HEAT TRANSFER
20-MECH-4012
AUTUMN SEMESTER 2015

Textbook: Fundamentals of Heat & Mass Transfer, Bergmann, Lavine, Incropera, DeWitt
7th, Wiley, 2011. (IHT: Interactive Heat Transfer Software is not required.)
(B&W softcover ~ $100 at bookstore; Hardcover color $286.95 was not ordered)

Instructor: Professor M. Kazmierczak, 627 Rhodes, 556-0259, mike.kazmierczak@uc.edu
Office Hours: Drop-in (usually available) and/or by appointment (definite).

Teaching Assistant: Ms. Dantong Shi ; shidg@mail.uc.edu

Grading System:

Conduction:	Exam I	17.5 % (1-D SS heat conduction, ~~heat gen~~)
Conduction:	Exam II	17.5 % (~~heat gen~~, fins, 2-D steady, 1-D transient)
Radiation:	Exam III	17.5 % (radiation heat transfer only)
Convection**:**	Exam IV	30 % (GE, external & internal convection)
	HW	17.5 % (no curve)

All exams will be OPEN book

Homework: Ten (10) homework problem sets from the textbook (1 set per each chapter) are given on the BB website, of which many of these problems will be discussed in class. *(Understand these problems, and you will be "good to go" for the exams.)* These HW problems from the textbook will not be collected, but rather, there will also be **one or two "additional problems"** in the set not from the textbook (or a textbook problem that has been significantly modified) which will be collected and graded by the TA (worth 17.5% of the total course grade). Solutions to all of the HW problems will be posted on the web.

Project: There is no formal class project.

Prerequisites: Thermodynamics. Ordinary differential equations. Spreadsheets (or simple Mathlab program) may be helpful in evaluating appropriate equations. Numerical methods and computer programming will not be required to solve the assigned HW problems. (Numerical methods, i.e. finite difference, are covered in great detailed in other courses, but overview and example of method / solution wrt to 2-D steady-state HT will be given.)

Class Handouts: For your convenience and to help with the class instruction, most of the lecture notes, all homework assignment/solutions, and sample solved exams (i.e. former exams from the very last semester that I taught HT) are posted on Blackboard.

Goal: Main objective of this class is to learn how to analyze and solve **<u>heat conduction</u>** (40%), **<u>convection</u>** (40%) & **<u>radiation</u>** (20%) **heat transfer problems**. More specifically, the student is expected to 1) gain a **fundamental understanding** of the basic underlying concepts and principles, and 2) learn the various **analysis tools** and techniques needed to **solve typical textbook and basic applied engineering heat transfer problems.**

CONDUCTION AND RADIATION OUTLINE

<u>Topics</u>	**<u>Chapters</u>**
I. Introduction	
Modes of heat transfer; Rate equations	1 (all)
II. Introduction to Conduction	
General heat conduction equation and thermal conductivity	2 (all)
Boundary and Initial Conditions	
III. 1-D Steady-State Heat Conduction	
Single layer system, Multilayer system	3.1 - 3.4
Electric analogy / resistance networks	
~~*Conduction with internal heat generation (as time permits)*~~	~~*3.5*~~

<u>CONDUCTION TEST I (*17.5%*)</u>

III. 1-D Steady-State Heat Conduction (continued…)	
Extended surfaces (i.e. fins)	3.6
IV. 2-D Steady-State Heat Conduction	
Part A - Overview of Analytical Methods	4.1 - 4.3
Part B - Finite Difference Solution (overview)	4.4 - 4.5
V. Transient 1-D Heat Conduction: Analytical Methods	
Lumped Capacitance Model	5.1 - 5.3
Distributed System (as time permits)	5.4 - 5.6
Semi-Infinite Solid (if time permits)	5.7
(We will <u>not</u> study numerical solution to transient heat conduction)	

<u>CONDUCTION TEST II (*17.5%*)</u>

XII. Radiation: Processes and Properties	
Fundamental concepts and definitions	12.1 - 12.2
Blackbody behavior	12.4
~~*Surface properties and*~~ *gray surface (as time permits)*	~~*12.5 - 12.8*~~
XIII. Radiation Exchange Between Surfaces	
View factor	13.1
Radiation exchange between blackbody	13.2
and diffuse gray surfaces, radiation HT shields	13.3

<u>RADIATION HT TEST (*17.5%*)</u>

CONVECTION OUTLINE

Overall Goal: Basically, to learn how to handle **heat transfer problems involving <u>fluid flow</u> (convection).** To become familiar with the governing equations, i.e., Navier-Stokes and differential thermal energy equations, and their underlining concepts. Learn the basic analysis tools (limited mainly to analytical techniques but with proper perspective given to experimental and numerical methods) and simplifying assumptions such as external "boundary layer approximations", "fully-developed" internal flows, and the benefits of nondimensionalization. To apply the above theory and / or <u>the results</u> obtained from theory, to **<u>understand</u>** and to be able to **<u>calculate</u> the rate of convective heat transfer** in engineering systems involving either external or internal forced flows. (We will not cover convective <u>mass</u> transfer.)

<u>Topics</u>	**<u>Chapters</u>**
VI. **Governing equations (GE)**	
Navier-Stokes, thermal energy equation	6.1 - 6.3
- momentum transport	Appendix E
- thermal energy transport	
Solution Methodology	
~~Nondimensionalization *(as time permits)*~~	~~6.5~~
- dimensionless parameters	6.6
VII. **External** Forced Convection	
Boundary layer approximations	6.4
Flat plate in parallel flow geometry:	7.2, 7.3
laminar similarity solution	7.2.1
- momentum transport	
- energy transport	
turbulent correlations.	7.2.2, 7.2.3
Single cylinder and tube bank in crossflow	7.4, 7.6
VIII. **Internal** Forced Convection	
Fully developed duct flow	8.1-8.4, 8.6
- momentum transport	
- thermal energy transport.	
Developing channel flow	8.4.2
Turbulent flow in circular tubes	8.5
Noncircular tubes	8.6

<u>CONVECTION TEST (*30%*)</u>