ME 410H, Heat Transfer, Fall 2007, Professor Brasseur
MWF 12:20 - 1:10 PM, 110 Walker Building

***Dept.. Curriculum Manual**	For departmental description of this course, course objectives and course outcomes, please go to http://www.mne.psu.edu/undergrad/ugmanuals/ME_Manual/ME_Required_Courses/ME410.htm
Text (required)	F.P. Incropera & D.P. DeWitt, *Fundamentals of Heat and Mass Transfer*, 5th Edition, Wiley, N.Y., 2002, and Spiegel & Liu, Mathematical Formulas and Tables, Schaums Outlines
2007-2008 Catalog	Heat Transfer (3 cr.) Steady and transient heat conduction; free and forced convection in laminar and turbulent flow regimes; heat exchangers; boiling and condensation.
Prerequisite courses	ME 33/320, CMPSC 201, MATH 220 or NUCE 309, MATH 251
Prerequisites by topic	Engineering Thermodynamics; Fluid Mechanics; Computer Programming; Matrices; Ordinary Differential Equations
Teacher **Office hours**	Professor Brasseur, 205 Reber Building, 865-3159 (office), brasseur@psu.edu ⇒ Wed 4:30-6:00 PM
Grading	Weekly Analyses: 30% 2 midterm exams (25% each): 50% total Final exam (comprehensive): 25%
Exam Dates	see outline
Exam Structure	The exams are a mix of concept-based analysis (roughly 20%) and model-based analysis (roughly 80%). Assignments have a similar mix.
Assignments	please see attachment
Dishonesty	Dishonesty is the purposeful misrepresentation of your work, including the copying of assignments, plagiarism, etc.. I certainly hope that none of you are dishonest so that I need not tell you that I take honesty as a serious issue, and the consequences of dishonesty will be serious.
Help	I am here to help you learn. Please take advantage of my desire for you to learn and see me before problems develop. Please email and set a time to visit for help. Or drop into my office and if I can see you that minute I will, otherwise we can fix a time to get together.

Course Objectives (see *)
[Course outcomes are mapped to course objectives below]

A. Develop both qualitative and quantitative understanding of the three modes of heat transfer.
B. Make appropriate approximations, develop and apply simplified model equations for specific applications.
C. Apply mathematical and numerical methods to solve heat transfer problems.
D. Understand the role of and use dimensionless parameters in heat transfer analysis.

Course Outcomes (see *)

1. Sketch and interpret temperature distributions and heat flux distributions for mathematical models of heat conduction with planar and radial geometries, including heat generation. [A]
2. Derive fundamental differential thermal energy equations and develop mathematical models for thermal/fluid systems, including:
   - Lumped capacitance for unsteady heat transfer
   - 1D unsteady heat conduction equation with heat generation
   - Quasi 1D heat conduction for extended surfaces (fins), including variable cross-sectional areas
   - Mean axial temperature variation for internal flows with uniform surface temperature or uniform wall heat flux. [B]

3. Apply ODE solution methods to solve the differential heat transfer equations for applications including:
    Lumped capacitance for unsteady heat transfer
    Steady 1D planar and radial conduction with heat generation
    Quasi 1D fins with variable cross-sectional area
    Internal flows with uniform surface temperature or uniform wall heat flux. [C]
3. Apply existing PDE solutions to analyze 1D and quasi 1D unsteady heat conduction systems. [C]
4. From an energy balance, derive the finite difference equations for conduction with surface convection. Describe numerical solution methods used to solve the finite difference equations. [B]
5. For convective heat transfer over a flat plate with uniform surface or uniform wall heat flux, sketch and interpret:
    Hydrodynamic and thermal boundary layer thicknesses
    Hydrodynamic and thermal boundary layer profiles
6. Local skin friction and local heat transfer coefficient as a function of distance from the leading edge. [A]
7. Sketch and interpret hydrodynamic and thermal profiles for internal flows with uniform surface or uniform wall heat flux. [A]
8. Develop and apply conduction and convection thermal circuits. [B]
9. Choose and apply appropriate dimensionless correlations for external and internal flows to solve convection heat transfer problems. [D]
10. Understand and apply the Reynolds Analogy for convection heat transfer. [B]
11. Analyze thermal sensors such as hot wires and thermocouples. [E]
12. Define and properly apply in an energy balance the following terms: emission, radiosity, irradiation, net radiation heat flux, emissivity, absorptivity, reflectivity, and transmissivity. [A]
13. Understand the spectral characteristics of radiation heat transfer including black and gray surfaces. [A]
14. Develop thermal circuit diagrams for radiation analysis and determine surface temperatures for two and three surface geometries including reradiating surface and radiation shield. [B]
15. Set up and solve combined conduction, convection, and radiation heat transfer problems. [B & C]
16. Apply fundamental heat transfer principles to perform heat exchanger design and performance calculations. [E]
17. Make effective use of spreadsheets as an analysis tool. [C]
18. Demonstrate the ability to solve problems in a clear step-by-step manner and follow policies and instructions as outlined in the syllabus and other course materials. [F]
19. Demonstrate professionalism in interactions with colleagues, faculty, and staff.[F]

Outline
ME 410H, HEAT TRANSFER, FALL 2007
Prof. Brasseur, MWF 12:20-1:10PM, 110 Walker

Text: F.P. Incropera & D.P. DeWitt, *Fundamentals of Heat and Mass Transfer,* 5th Edition, Wiley, N.Y., 2002.

