

MAE 105
Introduction to Mathematical Physics (4)

Class/Laboratory Schedule: four lecture hours per week, eight hours outside preparation. 12 hours/week total

Course Coordinator(s): Prab Bandaru

Textbook, Required Materials: R. Haberman, Elementary Applied Partial Differential Equations.

Catalog Description: Fourier series, Sturm Liouville theory, elementary partial differential equations, integral transforms with applications to problems in vibration, wave motion, and heat conduction.

Prerequisites: Admission to the major and grades C- or better in Phys.2A-2B, Math 20D or 21D

Prerequisites by Topic: elementary mechanics, elementary electricity and magnetism, differential and integral calculus, elementary ordinary differential equations

- Required Course
- Technical Elective Course
- Other: _____

Performance criteria:

Objective 1

- 1.1 To be able to set up appropriate initial and boundary conditions for simple heat conduction problems
- 1.2 To separate the time and spatial variation for heat conduction problems and identify the eigenvalue problem to solve to obtain the eigenfunctions and to complete the solution of the original problem
- 1.3 To be able to solve Laplace's equation using separation of variables and the necessary eigenvalue problems
- 1.4 To understand the method of characteristics and their physical meaning in the x-t plane
- 1.5 To understand the concept of reflection across boundaries and the periodic extension

Objective 2

- 2.1 To be able to use separation of variables to set up necessary eigenvalue problems for a given PDE
- 2.2 To be able to obtain Fourier series representation of a given function, and the solution of boundary value problems
- 2.3 To understand the concept of orthogonality of the eigenfunctions and its mathematical and physical importance
- 2.4 To be able to use the method of characteristics to obtain the value of dependent function in terms of initial displacement/velocity at any point within the domain in the x-t plane

- 2.5 To be able to find Fourier transform of given functions using tables and also the inverse Fourier transform
- 2.6 To be able to reduce given partial differential equation into an associated ordinary differential equation using the Fourier transform method
- 2.7 To be able to use convolution theorem to solve simple problems in infinite space

Course Objectives:

(Numbers in parenthesis refer to MAE Program Outcomes)

Objective 1: To teach students the relation between three fundamental physical phenomena (diffusion, static, and wave motion) and the corresponding mathematical formulation in terms of partial differential equations and the associated initial-boundary data. (1a,5e)

Objective 2: To teach students elementary techniques of solving simple linear partial differential equations to obtain complete solution in terms of given data. (1a,5e, 11k)

Course Topics:

1. Classification of Partial Differential Equations (PDE) in Terms of their Physical Applications
2. Parabolic PDE: Diffusion Phenomena
3. Elliptic PDE: Electrostatic, Torsion, etc
4. Hyperbolic: Vibration, Wave Motion
5. Initial-Boundary Value Problems: Heat Conduction
6. Method of Separation of Variables
7. Diffusion PDE
8. Laplace's Equation
9. Wave Equation
10. Fourier Series
11. Vibrating Strings and Membranes
12. Sturm-Liouville Eigenvalue Problem
13. PDE with Three Independent Variables
14. Non-Homogeneous Problems
15. Infinite Domain: Fourier Transform Solutions of PDE's
16. Method of Characteristics; wave equation with one space variable; infinite domain; finite domain

Prepared By: Nemat-Nasser, March 2000

Revised: H. Murakami April 2008 via Teaching Work Group Meeting

Reviewed: TWG, June 2010; August 2011, August 2012