As teachers we can choose between

(a) sentencing students to thoughtless mechanical operations and
(b) facilitating their ability to think.

If students' readiness for more involved thought processes is bypassed in favor of jamming more facts and figures into their heads, they will stagnate at the lower levels of thinking. But if students are encouraged to try a variety of thought processes in classes, they this can … develop considerable mental power. Writing is one of the most effective ways to develop thinking.

—Syrene Forsman

Reference: Forsman, S. (1985). "Writing to Learn Means Learning to Think." In A. R. Gere (Ed.), *Roots in the sawdust: Writing to learn across the disciplines* (pp. 162-174). Urbana, IL: National Council of Teachers of English.

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CM3120 Transport/Unit Operations 2

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Michigan Technological University

CM2120—Fundamentals of ChemE 2 (Steady Unit Operations Introduction)
CM3110—Transport/Unit Ops 1 (Momentum & Steady Heat Transport, Unit Operations)
CM3120—Transport/Unit Ops 2 (Unsteady Heat Transport, Mass Transport, Unit Operations

www.chem.mtu.edu/~fmorriso/cm3210/cm3210.html

CM3120 Transport/Unit Operations 2

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Department of Chemical Engineering
Michigan Technological University

Primary Text:
Welty, Rorrer, and Foster, *Fundamentals of Momentum, Heat, and Mass Transfer* 6th Edition (Wiley, 2015)

www.chem.mtu.edu/~fmorriso/cm3120/cm3120.html

9AM Section

EMERGENCY EVACUATION PROCEDURES

Important: The Michigan Bureau of Fire Services has adopted new rules for colleges and universities effective 2015

1. Only residence halls are required to hold fire and tornado drills.
2. In lieu of fire drills in other university buildings all faculty and instructional staff are required to do the following on the first day of class:
   - Explain the university fire evacuation procedures to the class (see below).
   - Explain the locations of the primary and secondary exit routes for your class location.
   - Explain your designated safe location where the class will meet after evacuating the building.
3. The class instructor is responsible for directing the class during a building evacuation.

General evacuation procedure:
- Use the nearest safe exit route to exit the building. **The nearest safe exit from room 19-102 is the front (south) entrance that is close to highway 41. The secondary exit is the campus (east) exit, that connects to the path between Chem Sci and EERC.**
- Close all doors on the way out to prevent the spread of smoke and fire.
- After exiting, immediately proceed to a safe location at least 100 feet from the building. **Our designated safe location is south of Chem Sci, in the parking lot in front of the MUB.**
- Do not re-enter the building until the all-clear is given by Public Safety or the fire department.

11AM Section

EMERGENCY EVACUATION PROCEDURES

Important: The Michigan Bureau of Fire Services has adopted new rules for colleges and universities effective 2015

1. Only residence halls are required to hold fire and tornado drills.
2. In lieu of fire drills in other university buildings all faculty and instructional staff are required to do the following on the first day of class:
   - Explain the university fire evacuation procedures to the class (see below).
   - Explain the locations of the primary and secondary exit routes for your class location.
   - Explain your designated safe location where the class will meet after evacuating the building.
3. The class instructor is responsible for directing the class during a building evacuation.

General evacuation procedure:

- Use the nearest safe exit route to exit the building. **The nearest safe exit from room MEEM 403 is to go down the neighboring stairs—do not use the elevator.**
- Close all doors on the way out to prevent the spread of smoke and fire.
- After exiting, immediately proceed to a safe location at least 100 feet from the building. **Our designated safe location is in the parking lot west of the Admin building (across from ROTC).**
- Do not re-enter the building until the all-clear is given by Public Safety or the fire department.

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Why study transport/unit ops?

Michigan Tech

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Why study transport/unit ops?

Michigan Tech

- Modern engineering systems are complex and often cannot be operated and maintained without analytical understanding
- Design of new systems will come from high-tech innovation, which can only come from detailed, analytical understanding of how physics/nature works

Image: wikipedia.org

Image: planetforward.ca

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Where are we now?

Michigan Tech

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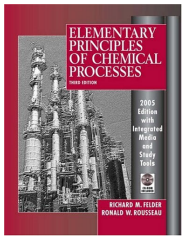
Where are we now?

Michigan Tech

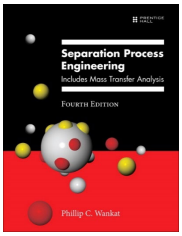
CM2110



Summary

CM2110
1. Steady mass balances
2. Steady energy balances (how to calc. energy)
3. MEB-Mechanical Energy Balance (no friction)

CM2120



CM2120
1. MEB-Mechanical Energy Balance (with friction)
2. Pumps
3. Introduction to Unit Operations
4. *Staged* Unit Operations (distillation, absorption)

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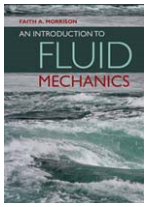
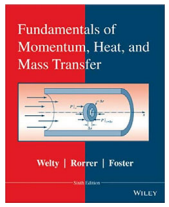
Where are we now?

