Course: Core Paper I - HPHCR1012T, HPHCR1012P

Semester	I
Paper Number	HPHCR1012T, HPHCR1012P
Paper Title	Mathematical Physics I
No. of Credits	06 (Theory – 4, Lab – 2)
Theory/Composite	Composite
No. of periods assigned	Th: 4 periods/week Pr: 3 periods/week
Name of Faculty member(s)	
Course description/objective	This course covers essential elements of mathematical analysis as required by physics students for handling scalar and vector fields as well as probability theory. It is a composite course with theory and computer lab modules. The computer labs help the students to visualize the mathematics and pickup programming skills necessary for physics.
Syllabus	As enclosed
Texts	As enclosed
Reading/Reference Lists	As enclosed
Evaluation	Total – 100 (Theory – 60, Practical – 40) Theory – CIA – 10 Semester Examination – 50 Group A (25 marks) Group B (25 marks) One 10 marks qs out of two qs One 10 mark qs out of two qs Three 5 mark qs out of five qs Three 5 mark qs out of five qs

Syllabus :

HPHCR1012T - MATHEMATICAL PHYSICS - I (Credits – Theory -4; Practicals - 2)

Module A [26 lectures]

Calculus

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only). [2]

First Order and Second Order Differential equations: general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral. [8]

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. [7]

Introduction to Probability

Independent random variables**:** Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance.

Dependent events: Conditional Probability. Bayes' Theorem and its applications. [7]

Dirac delta function & its properties

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. [2]

Module B [26 lectures]

Vector Calculus

Recapitulation of vectors: Properties of vectors under rotations and reflections; True and Pseudo vectors/ scalars. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Suffix notation. Scalar and Vector fields. [4]

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. [8]

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). [10]

Orthogonal Curvilinear Coordinates

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. [4]

References

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
3. Mathematical Physics, Goswami, 1st edition, Cengage Learning
4. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
5. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press
6. Mathematical methods in the Physical Sciences, M. L. Boas, 2005, Wiley.

HPHCR1012P – Mathematical Physics Lab – (Credits – 2) (39 periods)

1.Introduction and Overview

Computer architecture and organization, memory and Input/output devices

2.Basics of scientific computing

Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods

3.Errors and error Analysis

Truncation and round off errors, Absolute and relative errors, Floating point computations.

4.Introduction to plotting graphs with Gnuplot

Basic 2D and 3D graph plotting - plotting functions and data files, fitting data using gnuplot's fit function, polar and parametric plots, modifying the appearance of graphs, Surface and contour plots, exporting plots.

5.Introduction to programming in python:

Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object oriented programming.

6.Programs

Sum & 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

7.Random number generation

Area of circle, area of square, volume of sphere, value of pi (π)

8.Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods

Solution of linear and quadratic equation, solving $\alpha = \tan\alpha$.

Reference Books

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
2. Learning with Python-how to think like a computer scientist, J. Elkner, C. Meyer, and A. Downey, 2015, Dreamtech Press.
3. Introduction to computation and programming using Python, J. Guttag, 2013, Prentice Hall India.
4. Effective Computation in Physics- Field guide to research with Python, A. Scopatz and K.D. Huff, 2015, O'Rielly
5. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
6. Elementary Numerical Analysis, K.E. Atkinson, 3 rd. Edn . , 2007, Wiley India Edition.
7. Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
8. An Introduction to computational Physics, T.Pang, 2nd Edn., 2006,Cambridge Univ. Press
9. Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.
10. Learning Scientific Programming with Python, Christian Hill, 2015, Cambridge University Press