Spring 2010

Department of Chemical Engineering
West Virginia University

ChE 717
Advanced Heat Transfer

Time: Tuesday, Thursday 11 – 12:15

Room: 449 Engineering Sciences Building

Instructor: John W. Zondlo
Office: Room 415 ESB
Phone: 293-9366
Office Hours: Wednesday 1:00-3:00 or after class or by appointment

Recommended Text:

Transport Phenomena, 2nd Edition, R.B. Bird, W.E. Stewart, E.N. Lightfoot, John Wiley & Sons, 2002.

Reference Texts:

Fundamental Principles of Heat Transfer, Stephen Whitaker, Robert E. Krieger Publishing Co., Malabar, FL, 1983.

Heat Tansfer : A Basic Approach, M.N. Ozisik, McGraw-Hill, 1985.

*Heat Transfer, 9th Edition, J.P. Holman, McGraw-Hill, 2002.

*Convective Heat and Mass Transfer, 3rd Edition, W.M. Kays and M.E. Crawford, McGraw-Hill, 1993.

*Conduction Heat Transfer, V.S. Arpaci, Addison-Wesley Publishing Company, 1966.

*Convective Heat Transfer, V.S. Arpaci and P.S. Larsen, Prentice-Hall, Inc., 1984.

Heat Conduction, M.N. Ozisik, John Wiley & Sons, 1980.

Unit Operaitons of Chemical Engineering, 6th Edition, W.L. McCabe, J.C. Smith and P. Harriott, McGraw-Hill, 2001.

*Boundary Layer Theory, 7th Edition, H. Schlichting, McGraw-Hill, 1979.

An Introduction to Convective Heat Transfer Analysis, P.H. Oosthuizen and D. Naylor, McGraw-Hill, 1999.

Applied Mathematics and Modeling for Chemical Engineers, R.G. Rice and D.D. Do, John Wiley & Sons, 1995.

Advanced Engineering Mathematics, 3rd Edition, D.G. Zill and M.R. Cullen, Jones and Bartlett Publishers, 2006.

Introduction to Heat Transfer, 4th Edition, F.P. Incropera and D.P. Dewitt, John Wiley & Sons, Inc., 2002.

Conduction of Heat in Solids, Carslaw and Jaeger, Oxford Press, 19??

Convective Heat Transfer, L.C. Burmeister, John Wiley & Sons, 1983.

Convective Heat Transfer, A. Bejan, John Wiley & Sons, 1984.

*Analytical Methods in Conduction Heat Transfer, G. E. Meyers, Robert E. Krieger Publishing Co., 1987.

*Mathematical Methods in Chemical Engineering, V.G. Jenson and G.V. Jeffreys, Academic Press, Second Edition, 1977.

Advanced Engineering Mathematics, 3rd Edition, E. Kreyszig, John Wiley & Sons, 1972.

Course Goals: If you don't know where you are going, you probably won't get there.

- To learn the necessary mathematical skills that are frequently used in the field of analytical heat transfer.
- To understand the underlying physical laws governing conduction heat transfer and how they apply to engineering problems.
- To gain a familiarity of the equations of motion and energy and their applications to convective heat transfer.
- To have fun learning about Heat Transfer!!

Basis for Course Grade:

Hour Exam I	-	35%
Final Exam	-	35%
Homework	-	15%
Special Projects	-	15%

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Course Outline

I. Introduction

- A. Modes of Heat Transfer

II. Conduction Heat Transfer

- A. Formulation of Conduction Problems
  - 1) Differential Equations
  - 2) Fourier's Law
  - 3) Special Cases
  - 4) Initial and Boundary Conditions
- B. Normalization of Differential Equations
  - 1) Fourier & Biot Numbers
- C. Lumped and Partially-Lumped Problems
  - 1) Freezing of Solids
- D. Integral Methods - Approximate Solution
- E. Superposition Principle
- F. Cylindrical Geometry and Fin Problems - Bessel Functions
- G. Solution Techniques
  - 1) Separation of Variables
  - 2) Similarity Transformation
  - 3) Complex Temperatures
  - 4) Laplace Transforms

III. Convective Heat Transfer

- A. Fundamental Equations
  - 1) Equation of Continuity
  - 2) Equation of Momentum
  - 3) Equation of Energy

4) Viscous Dissipation

B. Internal Laminar Flow
1) Fully Developed Flow and Thermal Fields
2) Developing Fields

C. Boundary Layers
1) Hydrodynamic Boundary Layer Theory
2) Laminar Thermal Boundary Layers
3) Integral Methods
4) Injection or Suction
5) Viscous Dissipation
6) Evaporative Cooling

D. Turbulent Flow and Heat Transfer
1) Analogy Equations

IV. Natural Convection

A. Fundamental Equations

B. Similarity Solution

C. Integral Methods

V. Condensation Heat Transfer

A. Flat Plate or Tube
1) Vertical Configuration
2) Horizontal Configuration

B. Special Case - Fluted Tubes

VI. Numerical Methods - Finite Differences

A. Introduction and Fundamentals

B. Two-Dimensional Steady-State Problems

C. One-Dimensional Transient Problems

D. Multi-Dimensional Transient Problems

Note: Selected topics from items IV, V, and VI will be covered as time permits.