CHE 447: Heat and Mass Transfer in Chemical Engineering Processes
Spring 2023

Note: All times are in Pacific Time; PST prior to March 12 and PDT after March 12

Lectures
Mondays and Wednesdays, 2:00-3:50 PM, GFS 116

Instructor
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Course Description and Learning Objectives

This is an introductory course to mass and heat transfer in chemical engineering. Topics include molecular and continuum approaches to diffusion and convection in fluids. We will derive differential and macroscopic equations of mass and heat transfer and discuss their solutions for different geometries in different applications. The learning objectives are to understand mass and heat transfer concepts and definitions, to construct mathematical models, and to apply modeling methods in chemical engineering designs.

First, we will study the advective mass transfer by reviewing the fluid flows in pipes and in porous media, including the mathematical models in terms of partial differential equations (PDEs), initial and boundary conditions. The commonly used solutions and applications will be presented. Next, we will study the diffusion phenomena and formulate the mathematical models (PDEs, initial and boundary conditions). Steady-state and transient solutions of the diffusion models will be derived and discussed for linear, radial, and spherical geometries. The applications of such solutions in chemical engineering will be explored. Afterward, we will study heat transfer methods, including convection, conduction, and radiation. Mathematical models of heat transfer will be formulated and solved for linear, radial, and spherical geometries. The applications of heat transfer models in chemical engineering will be explored.

Upon completion of this course, students should be able to identify, formulate, and solve complex engineering problems in the context of mass and heat transfer by applying the principles learned in this course.

Books and References:

This course will be heavily based on the following textbooks. You are not required to purchase these books. However, you may consider doing so if you feel that you will need supplementary reading material for this course.

- Stanley Middleman (1998) *An Introduction to Mass and Heat Transfer: Principles of Analysis and Design*, New York: John Wiley & Sons
- Frank P. Incropera, David. P. Dewitt, Theodore L. Bergman, Adrienne S. Levine (1996) *Fundamentals of Heat and Mass Transfer*, New York: John Wiley & Sons

Lecture Schedule

This schedule is subject to change, with notice.

Part 1: Mass Transfer
Mass transfer by advection
Mass transfer in porous media, Darcy's law
Diffusive Mass Transfer (Steady State)
Convective Mass transfer (Steady State)
Mass Transfer Coefficients
Time-Dependent Mass Transfer

Part 2: Heat Transfer
Heat transfer by conduction and convection (Steady State, Time-Dependent)
Heat Transfer Coefficients
Two-dimensional Heat Transfer (Steady State, Time-Dependent)
Heat transfer through composite materials and volumes
Natural convection
Radiation
Heat exchangers and flow through pipes

Grading

Grades will be based on homework assignments, a midterm examination, a project, and a final examination.

Homework:	10%
Project:	10%
Midterm:	40%
Final Exam:	40%

Final letter grades will follow the scale below. However, a grading curve may be implemented if the average class grade falls below 80%. The details of the curve will be disclosed at the time of its implementation (assuming that a curve is necessary).

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A	A-	B+	B	C+	C	D+	D	F
$\geq$ 93%	[90%,93%)	[87%,90%)	[80,87%)	[77%,80%)	[70%,77%)	[67%,70%)	[60%,67%)	< 60%

Homework

Homework will be assigned weekly due one week after being assigned. Homework assignments must be submitted to Blackboard by 11:59 PM on their due date. Late assignments **WILL NOT** be accepted unless there are genuine extenuating circumstances. Homework assignments should be scanned/photographed such that they can be read easily (i.e., do not submit a low resolution .jpeg). Each problem within a homework assignment will be graded on a scale of 0-2 points scale. 2 points will be awarded for complete mastery of the problem. 1 point will be awarded for a substantive effort. 0 points will be given for little or no effort.

Exams
Exams will be in-person with a time limit corresponding to the length of the class period – 2 hours. If you have OSAS approval and need specific exam accommodations, please let the instructor know prior to the exams.

Given the ongoing COVID19 pandemic, there is a possibility that in-person exams become infeasible. In such an event, take-home exams will be administered instead. These take-home exams will be due 24 hours after being released.

Exams will be graded according to a rubric that will be made available after the exams are graded. Exams cannot be rescheduled unless there are genuine extenuating circumstances.

Project
Students will form groups (~4 students per group) that critically address a theoretical (or real life) problem that is relevant to mass and/or heat transfer. These student groups will propose a scenario or process where the principles taught in this course are applicable to solving the problem. The project will be graded on originality, creativity, accuracy, and technical rigor. The projects will consist of both a written report (due April 21) and a group presentation (on April 24). The detailed requirements for this group project will be provided after the midterm examination.

Special Dates
Monday January 16: No class, Martin Luther King Jr. Day
Monday February 20: No class, President's Day
Wednesday March 8: Midterm Exam (2:00 – 4:00 PM)
Monday March 13: No Class, Spring Recess
Wednesday March 15: No Class, Spring Recess
Friday April 21: Written Project Reports Due
Monday April 24: Project Presentations
Wednesday April 26: Last Day of Class
Monday May 8: Final exam (2:00 – 4:00 PM)

Collaboration Policy
Students are encouraged to discuss and work together on homework assignments, but the work each student hands in must be their own. It is not acceptable to merely copy another student's effort; each student must be capable of fully understanding and describing everything they have written in the submitted homework assignment. To ensure that this is the case, it is recommended that when working in a group (group sizes of five or fewer are recommended), students plan their approach to a problem making notes on scratch paper or a whiteboard. The work that each student submits, however, should be written independently without referencing these notes. If you have any doubts regarding whether a certain instance of collaboration is acceptable at any point in the semester, ask the instructor for clarification.

<u>Work on exams will be completely independent.</u>

Software
All commercial computer software used in this course must be properly licensed. Use of unlicensed commercial software is not allowed and it may result in a failing grade. MATLAB and Microsoft Office licenses are available for free to students through USC.

Academic Conduct
Plagiarism—presenting someone else's ideas as your own, either verbatim or recast in your own words—is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards:
https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/

Other forms of academic dishonesty are equally unacceptable. See additional information and university policies on scientific misconduct:
http://policy.usc.edu/scientific-misconduct
Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equality and Diversity (http://equity.usc.edu) or to the Department of Public Safety:
http://adminopsnet.usc.edu/department/department-public-safety/online-forms/contact-us
This is important for the safety of the whole USC community. Another member of the university community—such as a friend, classmate, advisor, or faculty member—can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men:
http://www.usc.edu/student-affairs/cwm
provides 24/7 confidential support, and the sexual assault resource center webpage (https://sarc.usc.edu) describes reporting options and other resources.

Support Systems
A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute (http://dornsife.usc.edu/ali), which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs:
http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html
provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information (http://emergency.usc.edu) will provide safety and other updates, including ways in which instruction will be continued by means of Blackboard, teleconferencing, and other technology.