SEMESTER-VII

PHYDSC401T

Mathematical Physics - III

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The emphasis of this course is on applications in on mathematical methods essential for solving the advanced problems in physics. It would be helpful in the development of the ability to apply the mathematical concepts and techniques to solve the problems in theoretical and experimental physics. The knowledge of this course on mathematical physics would be beneficial in further research and development as it serves as a tool in almost every branch of science and engineering Course.*

Unit 1: Linear Vector Space, Matrices and Tensors

Vectors in n-dimension, Linear independence, Basis and Dimension, Scalar product, Norm and Orthogonality, Schwarz inequality, Gram-Schmidt orthogonalization technique. Linear operators and their Matrix representation, Eigenvalues and Eigenvectors of a matrix, Cayley-Hamilton theorem, Orthogonal, Unitary and Hermitian matrices. Infinite dimensional space, Hilbert space.

Definition of Tensor, Covariant and Contravariant tensor, Fundamental operation with tensors, Metric tensor, Covariant differentiation and Christoffel symbols. **(12 Lectures)**

Unit 2: Differential Equations & Special functions

Second order linear differential equations, Series solution, Ordinary and Singular points. Partial differential equations: Classification. Boundary value problems. Concept of well posedness. Green's function technique for solution of Differential equations. Legendre, Hermite, Laguerre and Bessel Functions. **(12 Lectures)**

Unit 3: Complex Variables and Integral Transforms

Analytic functions, Cauchy-Riemann conditions, Cauchy integral theorem for simply and multiply connected regions, Cauchy integral formula, Taylor and Laurent series, Poles, Residue theorem, Evaluation of integrals.

Fourier transforms and its applications, convolution theorem, Parseval's relation, Laplace transforms, Laplace transform of derivatives, Inverse Laplace transform and Convolution theorem, use of Laplace's transform in solving differential equations. **(12 Lectures)**

Unit 4: Theory of Probability and Statistics and Numerical methods

Random Variables, Binomial, Poisson and Normal Distributions. Central Limit Theorem, Law of Large numbers. Hypothesis Testing. Finite difference, Interpolation and extrapolation (forward, backward and central), Roots of functions, Integration by trapezoidal and Simpson's rule, Solution of 1st order differential equation using Euler and 2^{nd} order Runge-Kutta method. **(12 Lectures)**

Unit 5: Group Theory

Abstract groups: subgroups, classes, cosets, factor groups, normal subgroups, direct product of groups; Homomorphism & Isomorphism. Representations: reducible and irreducible, unitary representations, Schur's lemma and orthogonality theorems, characters of representation, direct product of representations. Introduction to continuous groups: Lie groups, rotation and unitary groups. Representation of SO(3), SU(2). **(12 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to learn the basics of linear vector spaces, group theory, tensors and their applications in various physical problems. Moreover, the students are expected to gain the knowledge of various mathematical tools like complex analysis, integral transform which will equip the students with skills to solving a given ODE, PDE.*

Reference Books:

i. Murry R Spiegel, Vector Analysis McGraw Hill.
ii. Murry R Spiegel, Complex variables McGraw Hill.
iii. A W Joshi, Elements of Group Theory for Physicists New Age International.
iv. A W Joshi, Matrices and tensors in physics New Age International.
v. I Snedden, Elements of partial differential equations McGraw Hill.
vi. G B Arfken, Mathematical Methods for Physicists Academic Press.
vii. Corte S.D. and de Boor, Elementary Numerical analysis, 3rd Ed, McGraw Hill, 1980.
viii. James B. Scarborough, Numerical Mathematical Analysis, Oxford.
ix. F.B. Hildebrand, Introduction to Numerical Analysis, McGraw Hill, 1956.
x. L.A. Pipes and L.R. Harwill, Applied Mathematics for Physicists and Engineers, McGraw Hill.

PHYDSC402T

CLASSICAL MECHANICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The objective of this course is to build the concepts of classical mechanics with problems involving central force motion, small oscillations, rigid body dynamics and methods of formulations of Lagrangian and Hamiltonian and their applications.*

Unit 1:

Mechanics of a system of particles: Centre of mass, conservation of linear and angular momentum, energy conservation. Two-body central force problem: reduction to one body problem, equations of motion, classification of orbits, differential equation of the orbit, Kepler's laws. **(12 Lectures)**