**Fall 2020 Syllabus**

**CHEN 3210 Heat & Mass Transfer**

**Instructors**

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**Graduate Teaching Assistants and Undergraduate Course Assistants**

Advanced TA: Justin Tran, justin.tran@colorado.edu

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CA: Noelle Boyton, noelle.boyton@colorado.edu

*Please contact the Advanced TA with any questions about homework and its grading and solutions*

**Class Times and Information**

Remote Lectures: TTh 1:15 pm – 2:05 pm & 2:25 – 3:15 pm (*Zoom links posted on Canvas*)

In-person Highlights: TTh 1:15 pm – 2:05 pm (first four weeks only) & 2:25 – 3:15 pm in BIOT A115

*Students may attend the Weekly Highlights and Discussion in-person once per week, in cohorts*. *Cohorts and time assignments are posted on Canvas.*

Remote Highlights: Th 9:00 -9:50 am for fully remote students (*Zoom link posted on Canvas*)

Course Website: <https://canvas.colorado.edu/>

Lecture Postings: Recorded lectures and lecture notes will be posted on the Canvas site.

Announcements: Announcements concerning assignments, exams, clarifications of course notes, etc. will be made on Canvas and/or by email. To ensure you receive announcements, please be sure to check or forward your colorado.edu email accordingly.

**Office Hours (Help Sessions)**

*In-person:* Mondays 6 – 8 pm in A108, Tuesdays, 4:10 – 5:50 pm (3:15 -5:50 pm starting fifth week) in A115, Fridays (first three weeks only) 12 – 1 pm and 5:30 – 6:30 pm in A115 (*in-person help sessions will be limited to 20 - 25 students at a time*)

*Remote:* Sundays 6 – 7 pm (starting fourth week), Mondays 12 – 1 pm, Tuesdays 12 – 1 pm, Fridays 12 – 1 pm (*Zoom links posted on Canvas*)

***Professors Davis and Sprenger will also hold private office hours (by appointment, typically Zoom). Please email one of us to set up an appointment, including when you are available and the subject matter.***

**Textbook**

Required: *Fundamentals* *of Momentum, Heat and Mass Transfer. Seventh Edition.* Welty, Rorrer & Foster,

 Wiley, 2019

**Prerequisites**

CHEN 3200 Chemical Engineering Fluid Mechanics, or equivalent (minimum grade C-)

**Course Requirements and Grading Scheme**

The breakdown of course grades is as follows: The grading scale is:

 Midterm Exams (three) 45% A (or A-) 85 – 100%

 Mini-project 5% B (or B-, B+) 75 – 85%

 Homework 20% C (or C-, C+) 65 – 75%

 Short Exercises 15% D (or D-, D+) 55 – 65%

 Final Exam 15% F 0 – 55%

**Course Policies**

 *Homework & Mini-project.* Homework assignments will normally be posted on the course website at least one week in advance and *due via Gradescope at 11:59 pm* on Tuesdays, unless notified otherwise. Solution sets must be turned in individually, although you are encouraged to consult your classmates as needed. Homework will not be accepted late, except for special circumstances such as cases of illness or travel, in which case the student should contact an instructor ahead of the due date to make alternative arrangements. For each assignment, it may be that not all of the problems will be graded, and the emphasis will be on the approach rather than the final numerical result. The mini-project will be due after Thanksgiving in lieu of homework.

 *Short Exercises*. Short exercises or quizzes (group or individual) will be periodically given during class or other times throughout the semester, typically announced in advance. They will assess your knowledge of the material covered in recent lectures and homework. *Missed exercises will not be able to be made up*. The lowest exercise score for the semester will be dropped, to account for both excused and unexcused absences.

 *Exams.* Missed exams can be made up in extreme cases only, including, among others, illness that requires medical attention, travel, or death of a family member. If you know you will miss an exam, you must make arrangements with an instructor to make up the exam *at least two weeks in advance*. There will be three midterms, which will be in-person if allowable (with a remote option for those not able to attend in person). A short final exam will be remote. Note that the final exam will be cumulative and thus serve as a gauge of your overall understanding of the course material.

 *Classroom and Behavior*. It is requested that students make every effort to arrive on-time to class, such that class can be started as scheduled without interruption, and that Covid-19 safety, and professional behavior be exhibited at all times. Also, *any discovered incidents of academic dishonesty will be reported* to the CU Honor Code Council. Consequences will include receiving a failing grade in the course.

