
CM 3110: Transport/Unit Operations 1

(Spring 2021, Remote)

Instructor:

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Course Description and Timing:

Develop an understanding of the processes of momentum transfer (fluid mechanics) and heat transfer. Presents the basic equations of microscopic momentum and heat transfer, along with macroscopic transport equations that can be used in engineering analysis.

- TR 11:00am-12:20pm (enrolled 13; remote; Zoom link in Canvas)

Course materials are posted in Canvas and on the [course webpage](https://pages.mtu.edu/~fmorriso/cm310/cm310.html),
<https://pages.mtu.edu/~fmorriso/cm310/cm310.html>

Prerequisites:

PH2100, CM2120, plus math through differential equations. All the prerequisites to these classes are also prerequisites to this class.

This course will make intensive use of all of your math background (units, algebra, calculus, differential equations, vectors, partial derivatives), your physics background (Newton's laws, forces, problem solving, sig figs), and your chemical engineering background (mass and energy balances, macroscopic energy balances, heat exchanger basics, friction in flow, introductory unit operations and staged operations). For a handy sheet of commonly used integrals, see the [supplemental handouts link](http://www.chem.mtu.edu/~fmorriso/cm310/2014CommonIntegrals.pdf) (<http://www.chem.mtu.edu/~fmorriso/cm310/2014CommonIntegrals.pdf>) and the [recommended readings list](http://pages.mtu.edu/~fmorriso/cm310/reading_assignments.html) (http://pages.mtu.edu/~fmorriso/cm310/reading_assignments.html).

Office Hours:

Dr. Morrison's [office hours](http://www.chem.mtu.edu/~fmorriso/office_hours.html) are posted on the web and are hosted on Zoom (http://www.chem.mtu.edu/~fmorriso/office_hours.html); other times by arrangement - request by email.

Course Learning Objectives (*What is the course about? How is it relevant to your interests?*)

Upon successful completion of CM3110, students will be able to

1. Model fluid motion and the steady flow of heat;
2. Solve momentum and heat-transfer modeling equations;
3. Apply the solutions to engineering problems to describe or predict system behavior; and
4. Apply the models and model solutions to chemical engineering unit operations to predict how unit operations function and to enable troubleshooting.

Textbooks and Resources

Recommended

Faith A. Morrison, *An Introduction to Fluid Mechanics*, Cambridge University Press, New York (2013).

[Christie J. Geankoplis, *Transport Processes and Unit Operations*, 4th Edition](#), Prentice Hall, New York (2003). It is available **free** in electronic form through the Michigan Tech Library's Safari O'Reilly's Learning Platform for Higher Education, (<https://learning.oreilly.com/library/view/transport-processes-and/013101367X/?ar>). You can sign in with your Tech email, and if you confirm the reply email, your account will store your highlights and notes. If you prefer to use the book anonymously, you can create a dummy account (mickeymouse@mtu.edu) which will work for a few days and then go dead, but you can create it again. You cannot save your highlights and notes when working under a pseudonym.

I strongly recommend that you print and use the [unit conversion and physical property sheet](http://pages.mtu.edu/~fmorriso/cm310/convert.pdf) I have prepared (<http://pages.mtu.edu/~fmorriso/cm310/convert.pdf>).

Supplemental

Richard Felder and Ronald Rousseau, *Elementary Principles of Chemical Processes*, 3rd Edition, Wiley, New York, 2005. (If there is one book you do not sell back to the book store, make it this one; many CM courses will build on the material in this text. See also [my summary notes on the energy balance information from CM2110/CM2120](#) (https://pages.mtu.edu/~fmorriso/cm310/Energy_Balance_Notes_2008.pdf).

Perry's Handbook of Chemical Engineering, 8th Edition (McGraw-Hill Professional, New York, 2007). Note that if you join the AIChE (at the national level) you receive [access to the online Perry's](#) free (<https://www.aiche.org/publications/elibrary>). See the AIChE officers for more information.

Additional Resources (can be found as inexpensive used books)

Bird, R. B., W. E. Stewart, and E. N. Lightfoot, *Transport Phenomena*, 2nd Edition, Wiley, NY, 2002. Widely known as "BSL," the first edition of this book came out in 1960 and the second edition 42 years later, a testimony to the enduring value of this resource.

Bird, R. B., W. E. Stewart, and E. N. Lightfoot, *Transport Phenomena*, 1st Edition, Wiley, NY, 1960.

Learning Plan

The learning objectives for this course (see above) are written at a very high level and are designed to let you know what the course is about and how it is relevant to your interests. To actually get through the course learning objectives we need a plan, and so here is my learning plan for this course.

