

## Core I

## Semester I Mathematical Physics-I

### Course Outcomes

- Basic understanding of Differential equations and their solutions, conceptual understanding of calculus.
- Basic understanding of vector calculus and its differentiation.
- Use of vector calculus to understand vector integration. Dirac delta function and its properties.
- Understanding of orthogonal curvilinear coordinates and its application in vector differentiation.
- To understand the basic algorithm in application to functional algebra and error analysis.

### Unit I

- **Calculus -I:** Plotting of functions, Intuitive ideas of continuous, differentiable functions and plotting of curves, Approximation: Taylor and binomial series (statements only), First Order Differential Equations and Integrating Factor, Second Order Differential equations: Homogeneous Equations with constant coefficients, Wronskian and general solution, Statement of existence and Uniqueness Theorem for Initial Value Problems, Particular Integral.
- **Calculus-II:** Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor with simple illustration, Constrained Maximization using Lagrange Multipliers,

### Unit II

- **Vector algebra:** Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations, Vector product, Scalar triple product and their interpretation in terms of area and volume respectively, Scalar and Vector fields.
- **Vector Differentiation:** Directional derivatives and normal derivative, Gradient of a scalar field and its geometrical interpretation, Divergence and curl of a vector field, Del and Laplacian operators, Vector identities.

### Unit III

- **Vector Integration:** Ordinary Integrals of Vectors, Multiple integrals, Jacobian, Notion of infinitesimal line, surface and volume elements, Line, surface and volume integrals of Vector fields, Flux of a vector field, Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs)
- **Dirac Delta function and its properties:** Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function, Properties of Dirac delta function

### Unit IV

**Orthogonal Curvilinear Coordinates:** Orthogonal Curvilinear Coordinates, Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems, Comparison of velocity and acceleration in cylindrical and spherical coordinate system.

#### Text Books:

- ✓ *Mathematical Methods for Physicists, G.B.Arffen, H.J.Weber, F.E.Harris (2013, 7th Edn., Elsevier)*
- ✓ *Advanced Engineering Mathematics, Erwin Kreyszig (Wiley India)*

#### Reference books:

- ✓ *Mathematical Physics C. Harper (Prentice Hall India)*
- ✓ *Complex Variable: Schaum's Outlines Series M. Spiegel (2nd Edition, Mc- Graw Hill Education)*
- ✓ *Complex variables and applications, J. W. Brown and R.V. Churchill*
- ✓ *Mathematical Physics, Satya Prakash (SultanChand)*
- ✓ *Mathematical Physics, B. D. Gupta (4th edition, Vikas Publication)*
- ✓ *Mathematical Physics and Special Relativity, M. Das, P.K. Jena and B.K.Dash (Srikrishna Prakashan)*
- ✓ *Mathematical Physics –H.K.Das, Dr. Rama Verma (S. ChandPublishing)*
- ✓ *Mathematical Physics, B.S. Rajput, (Pragati Prakashana)*

### **LAB: Credit-1**

The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- Highlights the use of computational methods to solve physical problems
- Evaluation done not on the programming but on the basis of formulating the problem
- Aim at teaching students to construct the computational problem to be solved
- Students can use any one operating system Linux or Microsoft Windows

**Introduction and Overview:** Computer architecture and organization, memory and Input/output devices. Basics of scientific computing: Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods. Algorithm Errors and error Analysis: Truncation and round off errors, Absolute and relative errors, Floating point computations. Systematic and Random Errors, Propagation of Errors, Normal Law of Errors, Standard and Probable Error.

**Review of C and C++ Programming:** Introduction to Programming, constants, Variables and Fundamentals data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If Statement, Ifelse Statement, Nested If structure, ElseIf Statement, Ternary operator, Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D and 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects.

**Programs:** Sum and average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search.

**Random number generation:** Area of circle, area of square, volume of sphere, value of  $\tau$ .

### **Reference Books:**

- ✓ Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
- ✓ Schaum's Outline of Programming with C++. J. Hubbard, 2000, Mc Graw-Hill Pub.
- ✓ Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et al, 3rd Edn. 2007, Cambridge University Press.
- ✓ A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning.
- ✓ Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn. , 2007 , Wiley India Edition.
- ✓ Numerical Methods for Scientists and Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- ✓ An Introduction to computational Physics, T. Pang, 2nd Edn., 2006, Cambridge Univ. Press.