MAJOR COURSE- MJ 2	Mathematical Physics-I	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

The objective of this course is to equip students with the mathematical tools essential for solving physical problems. The course introduces fundamental concepts of calculus, differential equations, vector calculus, and special functions, which are widely applied in various branches of physics. Emphasis is placed on the physical interpretation of mathematical operations and their applications in real-world problems. By the end of the course, students will develop problem-solving skills necessary for advanced topics in theoretical and applied physics.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Apply calculus techniques** such as Taylor and binomial series expansions to approximate functions and solve problems in mathematical physics.
2. **Solve first and second-order differential equations**, including homogeneous equations with constant coefficients, and understand the significance of the Wronskian in determining the independence of solutions.
3. **Understand the fundamentals of vector calculus**, including vector algebra, triple products, and their physical interpretations in different coordinate systems.
4. **Compute derivatives of scalar and vector fields**, including directional and normal derivatives, and apply operators such as gradient, divergence, curl, and Laplacian with physical significance.
5. **Evaluate vector integrals** using multiple integration techniques, and apply Gauss' divergence theorem, Green's theorem, and Stokes' theorem to solve physics problems.
6. **Understand and derive vector differential operators** in orthogonal curvilinear coordinates, including Cartesian, spherical, and cylindrical systems.
7. **Grasp the concept of the Dirac delta function**, its representations, and its properties, and apply it in solving integral problems.
8. **Evaluate special integrals** involving Beta and Gamma functions, understand their interrelation, and use them in mathematical physics applications.
9. **Apply the error function** in statistical and probability distributions relevant to physics.

Course Contents:

Calculus (06 HRS): Functions and their graphical representation. Taylor and binomial series expansion. First-order differential equations and their solutions. Partial derivatives and applications. Exact and inexact differentials, integrating factor.

Second Order Differential equations (06 HRS): Homogeneous equations with constant coefficients, Wronskian and its significance, general solutions. Statement of existence and uniqueness theorem for initial value problems, Particular integrals.

Vector Calculus (05 HRS): Recapitulation of vector algebra, properties under rotations. Scalar and vector triple products with physical interpretation. Scalar and vector fields. **Vector Differentiation (05 HRS):** Directional derivative, normal derivative. Gradient, divergence, curl, and Laplacian with physical significance. Vector identities and their proofs.

Vector Integration (08 HRS): Ordinary Integrals of Vectors. Multiple integrals, Jacobian, Line, surface, and volume integrals, Gauss' divergence theorem, Green's theorem, and Stokes' theorem with applications in physics.

Orthogonal Curvilinear Coordinates (05 HRS): Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Dirac Delta function and its properties (05 HRS): Definition, Representation as limit of a Gaussian function and rectangular function, Properties of Dirac delta function.

Some Special Integrals (05 HRS): Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function.

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E. A. Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Mathematical methods for Scientists and Engineers, D. A. McQuarrie, 2003, VivaBook
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
8. Essential Mathematical Methods, K. F. Riley &M. P. Hobson, 2011, Cambridge Univ. Press
9. Mathematical Physics, H. K. Dass, S Chand
10. Mathematical Physics, B.S. Rajput, Pragati Prakashan Meerut

MAJOR COURSE- MJ 2	Mathematical Physics-I	(Practical Credit-01) (Total Marks=25)

1. Programming Language (C/C++/Python/Scilab) :
   Basic Syntax: Variables, data types, operators, Control Structures: if-else, loops (for, while), Functions, Arrays/Lists, Input/Output, Data Structures, String Manipulation, File Input/Output: Writing to a file in Python (open(), write()), C (fopen(), fprintf(), fclose()), Scilab (write()), Error Handling, Basic Algorithms: Linear search, Binary search, Bubble sort, Insertion sort, Quick sort.
2. Plotting/Visualization: Gnuplot/Python/Scilab
3. Programs:

I. Roots of a Quadratic Equation,
II. Sum and Average of Numbers,
III. Sum, Difference and Product of Matrices,
IV. Largest of Three Numbers,
V. Factorial of an Integer by Normal Method and by Recursion,
VI. Largest of a List of Numbers and its Location in the List,
VII. Fitting a Straight Line to a Data,
VIII. Deviations About an Average,
IX. Arrange a List of Numbers in Ascending and Descending Order,
X. Binary Search.
XI. Implement a function that approximates $f(x)=e^x$ using a Taylor series expansion around x=0. Write a program to compute and plot the approximation for different numbers of terms and compare it with the exact function.
XII. Write a program to visualize the divergence and curl of a vector field $\vec{F}(x,y) = (y,-x)$ in 2D.
XIII. Write a program to compute the Gamma and Beta functions for various inputs using their integral definitions. Compare the results with the known analytical expressions and visualize these functions.