To help you achieve the planned course learning objectives, I have: 1) chosen topics; 2) suggested readings; 3) provided lectures (prerecorded); 4) assigned problems; 5) produced study guides; 6) scheduled sessions for problem solving; and 7) structured a grading system. The details of the plan are given below. I have:

1) *Chosen topics* and divided these into five modules, each with its own learning objectives.

Module 1: Prerequisite material—Mechanical energy balance, fluid statics, macroscopic mass and energy balances, mathematics through differential equations

Module 2: Fluids 1—Newton’s law of Viscosity and the Microscopic Momentum Balance

Module 3: Fluids 2—Dimensional analysis for momentum transfer, classic solutions, macroscopic momentum balances, unit operations

Module 4: Heat 1—Fourier’s law of heat conduction, microscopic energy balances, dimensional analysis for heat transfer

Module 5: Heat 2 and Consolidate—Unit operations, radiation, consolidating our knowledge

2) *Suggested Readings*

[Reading recommendations](https://pages.mtu.edu/~fmorriso/cm310/reading_assignments.html), including on prerequisite materials, are provided on a handout (https://pages.mtu.edu/~fmorriso/cm310/reading_assignments.html). Readings of two types are assigned: basic and stretch. Stretch readings are provided for students who aspire to top comprehension and top class-performance.

3) *Provided lectures (prerecorded)*:

https://pages.mtu.edu/~fmorriso/cm310/selected_lectures_slides_and_videos_remote.html) on all the chosen topics. These lectures are the recorded lectures of the Fall 2019 sessions of CM3110. PDFs of the lecture slides are also posted on the same page. It is not mandatory to watch the lectures. They are a resource for you to use to help you to achieve the course learning objectives. Feel free to watch them at 1.25x speed (or faster) or to skip parts that are not helpful to you.

4) *Assigned Homework Sets*

Assigned homework sets are posted on the web. [Answers](#) to assigned problems are provided on the website; *solutions* to assigned problems are not provided on the website, but we will devote our class sections to problem solving, and this can include the assigned problems, as desired. Note that worked examples in the recommended texts are also opportunities to work out a problem and to compare to the published solution.

5) *Produced Study Guides*

The learning objectives for each module are given to you in the form of Study Guides. The five Study Guides tell you, directly, what types of problems/exercises you need to be able to do in order to reach the learning objectives. Some of the learning objectives in the Study Guides are identified as *stretch*. Stretch objectives are provided for students who aspire to top comprehension and top class-performance.

6) *Scheduled sessions for problem solving*

During our scheduled class times I will be on Zoom coordinating problem sessions based on the five modules and the study guides. These sessions will be interactive. The sessions will be recorded and posted.

7) *Structured a grading system*

There will be four exams plus a final exam. There will be [one individual project linked to the Study Guides](#).

Exams

The exams will be closed book, closed notes, closed internet (your own work), with two 8.5 by 11 sheets, both sides, allowed for formulas (may be computer printed; I will ask you to upload your exam sheets to Canvas along with your worked exam). Exams will include instructor-produced handout tables and formula sheets as well; these will also be available before the exam. An exam may include any topic covered in the course up to the class period indicated in the syllabus for that exam (see the syllabus for coverage). Prerequisite material may appear on any of the exams. The exams from Fall (and solutions) are posted on the class website. Exams 1-4 are 90 minutes long (excluding uploading time), will include an honors pledge, and may be scheduled to be taken within the 15-hour period between 7am and 11:59pm on the day indicated below.

Exam 1 (week 2): Thursday 21 January 2021

Exam 2 (week 6): Thursday 18 February 2021

Exam 3 (week 9): Thursday 18 March 2021

Exam 4 (week 12): Thursday 08 April 2021

Study Guide Project (week 14): Friday 23 April 2021

Final exam (week 15): As scheduled by the registrar; 120 minutes. The [final exam schedule](#) for all classes can be viewed at:
<http://www.mtu.edu/registrar/> at the end of the 6th week of the semester.

Study Guide Project

This is an individual project that is composed of five submissions, each due on the Friday after an exam. The submission is a cover memo organizing attached material that represents evidence of your efforts to learn the skills and knowledge outlined on the Study Guides. The details of this project are given in [a separate handout](#). The problem solutions submitted as part of the Study Guide Project will not be graded in detail; the course credit for the Study Guide Project will be apportioned based on assessment of your engagement with the study guide

process. If you are giving it a serious try, you are meeting my expectations for the Study Guide project.