*to be placed on Angel

Date	topics assign.	reading	example problems*
27- 31 August	**I. BASIC ELEMENTS OF HEAT TRANSFER**		
	Introduction	**1.1-1.2**	1.7
	Heat Transfer and Conservation of Energy	**1.3-1.7**	1.13, 1.25
	Heat Flux at Boundaries	**1.3-1.7**	
5 -September - 5 October	**II. CONDUCTION (HEAT TRANSFER THROUGH NON-MOVING MATTER)**		
	Mathematical Structure: Governing Equation + BCs	**2.1-2.5**	2.7, 2.24
5 - 19 September	**II(A) Analysis of Steady Heat Conduction**		
	Planar One-Dimensional Steady Conduction	**3.2,3.1**	3.3a, 3.8a
	Radial One-Dimensional Steady Conduction	**3.3-3.4**	3.36
	1-D Steady Conduction w/Internal Heat Generation	**3.5**	3.68
	Quasi 1-D Conduction through Extended Surfaces and Fins	**3.6**	3.101
	Quasi 1-D Conduction through Extended Surfaces and Fins	**3.6**	3.116
	Numerical calculation of 2-D temperature distributions	**4.1-4.5**	4.35, 4.37
	2-D temperature distributions		4.47, 4.51
21 September - 5 October	**II(B) Analysis of Time-dependent Heat Conduction**		
	The "Lumped Capacitance" Approximation, Time Constants	**5.1-5.3**	5.1, 5.5, 5.7, 5.10
	LC Approx, Dimensionless Grps/Charts	**5.1-5.6**	5.41a
	Semi-Infinite & Multi-Dimensional Effects	**5.7-5.8**	5.71, 5.87
	Finite Difference Methods	**5.9**	5.97a

EXAM 1 through II(B): tentatively Tuesday 9 October, in the evening (two hour exam)

Date	topics assign.	reading	example problems*
10 October - 16 November	**III. Convective Heat Transfer**		
10 - 15 October	**III(A) Basic Elements Underlying Convective Heat Transfer**		
	Introduction to Convection	**6.1-6.3**	6.2, 6.7
	Conservation Equations - Boundary Layer	**6.4-6.5**	6.18, 6.22
	Similarity Solutions	**6.6-6.7**	6.27, 6.28
	BL Analogies, Turbulence Correlations	**6.8-6.11**	6.40, 6.42
17 - 22 October	**III(B) Heat Transfer due to Flow External to Objects**		
	Convection - External Flow	**7.1-7.3**	7.2a/b, 7.6, 7.14
	Cross Flow over a Cylinder/Sphere	**7.4-7.5**	7.42, 7.78a/b
	Cross Flow over a Cylinder/Sphere, cont'd		7.83
24 - 29 October	**III(C) Heat Transfer due to Flow within Tubes**		
	Convection - Internal Flows	**8.1-8.2**	8.4, 8.7
	Energy Balance	**8.3**	8.12, 8.16a/b
	Correlations	**8.4-8.9**	8.23a, 8.26, 8.54a
31 October - 7 November	**III(D). HEAT EXCHANGERS**		

Heat Exchangers - Introduction	**11.1-11.**2	11.5
Heat Exchanger Analysis	**11.3**	11.9, 11.14
Heat Exchanger Analysis	**11.4-11.**5	11.32, 11.39
Heat Exchanger Analysis		11.50

EXAM 2, through III(D): tentatively Tuesday 9 October, in the evening (two hour exam)

9 - 16 November III(E) Free Convection

Free Convection - Governing Equations	**9.1-9.3**	9.7, 9.23
Problem Review		
Laminar/Turbulent Flow on External Surfaces	**9.4-9.6**	9.25a
Free convection in enclosures	**9.7, 9.8**	9.51, 9.54

26 November - 14 December IV. HEAT TRANSFER FROM ELECTRO-MAGNETIC RADIATION

26 November - 3 December IV(A) Properties and Mathematical Representation of Radiation

Radiation - Concepts and Intensity	**12.1-12.2**	12.6, 12.9, 12.10, 12.11
Radiation - Concepts and Intensity, cont'd		
Blackbody Radiation - Surface Characteristics	**12.3-12.5**	12.22a, 12.29a/b
Kirchhoff's Law and Gray Body Radiation	**12.6-12.9**	12.45, 12.49

5 - 14 December IV(B) Computing Radiation Exchange Between Surfaces

View Factor, SRTE	**13.1-13.2**	13.1, 13.2
Radiation Heat Transfer in Enclosures	**13.3**	13.16
Radiation Heat Transfer in Enclosures, cont.	**13.3**	13.21, 13.22a, 13.63
Review of Course		

FINAL EXAM: Comprehensive