 The instructors, assistants and students in this course affirm the value of all individuals and agree to treat one another with equity and respect. Please see the college webpage for our commitment to diversity, equity and inclusion: <https://www.colorado.edu/engineering/about/diversity-equity-and-inclusion>.

**Exam Dates**

Midterm Exam #1: September 27th (Sunday), 6:00 or 8:00 pm (BIOT A115, A108, A104, B115)

Midterm Exam #2: November 1st (Sunday), 6:00 or 8:00 pm (BIOT A115, A108, A104, B115)

Midterm Exam #3: November 22nd (Sunday), 6:00 or 8:00 pm (BIOT A115, A108, A104, B115)

 (*Each cohort will be assigned a time for the midterm via Canvas announcements*)

Final Exam : December 12th (Saturday), 4:30 pm (remote)

**Required Syllabus Statements:** Posted on Canvas &<https://www.colorado.edu/academicaffairs/policies-customs-guidelines/required-syllabus-statements>

**Review Sessions**

A review session will be held during a regularly-scheduled class time prior to each exam.

**Course purpose and Goals**

The purpose of this course is for students to gain understanding and knowledge of the transfer thermal energy (“heat”) and molecular species (“mass”) from one location to another. This knowledge will allow them to analyze and design processes to accomplish desired heat and mass transfer in engineering applications. Specific learning goals include:

**1. Heat Transfer**

**-** Knowledge of the three primary modes of heat transfer: conduction, convection and radiation

**-** Ability to perform microscopic and macroscopic thermal energy balances for various situations

**-** Ability to solve 1D-steady heat conduction problems in flat, cylindrical and spherical geometries, and

 2D steady and 1D-transient heat conduction problems in flat geometries

**-** Understanding of boundary-layer flow and heat transfer

**-** Knowledge and use of scaling and order-of-magnitude analysis for conduction and convection

**-** Ability to use heat-transfer correlations for forced and free convection

- Understanding of heat radiation and the ability to determine radiation exchange for black and gray

 surfaces

- Ability to apply resistance models for insulation design and energy balances for heating or cooling rates

 of objects

- Ability to analyze and design single-tube, double-tube, and crossflow or shell-and-tube heat exchanges,

 with and without phase change

**2. Mass Transfer**

- Knowledge of the two primary modes of mass transfer: diffusion and convection

- Ability to perform species mass balance and flux calculations for various situations

- Ability to solve 1D steady and unsteady diffusion problems, with and without chemical reaction

- Understanding of boundary-layer mass transfer, and scaling and order-of-magnitude analysis of

 diffusion and convection

- Ability to use mass-transfer correlations for forced convection

- Understanding of mass transfer between phases and ability to analyze two-phase mass-transfer problems

