BACHELOR WITH PHYSICS AS MAJOR

4^{th} SEMESTER

PHY422J2: MATHEMATICAL PHYSICS-I **CREDITS: THEORY – 4, Lab.Course: 2**

THEORY (4 CREDITS: 60 HOURS) **MAXIMUM MARKS: 100, MINIMUM MARKS: 36**

Learning Outcomes

This course equips students with a strong foundation in mathematical methods and statistical tools necessary for solving complex problems in physics, engineering, and other scientific disciplines. Students will develop the skills to analyze and model physical phenomena, perform advanced calculations, and make informed decisions based on data and statistical analysis.

2. Students will demonstrate a comprehensive understanding of various coordinate systems.
3. Students will develop proficiency in performing double and triple integrals, enabling them to solve complex problems involving multiple variables and multidimensional spaces.
4. Students will review fundamental concepts in vector analysis which are essential for describing physical phenomena in three dimensions.
5. Students will understand and apply integral theorems, such as Gauss's theorem and Stokes' theorem.
6. Students will study vectors in function spaces, learn techniques for Gram-Schmidt orthogonalization.
7. Students will learn to solve eigenvalue equations and matrix eigenvalue problems, including Hermitian eigenvalue problems and dealing with degeneracy.
8. Students will understand the concept of diagonalization, perform spectral decomposition, and work with positive definite and singular operators.
9. Students will grasp the fundamental definitions and properties of probability.
10. Students will be able to work with discrete and continuous probability distribution.
11. Students will become familiar with statistical distributions such as the chi-squared distribution and t-distribution, and apply them in hypothesis testing and confidence interval estimation.

Unit-I (15 Hours)

Review of coordinate systems. Double and Triple integrals. Jacobian of a coordinate transformation. Dirac Delta Functions, propertiesand representations. Vector Analysis: Review of Basic Properties, Vectors in 3D space, Coordinate Transformations. Rotations in R3.

Unit II

Unit-I (15 Hours)

Vector Integration. Integral Theorems. Potential theory. Curvilinear Coordinates. Vector Spaces: Vectors in Function Space, Gram-Schmidth Orthogonalization, Operators, Self-Adjoint Operators, Unitary operators. Transformations of operators, invariants.

Unit III

Unit-I (15 Hours)

Eigenvalue Problems: Eigenvalue equations, Matrix eigen value problems,Hermitian eigen value problems, Degeneracy, Diagonalization, Spectral Decomposition, Positive Definite and Singular operators. Normal and non-normal Matrices, Defective matrices.

Unit IV (15 Hours)

Probability: Definitions and Simple properties. Random Variables (continuous and discrete), mean, variance, moments , covariance, correlation. Marginal and conditional Probability distribution. Binomial and Poisson Distribution. Gauss normal Distribution. Limitations. Transformation of Random Variables. Error Propagation. Curve fitting. Chi squared and t-distribution. Confidence intervals.

Practical/Lab Course (2 Credit)

Lab Course : Elementary programming in FORTRAN (1 -credit)

Learning outcomes:

The Lab. course equips students with the essential skills to begin programming in FORTRAN, particularly in the context of scientific and numerical computing, and prepares them to approach computational challenges in various disciplines. It may include fundamental programming concepts such as variables, data types, operators, and basic control structures (conditionals and loops), Syntax and structure of the FORTRAN programming language. Write and implement simple algorithms and computational routines using FORTRAN, translating mathematical and scientific concepts into code. Identifying and rectifying common programming errors.

Practical: (1 - credit)

1. Roots of a quadratic equation using FORTRAN.
2. Matrix addition and multiplication using FORTRAN.
3. Eigenvalues of square matrix using FORTRAN
4. To plot a graph of some functions (x^n, sinx, cosx) using FORTRAN
5. Numerically Integrate of a simple function using FORTRAN .

Text Books:

1. Advanced Engineering Mathematics by Erwin Kreyszig
2. Mathematical Physics by H.K. Dass
3. Linear Algebra Done Right by Sheldon Axler
4. Numerical Recipes in FORTRAN.
5. Computer Programming in FORTRAN 90 and 95 by Rajaraman
6. Probability and Statistics for Engineers and Scientists" by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, and Keying Ye.

HoD