Subject: Physics
Semester: Two
Course Name: Mathematical Physics & Electricity and Magnetism
Existing Base Syllabus: HS Maths and Physics
Course Level: PHY151
Syllabus showing each unit against class number and marks

Unit no.	Unit content	No. of classes	Marks/Credit
Theory			
Part A: Mathematical Physics (Theory)			
Unit 1- Differential equations	First and second order ordinary differential equations (ODE). Homogeneous and inhomogeneous differential equations. Solutions of first order ODE – integrating factors (physical examples – radioactive decay, Newton's law of cooling, particle falling under gravity through a resistive medium). Concept of initial/boundary conditions. Solutions of second order ODE with constant coefficients - complementary function and particular integral (physical examples- simple harmonic oscillation, forced vibration). Wronskian- definition and its use to check linear independence of 2nd order homogeneous linear differential equation. Partial differential equations (PDE) (physical examples – wave equation, diffusion equation, Laplace and Poisson equation – introduction only). Exact and inexact differentials. Concept of variable separation in a PDE.	10	Credit - 1
Unit– II: Matrices	Properties of matrices. Determinant and rank. Transpose and complex conjugate of matrices. Hermitian and anti-Hermitian matrices. Unitary and orthogonal matrices. Representation of linear homogeneous and inhomogeneous equations through matrix equation. Inverse of a matrix. Eigen values and eigen-vectors. Cayley-Hamilton Theorem (statement only), Diagonalization of simple matrices.	5	
Part B – Electricity and Magnetism (Theory)			
Unit I: Electric field	Electrostatic field, electric flux. Gauss's law. Application of Gauss's law to charge distributions with planar, spherical and	13	Credit - 2

and electric potential	cylindrical symmetries. Conservative nature of electrostatic field. Electrostatic potential. Electrostatic energy of a system of charges. Electrostatic boundary conditions. Laplace's and Poisson's equations. Uniqueness theorem. Application of Laplace's equation involving planar, spherical and cylindrical symmetries. Potential and electric field of a dipole. Force and torque on a dipole. Capacitance of a system of charged conductors. Parallel plate capacitor. Capacitance on an isolated conductor.		
Unit –II: Dielectric properties of matter	Electric field in matter. Polarisation, polarisation charges. Electrical susceptibility and dielectric constant. Capacitor (parallel plate, spherical and cylindrical) filled with dielectric. Displacement vector, $\vec{D}$. Relation between $\vec{E}$, $\vec{P}$ and $\vec{D}$. Gauss's law in dielectrics.	4	
Unit –III: Magnetic field	Magnetic force on a point charge, definition and properties of magnetic field $\vec{B}$. Curl and divergence. Vector potential, $\vec{A}$. Magnetic scaler potential. Magnetic force on (i) a current carrying wire and (ii) between two elements. Torque on a current loop in a uniform magnetic field. Biot-Savart's law and its simple application: straight wire and circular loop. Current loop as a magnetic dipole and its dipole moment (analogy with electric dipole). Ampere's circuital law and its application to (i) solenoid and (ii) torus.	6	
Unit–IV: Magnetic properties of matter	Magnetization vector, $\vec{M}$. Magnetic intensity, $\vec{H}$. Magnetic susceptibility and permeability. Relation between $\vec{B}$, $\vec{H}$ and $\vec{M}$. Ferromagnetism. B-H curve and hysteresis.	2	
Unit–V: Electrical circuits	AC circuits: Kirchhoff's laws for AC circuits. Complex reactance and inductance. Series LCR circuits and parallel LCR circuits: (i) phasor diagram, (ii) resonance, (iii) power dissipation, (iv) quality factor, and (v) band width. Ideal constant-voltage and constant-current sources. Thevenin theorem and Norton theorem (only statements and solving of related problems).	5	
Laboratory			
	<u>At least four from the following:</u>		Credit-1

	1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses. 2. To study the characteristics of a series RC circuit. 3. To determine an unknown Low Resistance using Potentiometer. 4. To determine an unknown Low Resistance using Carey Foster's Bridge. 5. To compare capacitances using De' Sauty's bridge. 6. Measurement of field strength $\vec{B}$ and its variation in a solenoid (determine $\frac{dB}{dx}$). 7. To verify the Thevenin and Norton Theorems. 8. To verify the superposition and maximum power transfer theorems. 9. To determine the self-inductance of a coil by Anderson's bridge. 10. To study the response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width. 11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q. 12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer. 13. Determine a high resistance by leakage method using Ballistic Galvanometer. 14. To determine the self-inductance of a coil by Rayleigh's method.		

	15. To determine the mutual inductance of two coils by the Absolute method.		

Reading list

[1] Essential Mathematical Methods for the Physical Sciences; K. F. Riley and M. P. Hobson, Cambridge University Press.
[2] Advanced Engineering Mathematics; E. Kreyszic, John Wiley & Sons (New York)
[3] Mathematical Methods for Physicists; G. B. Arfken, H. J. Weber and F.E. Harris, Elsevier
[4] Mathematical Physics, H. K. Dass and Dr. Rama Verma, S. Chand Publication.
[5] Mathematical Physics-I; Krishna K. Pathak and Sangeeta Prasher, Vishal Publishing Co, Jalalandhar (Delhi).
[6] Introduction to Electrodynamics, D. J. Griffiths.
[7] Electricity and Magnetism [With electromagnetic theory and special theory of relativity], D. Chattopadhyay and P. C. Rakshit, 2013, New Central Book Agency (P) Limited.
[8] Electricity, Magnetism and Electromagnetic Theory, S. Mahajan and S. R. Choudhury, 2012, Tata Mcgraw.
[9] Schaum's outline of Theory and Problems of Electromagnetics, J. A. Edminister.
[10] Electromagnetics, B. B. Laud, New Age International Publishers.
[11] Feynman Lectures Vol. 2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
[12] Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
[13] Elements of Electromagnetics, M. N. O. Sadiku, 2008. Pearson Education.
[14] Electricity and Magnetism, J. W. Fewkes and J. Yarwood, Vol. I, 1991, Oxford Univ. Press.

Graduate Attributes

i. Course Objective

- *To introduce the methods of solving differential equations.*
- *To introduce various concepts of matrix algebra.*
- *Electric field from vector calculus point of view and use of potential formulation to solve electrostatic problems.*
- *Magnetic fields of current carrying conductors, torus, solenoids etc. Study magnetic properties of matter.*
- *Study and analysis of AC circuits like LCR, and use of network theorems in electrical circuits.*