MAE 105
Introduction to Mathematical Physics (4)

Designation: Required course

Catalog Data:
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

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

Class/Laboratory Schedule: 4 lecture hours per week

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

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, ME12)

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)

Methods of Evaluation:
1. Weekly homework, collected and graded and solutions provided (10% of course grade)
2. Weekly, closed book, 20 minute quizzes (25% of course grade)
3. Exams: Two Midterm's (30% of course grade); Final exam (35% of course grade)

Performance criteria:
(Numbers in parentheses refer to the methods of evaluation used to assess student performance.)

Objective 1
1.1 To be able to set up appropriate initial and boundary conditions for simple heat conduction problems (1,2,3).
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 (1,2,3).
1.3 To be able to solve Laplace's equation using separation of variables and the necessary eigenvalue problems (1,2,3).
1.4 To understand the method of characteristics and their physical meaning in the x-t plane (1,2,3).
1.5 To understand the concept of reflection across boundaries and the periodic extension (1,2,3).

Objective 2
2.1 To be able to use separation of variables to set up necessary eigenvalue problems for a given PDE (1,2,3).
2.2 To be able to obtain Fourier series representation of a given function, and the solution of boundary value problems (1,2,3).
2.3 To understand the concept of orthogonality of the eigenfunctions and its mathematical and physical importance (1,2,3).
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 (1,2,3).
2.5 To be able to find Fourier transform of given functions using tables and also the inverse Fourier transform (1,2,3).
2.6 To be able to reduce given partial differential equation into an associated ordinary differential equation using the Fourier transform method (1,2,3).
2.7 To be able to use convolution theorem to solve simple problems in infinite space (1,2,3).

Contribution of Course to Professional Component:
Engineering Science

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