

**UNIVERSITY OF NOTRE DAME**  
**DEPARTMENT OF AEROSPACE AND MECHANICAL ENGINEERING**

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Mathematical Methods II

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**TOPICAL OUTLINE**

**Scalar and Vector Fields**

Field Operators: Gradient, Divergence, Curl.  
General Theorems: Divergence, Green, Stokes.  
Orthogonal Curvilinear Coordinates.

**Partial Differential Equations**

Definitions and Examples: Linear, quasilinear, and nonlinear.  
Fundamental Equations: Conservation equation, Diffusion, Waves.  
Quasi-Linear Equations of First-Order- Characteristics.  
Cauchy's Problem.  
Waves, Shock Waves.  
Applications : Traffic Flow, Flood Waves.

**Self-Similar Solutions**

Existence.  
Dimensional Analysis.

**Separation of Variables**

Introduction and Examples: Reduction to a System of Ordinary Equations.  
Linear Equations and Linear Operators: Hilbert Space, Adjoint Operator.  
Sturm Liouville Theory:Completeness.  
Orthogonal Function Expansions.  
Fourier Series- Convergence, Gibbs Phenomenon.  
Special Functions.

**Classification of Quasilinear Partial Differential Equations**

System of First-Order Quasilinear Equations.  
Hyperbolic, Parabolic, and Elliptic Equations.  
Linear and Quasi-Linear Equations of Second Order.

**Elliptic Equations**

Laplace and Poisson Equations.  
Existence and Uniqueness-Dirichlet and Neumann Conditions.

Green's Function.  
Integral Transformation.  
Solution to Inhomogeneous Equations.

### **Hyperbolic Equations**

The Method of Characteristics.  
Hyperbolic Waves.  
Dispersive Waves.  
Acoustics.  
Gas Dynamics.  
Water Waves.

### **Parabolic Equations**

The Diffusion Equation.  
Burger's Equation.

### **Functions of a Complex Variable**

Introduction - Examples.  
Analytic Functions.  
Cauchy's Integral Formula.  
Series Expansions.  
Singularities - Branch Points.  
Evaluation of Integrals - Residues.  
Applications - Conformal Mapping - 2-D Flows.

### **Integral Transforms**

Introduction.  
Fourier Transform.  
Laplace Transform.

### **Singular Integral Equations**

Cauchy's Principal Value.  
Sectionally Analytic Functions.  
Plemelj Formula.  
Poisson Formula.  
Riemann's Problem.  
Hilbert's Problem.  
Inversion of Integral Equations.  
Applications.

### **Nonlinear Problems**

Algebraic and Differential.  
Approximate Methods and Solutions.  
Asymptotic Methods.  
Perturbation Methods.