Michigan Tech

CM3110

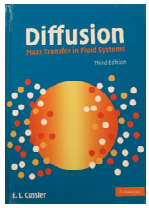


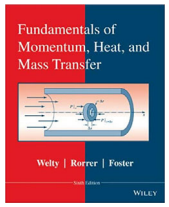


Summary

CM3110
1. Steady *momentum* balances (macro and micro)
2. *Rate-based* heat transfer processes (Fourier's law, heat transfer coefficients)
3. Unit Operations involving heat transfer (Heat Exchangers)

CM3120





CM3120
1. Unsteady energy balances
2. *Rate-based* mass-transfer processes (Fick's law, mass transfer coefficients)
3. Unit Operations involving mass transfer (separators)

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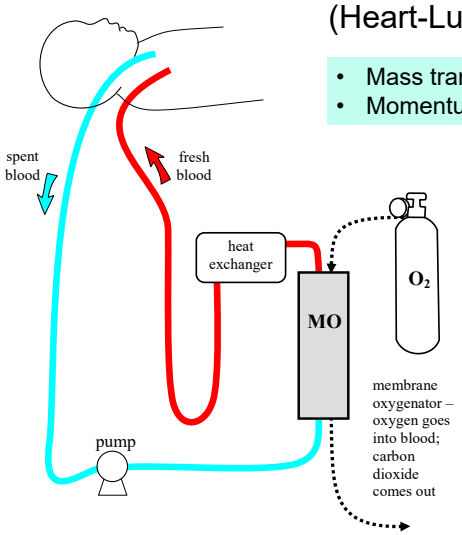
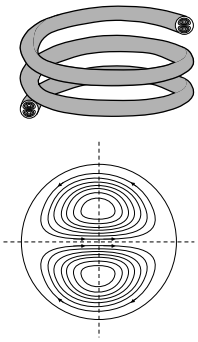
Membrane Oxygenator, MO
(Heart-Lung Machine)

- Mass transfer
- Momentum transfer





Secondary flow drives the O_2 mass transfer

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Where are we going?

Michigan Tech

CM3510—Chemical Reaction Engineering

- Performance of chemical reactors
- Advanced chemical kinetics

CM3120—Thermodynamics for Chemical Engineers

- Non-ideal solutions
- Mixtures
- More complex chemical behavior

CM4110/20—Unit Operations/Chemical Plant Operations Lab

- Capstone, hands-on study of the operation of units that produce chemical transformations

CM4855/4860/1—Chemical Engineering Process Analysis & Design

- Capstone, applied engineering of processes that produce chemical transformations

CM4310—Safety/Environment

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Where to start?

Michigan Tech

We've already started.

Michigan Tech

We need to bring what we've learned so far to advance along the path to becoming a chemical engineer.

1. Mathematics background
2. Macroscopic Mass Balances (steady)
3. Macroscopic Energy Balances (including Mechanical Energy balance)
4. Staged Operations
5. Momentum transfer (Newton's law, Newtonian fluid mechanics)
6. Steady Heat transfer (Fourier's law, Steady microscopic energy balances)

For more examples: see textbooks from prerequisite courses, CM2110/20 notes; HW1

Michigan Tech

- **Homework 1, with answers, posted; TA has solutions**
- **TA help sessions: Sundays 6:30-7:30pm, weeks: 2, 5, 7, 9, 12, Finals, (room 211).**
- **Website: http://pages.mtu.edu/~fmorriso/cm3120/cm3120.html**
- **Links in Canvas**

Prerequisite material

Resources:

- Richard Felder and Ronald Rouseau, *Elementary Principles of Chemical Processes*, 3rd Edition, Wiley, 2005.
- FAM summary notes on the energy balance information from CM2110/CM2120 (*http://www.chem.mtu.edu/~fmorriso/cm310/Energy_Balance_Notes_2008.pdf*).
- James R. Welty, Gregory L. Rorrer, and David C. Foster, *Fundamentals of Momentum, Heat, and Mass Transfer,* 4th edition, Wiley, 2015.
- Faith A. Morrison, *An Introduction to Fluid Mechanics*, Cambridge University Press, 2013.

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Michigan Tech

Prerequisite material

Exam 1: Next Tues

6:30-8:00pm
Dow 641

Exam topics: Those covered on HW1

- Steady state mass balances
- Macroscopic energy balances
- Mechanical energy balances
- Newtonian fluid mechanics
- Steady heat transfer (Fourier's law, microscopic energy balances)
- Heat exchangers
- Integration/differentiation

- **Homework 1, with answers, posted; TA has solutions**
- **TA help sessions: This Sunday 6:30-7:30pm, room 211).**
- **Website: http://pages.mtu.edu/~fmorriso/cm3120/cm3120.html**
- **Links in Canvas**

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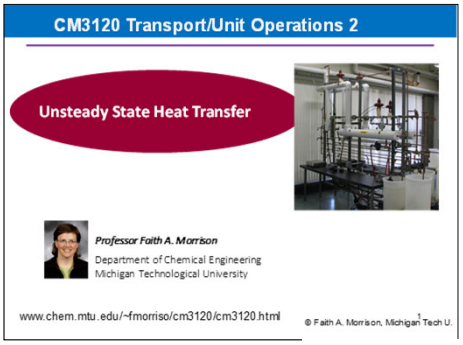
NEXT: Unsteady State Heat Transfer



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