**Lecture Schedule for CHEN 3210 – Fall 2020**

**Note: The lectures are given remotely by Zoom on Tuesdays and Thursdays at 1:15 pm and 2:25 pm.**

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| --- | --- | --- | --- | --- |
|  **Day** |  **Date** |  **Lect. No.** | **Instructor** | **Topic (Chapter in Text)** |
| T | 8/25 | 1a, b | KS | Heat Conduction Basics (15,16) |
| R | 8/27 | 2a, b | KS | Steady, 1D Conduction: Flat Walls (17) |
| T | 9/1 | 3a, b | KS | Steady, 1D Conduction: Curved Walls (17) |
| R | 9/3 | 4a, b | JT | Example; Steady Conduction with Generation (17) |
| T | 9/8 | 5a, b | KS | Extended Surfaces; Steady, 2D & 3D Conduction (17) |
| R | 9/10 | 6a, b | RD | Transient Heat Conduction & Scaling (16,18) |
| T | 9/15 | 7a, b | RD | Example; Introduction to Convection (19) |
| R | 9/17 | 8a, b | RD | Thermal Energy Equation; Dimensional Analysis (16,19) |
| T | 9/22 | 9a, b | RD | Forced Convection; Boundary-layer Flow & HT (19) |
| R | 9/24 | 10a, b | RD | Review; Heat-transfer Correlations (19,20) |
| T | 9/29 | 11a, b | KS | Discussion of MT #1; Example |
| R | 10/1 | 12a, b | RD | Free Convection, Scaling & Correlations (20) |
| T | 10/6 | 13a, b | KS | Introduction to Radiation; Emission of Radiation (23) |
| R | 10/8 | 14a, b | KS | Radiation Exchange Between Surfaces (23) |
| T | 10/13 | 15a, b | KS | Heat-transfer Design; Insulation (15,17,20,23) |
| R | 10/15 | 16a, b | RD | Transient Cooling; Single-tube Heat Exchangers (18,22) |
| T | 10/20 | 17a, b | KS | Double-tube Heat Exchangers: Example (22) |
| R | 10/22 | 18a, b | KS | Phase Change; Shell-and-Tube Heat Exchangers (21,22) |
| T | 10/27 | 19a, b | KS | NTU Method for Heat Exchangers; Example (22) |
| R | 10/29 | 20a, b | RD | Review; Introduction to Mass Transfer (24) |
| T | 11/3 | 21a, b | RD | Random Motion; Convection-diffusion Equation (24,25) |
| R | 11/5 | 22a, b | KS | Convection-diffusion Example; Equimolar Diffusion (25,26) |
| T | 11/10 | 23a, b | KS | Steady & Psuedo-steady Diffusion with Reaction (26) |
| R | 11/12 | 24a, b | RD | Unsteady Diffusion, With and Without Reaction (26,28) |
| T | 11/17 | 25a, b | RD | Evaporation in Diffusion Cell; Forced Convection (26,28) |
| R | 11/19 | 26a, b | RD | Review; Mass-transfer Correlations; Adsorption (30) |
| T | 11/24 | 27a, b | RD | Mass Transfer Between Phases; Absorption |
| R | 11/26 | n/a | n/a | Thanksgiving Break |
| T | 12/1 | 28a, b | RD, JT | Numerical Methods; Mini-project - Remote |
| R | 12/3 | n/a | n/a | No Class |
| T | 12/8 | 29a, b | RD, KS | Review for Final - Remote |
| R | 12/10 | n/a | n/a | No Class |

**RD = Robert Davis, KS = Kayla Sprenger, JT = Justin Tran**

**Weekly Highlights Schedule for CHEN 3210 – Fall 2020**

**Note:** The Weekly Highlights are given in person in BIOT A115, with Cohort A attending Tuesdays at 1:15 pm, Cohort B attending Tuesdays at 2:25 pm, Cohort C attending Thursdays at 1:15 pm, and Cohort D attending Thursdays at 2:25 pm. **Due to low attendance, in-person Weekly Highlights will be held only at 2:25 pm on Tuesdays (for Cohorts A and B) starting 9/22/2020 and at 2:25 pm on Thursdays (for Cohorts C and D) starting 9/24/2020.** The same Weekly Highlights are given to Cohort E and other remote students by Zoom on Thursdays at 9:00 am.

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| --- | --- | --- | --- | --- | --- |
| **Dates** | **Cover Lect.** | **Tues.** | **Thurs.** | **Prep** | **Comments** |
| 8/25,27 | 1,2 | RD | RD | RD |  |
| 9/1,3 | 3,4 | RD | KS | RD | JT give 9/3 remote lectures |
| 9/8,10 | 5,6 | RD | KS | RD |  |
| 9/15,17 | 7,8 | KS | KS | KS |  |
| 9/22,24 | 9,10 | KS | KS | KS |  |
| 9/29, 10/1 | 11,12 | RD | KS | RD |  |
| 10/6,8 | 13,14 | RD | RD | RD |  |
| 10/13,15 | 15,16 | RD | KS | KS |  |
| 10/20,22 | 17,18 | RD | RD | RD |  |
| 10/27,29 | 19,20 | RD | KS | KS |  |
| 11/3,5 | 21,22 | KS | RD | KS |  |
| 11/10,12 | 23,24 | RD | KS | RD |  |
| 11/17,19 | 25,26 | KS | KS | KS |  |
| 11/24,26 | n/a | n/a | n/a | n/a | Thanksgiving Break |
| 12/1,3 | n/a | n/a | n/a | n/a | Mini-Project, No Class |
| 12/8,10 | n/a | n/a | n/a | n/a | Finals Start |

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