

  
**MANGALORE UNIVERSITY**  
**Department of Physics**  
**MSc Physics**

**I Semester**

**PHH 401: METHODS OF MATHEMATICAL PHYSICS I**

**[52 Hrs.]**

**Course outcome**

**CO1** The student gains a compressive knowledge on vector analysis and curvilinear coordinates.

**CO2** Have knowledge of matrix representation of operators, Hilbert space and diagonalization of matrices.

**CO3** Have understanding on complex variables.

**CO4** Have clear idea of partial differential in equations and boundary value problems in partial differential equations.

**CO5** Have knowledge of special function and their applications in physics.

[13 hrs]

**Unit I** **Vector analysis and curvilinear coordinates:** Integration of vector functions - line integrals, surface integrals and volume integrals - vector theorems without proof (Gauss, Green's and Stokes') and their applications in physics.

Generalized coordinates - elements of curvilinear coordinates - transformation of coordinates - orthogonal curvilinear coordinates - unit vectors - expression for arc length, volume element. The gradient, divergence and curl in orthogonal curvilinear coordinates. Laplacian in orthogonal curvilinear coordinates, spherical polar coordinates, cylindrical coordinates.

[13 hrs]

**Unit II** **Matrices and complex variables:** Matrix representation of linear operators, Hermitian and unitary operators, Hilbert space. Diagonalisation of matrices – simultaneous diagonalisation.

Complex variables and integral transforms: Review of functions of a complex variable – Cauchy Riemann conditions. Contour integrals. Cauchy integral theorem, Cauchy integral formula. Taylor and Laurent series. Zero isolated singular points, simple pole,  $m^{\text{th}}$  order pole. Evaluation of residues. The Cauchy's residue theorem. The Cauchy principle value. Evaluation of different forms of definite integrals. A digression on Jordan's lemma.

[13 hrs]

Unit III Partial differential equations: Review of system of surfaces and characteristics.  
First order partial differential equations for a function of two variables.

Linear second order partial differential equations. Classification into elliptic, parabolic and hyperbolic types.

Boundary value problems - solutions by method of separation of variables - solution of 1-, 2- and 3- dimensional wave equation and diffusion equation in Cartesian, plane, cylindrical and spherical polar coordinates.

[13 hrs]

Unit IV **Special functions:** Review of power series method for ordinary differential equations – description of beta and gamma functions.

Bessel functions – solution of Bessel's equation - generating function and recurrence relations – orthogonality of Bessel functions.

Legendre polynomials – solution of Legendre equation – generating function and recurrence relations – orthogonality property of Legendre polynomials.

Solution of Hermite equation – Hermite polynomials – generating functions and recurrence relations.

#### Text Books:

1. Arfken G, 'Mathematical Methods for Physicists' (Academic Press)
2. Harper C, 'Introduction to Mathematical Physics' (PHI, 1978)
3. Chattopadhyaya P K, 'Mathematical Physics' (Wiley Eastern, 1990)
4. Harry Lass, 'Vector and Tensor Analysis' (McGraw Hill, 1950)
5. Mary L Boas, 'Mathematical Methods in the Physical sciences' (John Wiley, 1983)
6. Joshi A W, 'Matrices and Tensors in Physics' (Wiley Eastern, 1995)
7. Ayres F, 'Differential Equations' (Schaum series, McGraw Hill)
8. Spiegel M R, 'Vector Analysis' (Schaum series, McGraw Hill, 1997)
9. Ayres F, 'Differential Equations' (Schaum series, McGraw Hill)
10. Sneddon I A, 'Elementary Partial Differential Equations' (McGraw Hill, 1957)

#### Reference Books:

1. Bose A K and Joshi M C, 'Methods of Mathematical Physics' (Tata McGraw Hill, 1984)
2. Sokolnikoff and Redheffer, 'Mathematics of Physics and Modern Engineering, (McGraw Hill, 1958)
3. Irving J and Mullneu N, 'Mathematics in Physics and Engineering' (Academic Press, 1959)
4. Kreysig E, 'Advanced Engineering Mathematics' (Wiley Eastern, 1969)
5. Mathews J and Walker R L, 'Mathematical Methods of Physics' (W A Benjamin, Inc, 1979)