CH EN 3453

HEAT TRANSFER

Welcome!

Please take one of each:

- Course syllabus
- Homework assignment #1

CH EN 3453 – Heat Transfer

Course Introduction
and
Fundamentals of Conduction

Contact Information

- Kevin Whitty, Instructor
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  - Office hours: Open door, or by appointment
- Teaching Assistants
  - Cody Barnhill ta1@chen3453.com
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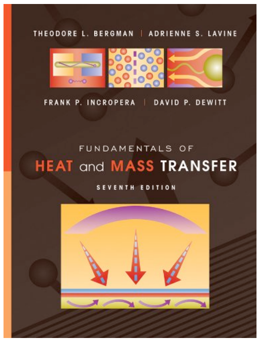
Prerequisites

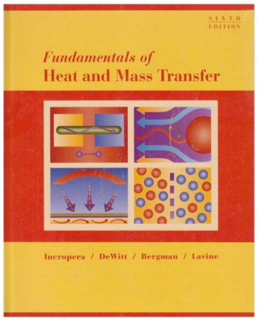
- Major status in Chemical Engineering
- Passing grade in all of the following:
  - CH EN 2300 (Thermodynamics I)
  - CH EN 2450 (Numerical Methods)
  - CH EN 2800 (Process Engineering)

Textbook



Bergman, T., et al.
Fundamentals of Heat and Mass Transfer
7th ed. (2011)
John Wiley & Sons
ISBN 978-0-470-50197-9

or….



Incropera, Frank P., et al.
Fundamentals of Heat and Mass Transfer
6th ed. (2007)
John Wiley & Sons
ISBN 978-0-471-45728-2

Grading

- Homework (18% of grade)
  - 12 assignments, each worth 1.5% of overall grade
  - Due at 4:00 PM on day it is due (see schedule)
  - Turn in to basket in Chem. Eng. office
    - I will also pick any that are ready during class
  - Solutions to most problems are posted on web site when homework is assigned
  - All solutions available upon return of homework
  - Late policy:
    - If turned in after 4:00 PM, minus 50% of score
    - If turned in after 9:25 AM next class period, no credit
  - Help session most Wednesdays
    - 4:30 pm in Merrill Engineering Building (MEB) 2325

Grading (continued)

- Exams (70% of grade)
  - Two midterms (20% each) and one final (30%)
  - Closed book
  - One 8.5 x 11 inch sheet of notes (both sides) allowed
- Project (12% of grade)
  - Analysis and reporting of heat exchanger performance
  - Scientific reporting
  - Experimental design and analysis
  - Individual formal report
  - Peer review of report drafts

Grading Basis

- Scores normalized to the top score in the class
- Normalized scores used to assign grades as per the following:

95-100	A	70-75	C+
90-95	A-	65-70	C
85-90	B+	60-65	C-
80-85	B	50-60	D
75-80	B-	0-50	E

- Grades are non-negotiable
- It is your responsibility to get a good grade by actively participating, doing the assignments, studying and learning the material

Course Web Site:
www.chen3453.com

- Syllabus
- Current course schedule
- Homework
  - Homework assignments
  - Solutions to selected problems posted when homework is assigned
  - Solutions to all problems posted when homework is returned
- Project information
- Miscellaneous information
- Update of student scores/ranking

ADA Statement

"The University of Utah seeks to provide equal access to its programs, services and activities for people with disabilities. If you will need accommodations in the class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Union Building, 581-5020 (V/TDD). CDS will work with you and the instructor to make arrangements for accommodations."

Internships

- Next summer is last chance to do an internship
- To employers, work experience (e.g., internships) is frequently considered more important than academic performance
- Many internship opportunities for chemical engineers
  - Science & Engineering Career Fair Tues, Sept 23
  - Check careers.utah.edu
  - Postings on Chem. Eng. web site
  - Employer visits
- You should start looking for internships NOW!

Let's get started...

- What is heat transfer?

Heat transfer is thermal energy in transit due to a temperature difference.

- What is thermal energy?

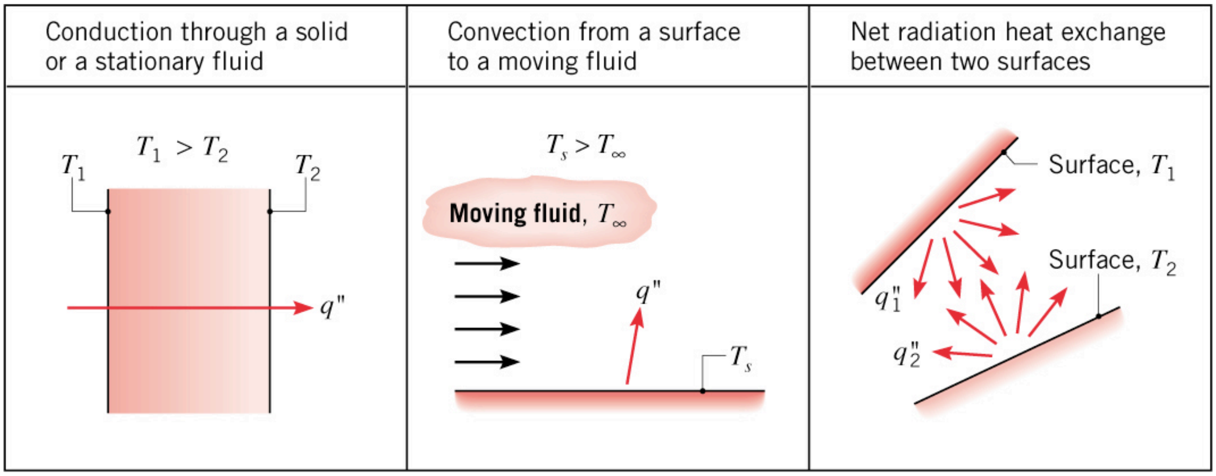
Thermal energy is associated with the translation, rotation, vibration and electronic states of the atoms and molecules that comprise matter. It represents the cumulative effect of microscopic activities and is directly linked to the temperature of matter.

