

CHE 447: Heat and Mass Transfer in Chemical Engineering Processes Spring 2024

Note: All times are in Pacific Time; PST prior to March 10 and PDT after March 10

Lectures

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

Instructor

Wade Zeno

Office: VHE 718

Email: wzeno@usc.edu

Office hours: Monday 4-5 PM

Wednesday 4-5 PM

Teaching Assistant

Nicoletta Bouzos

Office: VHE 708

Email: nbouzos@usc.edu

Office Hour: Tuesday 1-2 PM

Thursday 2-3 PM

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.

The first half of the course will focus on Mass Transfer. We will first study advective mass transfer by reviewing fluid flow in pipes and in porous media. Next, we will study diffusion and formulate the mathematical models to describe this phenomenon. These models include partial differential equations (PDEs) with initial and boundary conditions. We will examine both steady-state and transient solutions for these diffusion models in cartesian, radial, and spherical geometries. We will then consider systems in which convection and reactions are coupled into our models. The second half of the course will focus on Heat Transfer. We will study the 3 modes of heat transfer: convection, conduction, and radiation. Mathematical models of heat transfer will be formulated and solved for various geometries, and we will explore the applications these phenomena in in chemical engineering problems.

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

Required 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.

- Microsoft Office, available through USC ITS, <https://itservices.usc.edu/office/>
- MATLAB, available through USC ITS, <https://itservices.usc.edu/matlab/>

USC Technology Support Links

[Blackboard help for students](#)

[Software available to USC Campus](#)

Lecture structure

Lectures will consist of two 110-minute sessions per week, except in instances where university holidays are observed or instances where the instructor and TA must be absent. The theoretical concepts underlying mass and heat transfer will be introduced by the instructor and students are expected to take their own notes on the presented material. Students are also expected to attend lectures in person. Students may be able to attend lectures via Zoom or have access to prerecorded lectures during extenuating circumstances at the discretion of the instructor. **All Zoom attendances require approval from the instructor.**

Lecture Schedule

This schedule is subject to change, with notice.

Part 1: Mass Transfer

Mass transfer in porous media, Darcy's law

Diffusive Mass Transfer (Steady State)

Mass Transfer with Diffusion, Convection, and/or Chemical Reaction (Species Balance)

External Convective Mass Transfer and Mass Transfer Coefficients

Time-Dependent Mass Transfer (Analytical and Numerical Solutions)

Quasi-steady Mass Transfer

Part 2: Heat Transfer

Heat transfer by conduction and convection

Heat transfer through composite materials and volumes

Two-dimensional Heat Transfer (Analytical and Numerical Solutions)

Radiative Heat Transfer

Heat Transfer Coefficients for Natural and Forced Convections

Quasi-steady Heat Transfer

Heat Exchangers

Grading

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

Homework:	10%
Project:	20%
Midterm:	35%
Final Exam:	35%

Final letter grades will follow the scale below. However, a grading curve may be implemented at the discretion of the instructor.

A	A-	B+	B	C+	C	D+	D	F
≥ 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. Exams cannot be rescheduled unless there are genuine extenuating circumstances.

Project

Students will form groups (~4 students per group) that critically address a hypothetical 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 19) and a group presentation (on April 22). The detailed requirements for this group project will be provided after the midterm examination.

Special Dates

Monday January 15: No class, Martin Luther King Jr. Day

Monday February 12: Class canceled (Instructor and TA will be at a Research Conference)

Wednesday February 14: Class canceled (Instructor and TA will be at a Research Conference)

Monday February 19: No class, President's Day

Wednesday March 6: Midterm Exam (2:00 – 4:00 PM)

Monday March 11: No Class, Spring Recess

Wednesday March 13: No Class, Spring Recess

Friday April 19: Written Project Reports Due

Monday April 22: Project Presentations

Wednesday April 24: Last Day of Class

Monday May 6: 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.

Work on exams will be completely independent.

Artificial Intelligence (AI) Programs

Since creating, analytical, and critical thinking skills are part of the learning outcomes of this course, all assignments should be prepared by the student working individually. Students may not have another person or entity complete any portion of assigned works. Developing strong competencies in these areas will prepare you for a competitive workplace. Therefore, using AI-generated tools is prohibited in this course, will be identified as plagiarism, and will be reported to the Office of Academic Integrity.

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Students and Disability Accommodations

USC welcomes students with disabilities into all of the University's educational programs. [The Office of Student Accessibility Services](#) (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-5086 or (213) 821-8298

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.