Course Grades

1. First exam: 15% (lecture 1 and prereqs)
2. Second exam: 15%; (lectures 2-7)
3. Third exam: 20%; (lectures 8-13)
4. Fourth exam: 20%; (lectures 14-17)
5. Study Guide Project: 10%
6. Final exam: 25%; (lectures 1-23)

Scale: 90-105 %A; 86-89 AB; 80-85 B; 76-79 BC; 70-75 C; 66-69 CD; 60-65 D; Less than 60% F

Students who have registered their need for accommodations with the Dean of Students (Disability Services) will be accommodated as requested. University policy requires 5-day advance notice of a request for accommodation.

Make-up exams will not be given except under extraordinary circumstances and when appropriate documentation is provided (medical, for example). Check the exam schedule and your final exam schedule early and report any conflicts as soon as possible.

No cell phone use or internet use of any sort allowed during exams.

Tips for better exam performance

The problems on the exams are not directly modeled on the homework problems, but the homework problems are designed to employ the same problem-solving skills as will be needed to do well on the exam. Your aim is meant to be to develop those problem-solving skills and critical thinking skills (to learn to formulate the right questions; this guides you to solving real problems). One of these skills is to read the problem carefully and to determine how to frame the solution to the problem (trouble shooting). Significant figures are important on anything that is submitted in this course or shared with an instructor or colleague.

Tips for better course performance

Readings, problems, and objectives of two types are assigned: *basic* and *stretch*. Stretch activities are provided for students who aspire to top comprehension and top class-performance. Your best preparation for the exams is to attend class sessions, do the readings, do the assigned problems, engage seriously with the Study Guides, and see the professor or Learning Center with questions you have on the homework assignments and class sessions. Starting the problem (setting it up) is typically the hardest part of a transport/unit operations modeling problem. Simply reading over solutions is not good preparation for actually carrying out a calculation yourself.

Study Groups

You are encouraged to work together in study groups to trade ideas on how to solve problems and to help to teach each other the subject. The students who have done best in my classes in the past formed a study group (4-8 students) and met regularly to work on the homework. They came to

student office hours regularly with any questions they could not resolve themselves. During this pandemic year it will be more difficult to arrange study groups, but I encourage you to be creative. You may use Zoom, texting, Facetime/WhatsApp, socially distanced meetings. Please follow the guidance on health measures so that you remain healthy.

CM Learning Center

The CMLC is staffed Monday through Thursday 6-8pm for the weeks that classes are in session. Direct questions on the CMLC to Dr. Tim Eisele at tceisele@mtu.edu.

Cheating

Cheating of any form will not be tolerated. All exam work must be your own and all exam rules must be followed (see exam rules above); you will be asked to sign an honors pledge. What you submit for your Study Guide Project must follow the rules of this project (see separate handout). Submitting for credit a solution that is not your own, without attribution, is plagiarism and is considered cheating. If you use any solutions from the literature (the internet, a book, a friend), you must cite the source with a formal reference. Using someone else's work without attribution is considered cheating.

Any student found to be cheating would be reported to the Dean of Students. The punishment for plagiarism ranges from an F in the course to expulsion.

University Policies

The Michigan Tech University Senate Policy states that this course syllabus must provide information on university policies, including those related to academic integrity, disability services and institutional equity. Since policies and web links to these policies could change over time, we have been encouraged to include the following web link to provide up-to-date information:
<http://www.mtu.edu/ctl/instructional-resources/syllabus/policies.html>.

Program Assessment:

Student work products (exams, essays, projects, etc.) may be used for the purposes of university, program, or course assessment. All work used for assessment purposes will not include any individual student identification.

Educational Objectives and Student Outcomes for the Department of Chemical Engineering

Michigan Tech Chemical Engineering ABET link:

<https://www.mtu.edu/chemical/undergraduate/accreditation/>

Educational Objectives

Michigan Tech Chemical Engineering alumni:

1. are successful early and have sustained success in their professional careers;
2. are valued for their hands-on engineering ability and safety culture;
3. have effectively communicated their technical knowledge via publications, reports, the Internet, and other media;
4. are providing service to society;
5. are earning or have earned advanced degrees or have participated in continuing education; and
6. have achieved leadership positions in their chosen professions.

Student Outcomes for the Department of Chemical Engineering

Graduates will have the following:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Program Criteria for the Department of Chemical Engineering

The curriculum provides a thorough grounding in the basic sciences including chemistry and physics, with some content at an advanced level. The curriculum includes the engineering application of these basic sciences to the design, analysis, and control of chemical and physical processes, including the hazards associated with these processes.