King Fahd University of Petroleum and Minerals
Department of Mathematics
SYLLABUS
Semester II: 2022-2023 **(222)**

Coordinator: Dr. A. Bonfoh
Course #: MATH 568
Title: Advanced Partial Differential Equations I

Textbook: A basic course in Partial Differential Equations by Y. Qing Han, First Edition.

References: 1. Partial Differential Equations by L. C. Evans (Second Edition, 2010)
2. Beginning Partial Differential Equation. by P. O'Neil. (Second Edition, 2008)

Objectives: The course aims to reinforce students knowledge on concepts of existence, uniqueness and properties of solutions to first and second-order linear and quasilinear PDEs. Energy methods to solve nonlinear PDEs will be introduced. Applications to the wave equation, the heat equation and the Laplace equation are considered. In particular, the weak solution and its regularity of the non-homogeneous Laplace IBVP will be considered.

Course description: First order linear and nonlinear equations. Classification of Second order equations. The wave equation, heat equation and Laplace's equation. Green's functions, conformal mapping. Separation of variables, Sturm-Liouville theory. Maximum principles and regularity theorems.

Prerequisites: MATH 437

Learning outcomes: Upon successful completion of this course, a student should be able to:

- Solve quasilinear first order equation by the method of characteristics.
- Classify and solve 2nd order PDE's by the method of characteristics.
- Solve the wave equation and analyze the well-posedness.
- Solve IBVP heat equation by using the maximum principle.
- Know the proofs of the representation theorems, Mean value problem, and maximum principles for Laplace equation.
- Apply Green's function method and method of images to solve the Dirichlet and Neumann problems for the Laplace equation.
- Apply Energy methods to solve 2nd order linear and nonlinear PDEs.
- Prove the existence, uniqueness and regularity of the weak solution of the non-homogeneous Laplace IBVP.

Week	Date	Sec.	Topics	Suggested Homework Problems
1	Jan16 – 19		The linear first-order equation The significance of characteristics	
2	Jan 22 – 26		The Quasilinear equations Second order PDEs in two variables: classification	

3	Jan 29 - Feb 2		The hyperbolic canonical form The parabolic canonical form The elliptic canonical form	
4	Feb 5 – 9		The second-order Cauchy problem Characteristics and the Cauchy problem The wave equation : d'Alembert's solution of the the Cauchy problem d'Alembert solution as a sum of waves	
5	Feb 12– 16		The characteristic triangle The wave equation in 1-d A nonhomogeneous problem in 1-d	
6	Feb 19 – 21		A wave equation in 2-d The Kirchoff-Poisson solution of the wave equation in 3-d Hadamard's method of descent	
7	Feb 26-March 2		The heat equation: IBVP The maximum principles	
8	March 5 – 9		The heat equation in 1-d The nonhomogeneous heat equation in 1-d The heat equation in 2-d	
Midterm Exam				
9	March 12- 16		Setting of Dirichlet and Neumann problems Some harmonic functions Representation theorems Maximum principle, Mean value property	
10	March 19- 23		Existence, Uniqueness and Well-posedness Dirichlet problem in 2-d Poisson's integral representation for a disk Green's function for a Dirichlet problem	
11-12	March 26- April 6		The Neumann problem in 2-d Conformal mapping Sturm-Liouville theory	
13-16	April 9– May 15		Eigenvalue problem for the Laplace operator Weak solution of the non-homogeneous Laplace IBVP (existence, uniqueness and regularity) Energy methods to solve 2nd order nonlinear PDEs	
Final Exam				

Grading:

Midterm Exam	35%
Homework assignments	20%
In class Presentations	10%
Final Exam	35%