Do not confuse or interchange the meanings of Thermal Energy, Temperature and Heat Transfer

Quantity	Meaning	Symbol	Units
Thermal Energy	Energy associated with microscopic behavior of matter	U or u	J or J/kg
Temperature	A means of assessing the amount of thermal energy stored in matter	T	K or °C
Heat Transfer	Thermal energy transport due to temperature gradients		
Heat	Amount of thermal energy transferred over a time interval $\Delta t > 0$	Q	J
Heat Rate	Thermal energy transfer per unit time	q	W
Heat Flux	Thermal energy transfer per unit time and surface area	q''	W/m^2

Modes of Heat Transfer

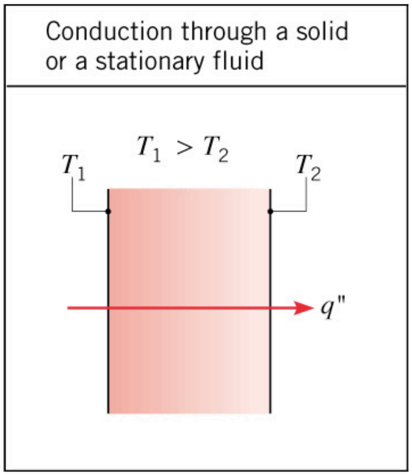
- Conduction
- Convection
- Radiation


Conduction through a solid or a stationary fluid

Convection from a surface to a moving fluid

Net radiation heat exchange between two surfaces

Conduction



- Heat transfer in a solid or a stationary fluid (gas or liquid) due to the random motion of its constituent atoms, molecules and /or electrons.
- Requires the presence of temperature variations in the material medium

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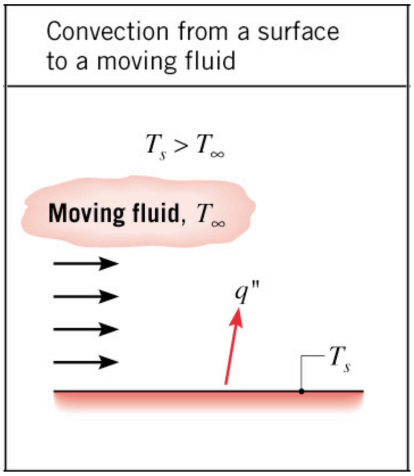
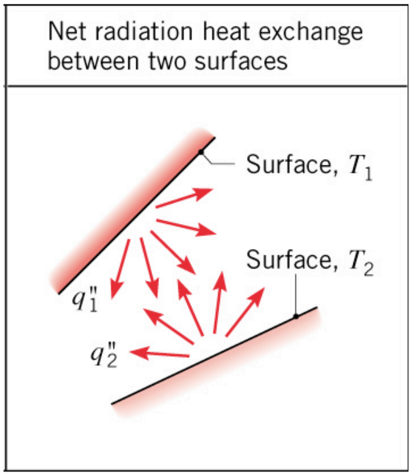
Convection



- Heat transfer due to the combined influence of bulk and random motion for fluid flow over a surface.
- Requires the presence of temperature variations in the material medium

Radiation



- Energy that is emitted by matter due to changes in the electron configurations of its atoms or molecules and is transported as electromagnetic waves (or photons).
- Transport does not require a material medium and occurs most efficiently in a vacuum.

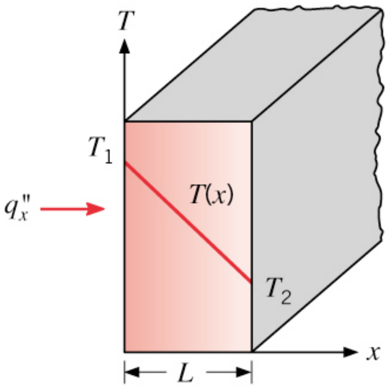
Conduction Rate Equation

Fourier's Law: $$\vec{q}'' = -k\underbrace{\vec{\nabla} T}$$

Heat flux
W/m²

Thermal
conductivity
W/m·K

Temperature
gradient
°C/m or K/m

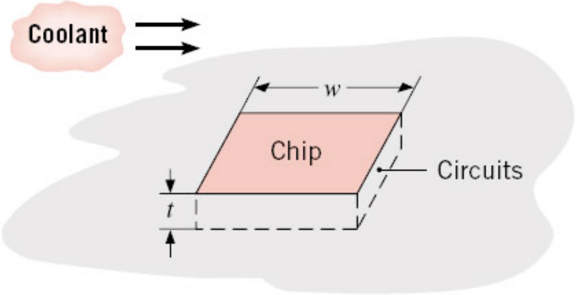


$$q''_x = -k\frac{dT}{dx} = -k\frac{T_2 - T_1}{L} = k\frac{T_1 - T_2}{L}$$

Heat rate (W): $q_x = q''_x \times A$

Example – Book Problem 1.11

A square silicon chip (*k* = 150 W/m·K) is of width w = 5 mm on a side and is of thickness *t* = 1 mm. The chip is mounted in a substrate such that its side and back surfaces are insulated, while the front surface is exposed to a coolant.



If 4 W are being dissipated in circuits mounted to the back surface of the chip, what is the steady-state temperature difference between back and front surfaces?