from solutions of the balance equations to calculate engineering quantities of interest – drag force, rate of heat and mass transfer in a wide variety of problems. The students will gain an appreciation of transport principles in diverse applications of chemical, biological, and materials science and engineering
   - Professional Component Contributions – Students learn how to apply basic chemical engineering principles in fluid mechanics and heat and mass transfer to solve problems encountered in the chemical process industry, and biomedical product sdesign and development.

   "It is the responsibility of each student enrolled in the course to ensure that they satisfy the course prerequisites and co-requisites. The department will drop students who do not do so voluntarily, and the department assumes no responsibility for any drop fees assessed by the university"

   - Prerequisites: ECH 3101, ECH 3266, ECH 3854.
   - Corequisites: ECH 3274L, ECH 3418.

b. Required, Elective, or Selected Elective.
   - Required Course.

Brief List of Topics to be Covered

1. Differential equations of fluid flow.
2. Viscous flow.
3. Boundary layer theory.
4. Differential equations of heat transfer.
5. Steady-state conduction. Boundary conditions.
6. Unsteady-state conduction.
7. Convective heat transfer. Boundary layer analysis and heat transfer coefficient.
8. Differential equations for mass transfer.
9. Steady-state molecular diffusion.
10. Convective mass transfer.
11. Mass transfer with chemical reactions. Combined heat and mass transfer.
12. Diffusion in membranes.

Specific Goals for the Course

Course Outcomes and their Relationship to Student Outcomes (Criterion 3, ABET)

SO: Student Outcomes A-K. **LOL**: Level of Learning corresponding to Bloom's taxonomy.
HW: Homework; **Q**: Quizzes; **T**: Tests; **P**: Project.

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

Course Instructional Outcomes	**Student Outcome & LOL**	**Proficiency Assessed by**
Establish and simplify appropriate conservation statements (the general equations of change and macroscopic balances) to obtain differential equations for steady and unsteady mass, momentum and heat transfer processes at microscopic and macroscopic level.	A4, E4	HW, Q, T
Reduce and solve the appropriate differential equations of change to obtain desired profiles for velocity, temperature and concentration by applying boundary and initial conditions.	A4, E4	HW, Q, T
Employ shell balance equations to obtain desired profiles for velocity, temperature and concentration	A3, E4	HW, Q, T
utilize information obtained from solutions of the balance equations to obtain engineering quantities of interest – drag force, rate of heat and mass transfer	C2, A3, E3	HW, Q, T
Perform approximate integral analysis of the momentum, thermal and concentration boundary layers to obtain the appropriate transfer coefficients.	A3, E3	HW, Q, T
Specify and explain the fundamental transport equations that describe non steady-state heat and mass transfer, i.e conduction and diffusion equations	A3, E3	HW, Q, T

Solve steady-state problems in counter-diffusion and uni-molal, uni-directional diffusion using Fick's first law.	A3, E3	HW, Q, T
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.	C2, A3, E3	HW, Q, T
Students will have the ability to apply modern engineering tools such as COMSOL Multiphysics software (finite element analysis and solver software package) to transport phenomena processes for chemical and biomedical engineering practice.	A3, K2	HW
Appreciate relevance of transport principles in diverse applications of chemical, biological, and materials science and engineering.	H2,	HW, class lectures

Course Format:

Two 75-minute lecture sessions per week.

Computer Usage:

Some Homework assignments require use of COMSOL Multiphysics software (formerly FEMLAB) , which is a modeling package for the simulation of any physical process that can be described with partial differential equations (PDEs). It is essentially a finite element analysis and solver software package for various physics and engineering applications.

Course Policies:

Grading: **Homework Assignments:** 10 points; **3 Exams:** 75 points; **Quizzes/possible comsol project/Exam 3:** 15 points; **Total:** 100 points.

***Quizzes are closed book*.** Quizzes will be usually given right at the beginning of class – sharp 11:20 start. **You miss three quizzes → 0%**

Exams might be open book/closed book – If open Book, only book is allowed – no notes are allowed.

FINALS APRIL 28 - Tuesday 12.30 – 2:30

Grading Policy: If a student has questions concerning the grading of exams, quizzes, or homework, the exam, quiz, or homework may be resubmitted for regrading up to one week following the return of the exam to the student. After this time no homework or exam will be reviewed. Note that the entire exam or homework will be subject to regrading and points can be taken away as well as added.

Help Session: To be decided. During this time period, I will solve extra problems, rework problems that were solved in class, go over concepts again etc. **No new concepts will be covered in the help session.** The aim is to expose students to wide variety of problems in order to improve

their problem solving skills. It is not compulsory to attend the help session but highly recommended as in previous years, students have found it to be extremely useful.

Student Teams: Student collaboration/discussion is allowed on some homework assignments.

Honor Code: Students are expected to abide by the honor code of the Universities. The academic Honor Policy of Florida State University may be accessed at http://dof.fsu.edu/honorpolicy.htm. The FAMU academic honor policy may be accessed through http://www.famu.edu.

Professional Component Contributions:

Students apply basic science, mathematics, and chemical engineering principles to the solution of transport phenomena problems relevant to chemical and biomedical engineering.

Prepared By: S. Ramakrishnan

Spring Important Dates and Deadlines

http://www.eng.fsu.edu/current/deadlines.html

Spring

Drop/Add Deadline with fee reimbursement:

- January 12 (FSU Students)
- January 12 (FAMU Students)

Last day to drop/withdraw from a course (any course not just one in engineering):

- February (end of 7th week deadline)
- April (late drop deadline)

The Course Drop/Withdrawal policy at the College of Engineering is different from the policy used at either university. Undergraduate engineering students may "drop" (or withdraw) from any course in the current semester for any reason up to and including the 7th week of classes. There may be financial aid and other implications dropping a course, so you should always contact your academic advisor first. After the end of 7th week deadline of each semester is considered the Engineering "Late Drop" Period. Depending on your academic classification, there are restrictions on the number of times you will be permitted to "late drop" a course during this period. They are as follows: (a) all pre-engineering students and those classified as Basic Division by FSU are limited to a total of two (2) "late drops" during their tenure in the pre-engineering or FSU Basic Division programs. Students who reach their "two late drops" limit will NOT be permitted another late drop until they enter their intended engineering major and for FSU students leave Basic Division. Students who are coded in a degree granting engineering major and are classified as IE (FSU only) are permitted an unlimited number of "late drops" between the 7th week and the late drop deadline.

Review of retroactive course drop/withdrawal deadline: February 3

Did you do poorly in a course due to extenuating circumstances beyond your control? If so, you might consider applying for a retroactive course withdrawal. Please go to www.eng.fsu.edu (Quick Links/Appeals Process), or contact the Office of Student Services, B-111, for more information. This will be your last opportunity to request a review of courses taken during the **Spring 2016** Semester.

Final Exam:

Exam Schedule can be found on the engineering website, eng.fsu.edu>Quick Links>Final Exam Schedule

Additional information:

It is the student's responsibility to be aware of the prerequisites for any engineering course in which he or she is enrolled. Failure to satisfy course prerequisites may result in cancellation of your course enrollment at any time during the semester with no refund of tuition or fees. **To avoid any fee liability**, it is the student's responsibility to drop the course **on or before the Drop/Add Deadlines listed above**.