

Mathematical Physics - I

Assam University

FYUG · Semester 1 · Credits 3

PHYDSC101T

OBJECTIVES

- To introduce mathematical tools required for solving problems of interest to physicists
- To enable students to model physical problems mathematically and solve them using appropriate techniques
- To expose students to fundamental mathematical methods applicable to a wide range of physics problems

COURSE CONTENT

Unit 1: Vector Algebra and Matrices (9 Hours)

- Scalar and vector products
- Physical interpretation of vector product
- Scalar and vector triple products and their properties
- Derivation of important vector identities
- Preliminary ideas of scalar and vector fields
- Different types of matrices
- Symmetric and antisymmetric matrices
- Hermitian matrix and its properties
- Inverse and transpose of matrices
- Solution of simultaneous linear equations
- Eigenvalues and eigenvectors
- Diagonalization of a matrix

Unit 2: Ordinary Differential Equations (9 Hours)

- Order and degree of a differential equation
- General form of first order differential equations
- Separation of variables
- Exact differential equations
- Inexact differential equations and integrating factors
- Linear differential equations
- Second order differential equations
- Homogeneous differential equations with constant coefficients
- Wronskian and general solution
- Complementary function
- Methods for finding particular integrals

Unit 3: Vector Calculus (10 Hours)

- Directional derivative and normal derivative
- Gradient of a scalar field and its geometrical interpretation
- Divergence of a vector field

- Curl of a vector field
- Laplacian operator
- Vector identities
- Ordinary integrals of vectors
- Line integrals of vector fields
- Surface integrals of vector fields
- Volume integrals of vector fields
- Gauss's divergence theorem
- Stokes' theorem

Unit 4: Orthogonal Curvilinear Coordinates (8 Hours)

- Definition of orthogonal curvilinear coordinates
- Examples of orthogonal curvilinear coordinate systems
- Transformation between curvilinear and Cartesian coordinate systems
- Expressions for infinitesimal line, surface and volume elements
- Gradient in curvilinear coordinate systems
- Divergence in curvilinear coordinate systems
- Curl in curvilinear coordinate systems
- Laplacian in curvilinear coordinate systems
- Spherical coordinate system
- Cylindrical coordinate system

Unit 5: Beta and Gamma Functions and Numerical Techniques (9 Hours)

- Beta and Gamma functions
- Relation between Beta and Gamma functions
- Expression of integrals in terms of Gamma functions
- Solution of algebraic and transcendental equations by bisection method
- Solution of equations by Newton-Raphson method
- Numerical integration using Simpson's rule
- Interpolation using Newton-Gregory forward difference formula
- Interpolation using Newton-Gregory backward difference formula

LEARNING OUTCOMES

- Understand the concepts of vector algebra and vector calculus
- Perform line, surface and volume integrations and apply relevant theorems
- Apply concepts of curvilinear coordinates to physical problems
- Understand special functions such as Beta and Gamma functions
- Apply basic numerical techniques to solve algebraic and transcendental equations

REFERENCES

- Mathematical Physics – H. K. Dass
- Mathematical Physics with Classical Mechanics – S. Prakash
- Mathematical Methods for Physicists – G. B. Arfken, H. J. Weber, F. E. Harris
- Differential Equations – George F. Simmons

