



September 2007

## MATH 418 Partial Differential Equations

### 1. Catalog Description

#### **MATH 418 Partial Differential Equations (4)**

Mathematical formulation of physical laws. Separation of variables. Orthogonal functions and generalized Fourier series. Bessel functions, Legendre polynomials. Sturm-Liouville problem. Boundary value problems; nonhomogeneous techniques. Applications to heat flow, potential theory, vibrating strings and membranes. 4 lectures. Prerequisite: MATH 344 or consent of instructor. Recommended: MATH 304.

### 2. Required Background or Experience

Math 344 or consent of instructor.

### 3. Learning Objectives

This course will:

- a. Help students gain insight into and appreciation for the application of advanced mathematics to problems in physics and engineering.
- b. Guide students through derivation of appropriate partial differential equations governing the behavior of several standard physical problems.
- c. Introduce students to methods of solving three different types of second order partial differential equations with constant coefficients and various boundary conditions.
- d. Strengthen students' ability to work with Fourier series expansions through employment of separation of variables method.
- e. Reinforce students' capacity to solve ordinary differential equations with variable coefficients through use of power series.
- f. Familiarize students with some properties of the most common special functions in physics and engineering.

### 4. Text and References

The instructor will choose a text for this course from the following list:

Churchill, R. V. and J. W. Brown, Fourier Series and Boundary Value Problems, 7th ed., McGraw-Hill, 2007.

Constanda, Christian, Solution Techniques for Elementary Partial Differential Equations, Chapman & Hall (CRC), 2002.

Haberman, Richard, Elementary Applied Partial Differential Equations with Fourier Series and Boundary Value Problems, 4th ed., Prentice-Hall, Inc., 2004.

Logan, J. David, Applied Partial Differential Equations, Springer, 2nd ed., 2004.

Powers, David L., Boundary Value Problems, 5th ed., Academic Press, 2005.

Andrews, Larry C., Elementary Partial Differential Equations With Boundary Value Problems, Harcourt, 1986.

Articolo, George A., Partial Differential Equations & Boundary Value Problems with Maple V, Academic Press, 1998.

Bassanini, Piero and Alan R. Elcrat, Theory and Applications of Partial Differential Equations, Plenum Press, 1997.

Berg, P. W., Elementary Partial Differential Equations, McGraw-Hill, 1966.

Colton, David, Partial Differential Equations, An Introduction, Dover, 2004.

Duffy, Dean G., Solutions of Partial Differential Equations, McGraw-Hill, 1986.

Farlow, S. J., Partial Differential Equations for Scientists and Engineers, Dover, 1993.

Humi, Mayer, and William B. Miller, Boundary Value Problems and Partial Differential Equations, PWS-Kent, 1991.

Kovach, Ladis D., Boundary Value Problems, Addison-Wesley, 1984.

Pinsky, Mark A., Partial Differential Equations and Boundary Value Problems with Applications, Waveland Press, 2003.

Snider, Arthur D., Partial Differential Equations: Sources and Solutions, Prentice Hall, 1999.

Strauss, Walter A., Partial Differential Equations: An Introduction, Wiley, 1992.

Trim, Donald W., Applied Partial Differential Equations, PWS-Kent, 1990.

**NOTE:** The instructor must notify the course supervisor of his/her choice of text at the earliest possible time.

### References

Kreyszig, Erwin, Advanced Engineering Mathematics, 8th ed., Wiley, 1998.

Chapter 11 - Partial Differential Equations

Chapter 10 - Fourier Series and Integrals

Chapter 9 - Integral Theorems

Chapter 4 - Power Series Solutions for Differential Equations, Legendre Polynomials, Bessel Functions

### 5. Minimum Student Materials

Paper, pencils and notebook.

### 6. Minimum University Facilities

Classroom with ample chalkboard space for class use.

### 7. Content and Method

#### A. **Elementary Partial Differential Equations** (Berg text)

1. Introduction to differences between partial differential equations and ordinary differential equations (3 lectures)
2. First and second order linear equations with constant coefficients (2 lectures)
3. The heat equation
4. The method of eigenfunction expansions
5. Solution of inhomogeneous problems
6. The wave equation
7. Laplace's equation (use Kreyszig reference)
8. Maximum principles, Green's identities and uniqueness theorems

**B. Fourier Series and Boundary Value Problems** (Churchill & Brown text)

1. Partial differential equations of mathematical physics
2. The method of separation of variables
3. A review of Fourier series
4. Orthogonal sets of functions
5. Boundary value problems
6. Fourier integrals and applications
7. Bessel functions and applications
8. Legendre polynomials and applications
9. Green's identities and the uniqueness of solutions

**C. Boundary Value Problems** (Powers text)

1. Fourier series and intervals review
2. The heat equation
3. The wave equation
4. The potential equation
5. Problems in several dimensions
6. Application of Laplace transforms to partial differential equations

**D. Partial Differential Equations of Mathematics Physics**

1. Math models and introduction
2. Classification of second order equations
3. The Cauchy problem
4. Method of separation of variables
5. Eigenvalue problems
6. Boundary value problems
7. Higher dimensional problems
8. Green's function
9. Integral transforms

**E. Partial Differential Equations for Scientists & Engineers** (Farlow text)

1. Diffusion-type problems
2. Hyperbolic-type problems
3. Elliptic-type problems
4. Additional methods

Method

Lecture-discussion including chalkboard development, application problems, supervised work, and individual conferences. It is recommended that students evaluate the solution of a boundary value problem on the computer by calculating partial sums. Use Goldenberg movie on vibrating membrane.

8. Methods of Assessment

Student recitation, homework assignments, short tests on judgment and problem solving, and scheduled examinations.