MAE 623 – Conduction Heat Transfer

Instructor: Terence Musho, Ph.D., P.E.
Office: 727 ESB
Phone: (304) 293-3256
tdmusho@mail.wvu.edu
Office hours: T 1:00-1:50pm and by appointment. In person or Zoom.

Lecture: MW 10:00 – 11:15 PM Room ESBE851

Optional Text: Heat Conduction, David Hahn (WVU eLibrary)
Heat Conduction using Green's Functions, J.V. Beck
Nano/Microscale Heat Transfer, Zhuomin Zhang (WVU eLibrary)
Inverse Heat Transfer: Fundamentals and Applications, M. Necat Ozisik

References: Analytical Methods in Heat Conduction, Glen Myers
Introduction to Heat Transfer, F.P. Incropera. D.P. DeWitt, T.L. Bergman, and A.S. Lavine

Course Objectives: The objective of this course is to provide students with the necessary knowledge to solve advanced conduction heat transfer problems. The course will begin with a review of general heat transfer concepts and transition into advanced heat transfer concepts. These advanced heat transfer concepts include analytical approaches to solving 2D and 3D steady state and transient conduction problems with an emphasis on solving these problem using a Green's Function method. The course will also cover special topics in area of nanoscale heat conduction and Finite Element Method for solving the transient heat conduction problem.

Grading:

Mid Term Exam	40%
Homework	20%
Final Exam	40%

Course Content:

1. Introduction/Review of Heat Transfer

A. Modes of Heat Transfer: Conduction, Convection, Radiation
B. Fundamental mechanisms of Heat Transfer
   i. Atomistic Considerations
   ii. Material Considerations – Alloys, Temperature, Microstructure

2. Introduction to Heat Conduction

A. Fourier's Law of Heat Conduction
   i. Definitions: Thermal conductivity, Thermal diffusivity
   ii. Mathematical Consideration of Linear PDEs

B. Steady Heat Conduction Solution
  i. Solving PDEs using Separation of Variables
  ii. 2D and 3D Steady State Example

4. Fourier Analysis of Boundary Value Problems – Transient Conduction
  i. Introduction to Fourier series – Orthogonal Functions
  ii. Mathematical Treatment of Non-Homogenous Boundary Conditions
  iii. Superposition Solutions
  iv. Product Solutions
  v. Duhamel's Theorem
  vi. Bessel Functions – Cylindrical Solution

5. Green's Function Method – Transient Conduction
  i. Green's Function Derivation
  ii. 2D Transient GF Solution
  iii. 3D Transient GF Solution

6. Numerical Analysis
  i. ANSYS FEA Heat Conduction Hands-on Demonstration

7. ***Inverse Heat Transfer Methods***
  i. Inverse Heat Transfer Techniques
  ii. Conjugate Gradient Method

8. Micro/nano-scale Conduction Heat Transfer

A. Quantized Heat Conduction
  i. Quantum Mechanical Considerations
  ii. Heat Capacitance – Debye Temperature
  iii. Mean-free Path – Scattering Mechanisms

B. Solution to Ballistic Thermal Transport
  i. Quantum Conductance
  ii. Small Gap Conduction – Dielectric Interactions

TENTATIVE COURSE Schedule

Date	Topics	Notes
Week 1	Introduction to Heat Transfer Mechanisms of Heat Conduction in Solids	
Week 2	LCM, Semi-infinite Solids, Infinite Solids Separation of Variables Solution to PDE	
Week 3	Orthogonal Functions, Fourier Series Boundary Value Problems	Univ. Closed Sep. 4
Week 4	1D Transient Conduction Homogenous BC Example 1D Transient Conduction 1 NH BC Example	
Week 5	2D and 3D Steady State Conduction Example Superposition of Solutions Derivation	
Week 6	Superposition of Solutions Example Product Solution Example	
Week 7	Duhamel's Solution Example Bessel Functions	
Week 8	Introduction to Green's Functions, Naming Convention X22 GF Derivation	Fall Break Oct. 5-6
Week 9	X23 GF Example X30 GF Example	
Week 10	Radial GF Example Mid Term Exam	
Week 11	2D and 3D GF Example Time Partitioning GF Solution	
Week 12	Intro to Inverse Heat Transfer Conjugate Gradient Method	
Week 13	Finite Element Solution	
Week 14		Fall Recess Nov. 18-26
Week 15	Micro/Nanoscale Heat Transfer Debye Derivation	
Week 16	Small Gap Considerations Quantum Conductance	Last Class Dec. 7
Week 17	Final Term Paper Due at Final Time	Winter Recess Dec. 16