Reference Books:

1. The C Programming language, Brian W.Kernigham and Dennis M.Ritchie
2. Programming in ANSI C, E Balagurusamy
3. Let Us C, Yashavant Kanetkar
4. Python in a Nutshell, Alex Martelli
5. Core Python Programming, Wesley J. Chun
6. Scilab, from theory to practice, Perrine Mathieu and Philippe Roux, 2016
7. Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
8. Scilab (A free software to Matlab): H. Ramchandran, A. S. Nair. 2011 S. Chand & Company.
9. Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
10. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
11. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw Hill Pub.
12. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn., 2007, Cambridge University Press.
13. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.

14. Elementary Numerical Analysis, K.E. Atkinson, 3 r d Edn., 2007, Wiley India Edition.
15. Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
16. An Introduction to computational Physics, T. Pang, 2nd Edn. , 2006,Cambridge Univ.

MAJOR COURSE- MJ 3	Electricity and Magnetism-I	(Theory Credit -03) (Total Marks=60+15)

Course Objective:

This course aims to develop a strong conceptual foundation in electricity and magnetism by introducing fundamental circuit elements, DC and AC circuits, network theorems, and measurement techniques. Emphasis is placed on analytical problem-solving, practical applications, and understanding the behavior of electrical circuits using mathematical techniques. The course also covers AC bridges and ballistic galvanometers, which are essential for precise electrical measurements.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. **Understand basic circuit elements** and apply Kirchhoff's Voltage Law (KVL) and Kirchhoff's Current Law (KCL) to analyze resistive networks using mesh and nodal methods.
2. **Analyze DC circuits**, including the growth and decay of current in CR, LR, and series LCR circuits.
3. **Solve AC circuit problems** by applying Kirchhoff's laws, calculating complex reactance and impedance, and analyzing series and parallel LCR circuits for resonance, power dissipation, quality factor, and bandwidth.
4. **Understand the working principles of a ballistic galvanometer**, including torque on a current loop, charge sensitivity, and logarithmic damping.
5. **Apply AC bridge techniques**, such as Anderson's, De Sauty's, Owen's, Schering's, and Carey-Foster's bridges, to measure electrical parameters accurately.
6. **Utilize network theorems**, including Thevenin's, Norton's, Superposition, Reciprocity, Maximum Power Transfer, Miller's, Wye-Delta transformation, and Tellegen's theorem, for circuit analysis and simplification.
7. **Analyze two-port networks** using T and π representations and understand parameter representations such as H, Y, Z, and ABCD matrices.

Course Contents:

Introduction (09 HRS): Review of ideal circuit elements, Kirchhoff's Voltage Law (KVL), Kirchhoff's Current Law (KCL), resistive networks, mesh and nodal analysis, delta and star connections.

DC circuits (06 HRS): growth and decay of current in CR, LR and Series LCR circuit.

AC Circuits (07 HRS): Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width, Parallel LCR Circuit.

Ballistic Galvanometer (04 HRS): Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Logarithmic damping.

AC bridges (06 HRS): Anderson's, De Sauty's, Owen's, Schering and Carey-Foster's bridges with their vector diagrams.

Network theorems (12 HRS): Ideal Constant-voltage and Constant-current Sources, 2-port networks and its T and π representations, T and π equivalence, H, Y, Z and ABCD- parameters representations, Thevenin, Norton, Superposition, Reciprocity and Maximum power transfer theorems, Miller theorem, Wye-delta transformation, Tellegens theorem.

Reference Books

1. Hayt and Kermerley: ENGINEERING CIRCUIT ANALYSIS
2. Chua, Desoer, Kuh: LINEAR AND NON-LINEAR CIRCUITS.
3. Van Valkenburg: NETWORK ANALYSIS
4. Van Valkenburg: INTRODUCTORY NETWORK SYNTHESIS
5. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
6. A Text Book in Electrical Technology, B. L. Theraja.
7. Electricity and Magnetism, K. K. Tewari
8. Electricity and Magnetism, Rakshit and Chottopadhay

MAJOR COURSE- MJ 3	Electricity and Magnetism-I	(Practical Credit -01) (Total Marks=25)

1. To verify the Thevenin and Norton theorems.
2. To verify the Superposition and Maximum power transfer theorems.
3. To determine self-inductance of a coil by Anderson’s bridge.
4. To determine an unknown Low Resistance using Potentiometer.
5. To compare capacitances using De’Sauty’s bridge.
6. Determination of constants of a ballistic galvanometer.
7. Determination of figure of merit of a moving coil galvanometer.
8. To study a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor.
9. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
10. To study the Characteristics of a Series RC Circuit.

Reference Books

1. Advanced practical Physics for students, B. L. Flint & H. T. Worsnop, 1971, Asia Publishing House.
2. Engineering practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. A Text Book of practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4. Practical Physics, J. P. Agarwal