Department of Physics

Syllabi and Class Distribution of Even Semester Courses, 2023-24

	HB	NKD	PB
4th Sem PHY-HC-4016 Mathematical Physics III	All Units & Laboratory		
4th Sem PHY-HC-4026 Elements of Modern Physics		All Units & Laboratory	
4th Sem PHY-HC-4036 Analog Systems & Applications			All Units & Laboratory
4th Sem PHY-HG-4016 Waves and Optics	Units I, II, III, IV, V, X & Laboratory		Units VI, VII, VIII, IX & Laboratory
4th Sem PHY-SE-4064 Radiation Safety		All Units & Laboratory	
2nd Sem PHY-HC-4016 Mathematical Physics & Electricity and Magnetism	Units A-I, A-II & Laboratory	Units B-I, B-IV & Laboratory	Units B-II, B-III, B-V & Laboratory

PHY-HC-4016
Mathematical Physics III
Total Lectures: 60 Credits: 6 (Theory: 04, Lab:02)

Course Outcome: On successful completion of the course students will able to solve complex integrals using residue theorem, apply Fourier and Laplace transforms in solving differential equations, understand properties of Tensor like Transformation of coordinates, contravariant and co-variant tensors, indices rules for combining tensors.

Theory

Unit I: Complex Analysis (Lectures 10)

Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity.

Unit II: Complex Integration (Lectures 10)

Integration of a function of a complex variable. Cauchys Integral formula. Simply and multiply connected region. Laurent and Taylors expansion. Residues and Residue Theorem with numerical application.

Unit III: Fourier Transforms (Lectures 15)

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier trans- form of trigonometric, Gaussian functions Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem (Statement only). Properties of Fourier transforms (translation, change of scale, complex conjugation).

Unit IV: Laplace Transforms (Lectures 15)

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem (Statement only). Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator.

Unit V: Tensor Algebra (Lectures 10)

Introduction to tensor, Transformation of co-ordinates, Einsteins summation convention. contravariant and co- variant tensor, tensorial character of physical quantities, symmetric and antisymmetric tensors, kronecker delta, Levi-Civita tensor. Quotient law of tensors, Raising and lowering of indices Rules for combination of tensors- addition, subtraction, outer multiplication, contraction and inner multiplications.

Reference Books

[1] Mathematical Methods for Physicists, G. B. Arfken, H. J. Weber, and F. E.. Harris, 2013, 7th Edn., Elsevier.

[2] An introduction to ordinary differential equations, E. A. Coddington, 2009, PHI

[3] Learning 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, Viva Book

[6] Advanced Engineering Mathematics, D. G. Zill and W. S. Wright, 5 Ed., 2012, Jones and Bartlett Learning

[7] Mathematical Physics, Goswami, 1st edition, Cengage Learning

[8] Engineering Mathematics, S. Pal and S. C. Bhunia, 2015, Oxford University Press

[9] Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India

[10] Essential Mathematical Methods, K. F. Riley and M. P. Hobson, 2011, Cambridge University Press

Lab

1. Solve differential equations

   $\frac{dy}{dx} = e^x$ with $y = 0$ for $x = 0$

   $\frac{dy}{dx} + e^{-x}y = x^2$

   $\frac{d^2y}{dt^2} + 2\frac{dy}{dt} = -y$

   $\frac{d^2y}{dt^2} + e^{-t}\frac{dy}{dt} = -y$

2. Dirac Delta Function

   Evaluate the integral I

   $I = \frac{1}{\sqrt{2\pi\sigma^2}} \int exp\left[-\frac{(x-2)^2}{2\sigma^2}\right](x+3)dx$ for $\sigma = 1.0, 0.1, 0.01$ and show the $I \to 5$

3. Fourier Series

   Make a program to evaluate

   $$\sum_{n=1}^{\infty}(0.2)^n$$

   Evaluate the Fourier coefficients of a given periodic function (square wave)

4. Frobenius method and Special Functions

   Evaluate

   $$\int_{-1}^{1} P_n(x)\, P_m(x) dx = \delta_{n,m}$$

   Plot $P_n(x)$, $j_\vartheta(x)$ and show the recursion relation.

5. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two)

6. Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.

7. Evaluation of trigonometric functions e.g. $sin\theta$, ,given Bessel'sfunctionat N points find its value at an intermediate point.

8. Integrate

   $$\frac{1}{(x^2+2)}$$

   Numerically in a given interval.

9. Compute the nth roots of unity for n=2, 3, and 4.

10. Find the two square roots of 5+12j.

11. Integral transform

    Evaluate FFT of e^{-x^2}

12. Solve Kirchoff's Current law for any node of an arbitrary circuit using Laplace's transform.

PHY-HC-4026
Elements of Modern Physics
Total Lectures: 60 Credits: 6 (Theory: 04, Lab: 02)

Course Outcome: *On completion of the course students will be able to understand modern development in Physics, Starting from Planck's law, it development of the idea of probability interpretation and the formulation of Schrodinger equation. Students will also get preliminary idea of structure of nucleus, radioactivity Fission and Fusion and Laser*

Theory

Unit I: Quantum Theory and Blackbody Radiation (Lecture 12)

Quantum theory of light; photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. group and phase velocities and relation between them. Two-slit experiment with electrons. Probability. wave amplitude and wave functions.

Unit II: Uncertainty and Wave-Particle Duality (Lecture 05)

Position measurement : gamma ray microscope thought experiment; wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from wave packets, impossibility of a particle following a trajectory; estimating minimum energy of a confined particle using uncertainty principle; energy-time uncertainty principle- application to virtual particles and range of an interaction.

Unit III: Schrödinger Equation (Lecture 8)

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrödinger equation for non- relativistic particles; expectation value, momentum and energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; probability and probability current densities in one dimension.

Unit IV: One-dimensional Box and Step Barrier (Lecture 9)

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; quantum dot as example; quantum mechanical scattering and tunnelling in one dimension-across a step potential and rectangular potential barrier.

Unit V: Structure of the Atomic Nucleus (Lecture 06)

Size and structure of atomic nucleus and its relation with atomic weight; impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Atomic Mass Unit. Nature of nuclear force, $N - Z$ graph, liquid drop model: semi-empirical mass formula and binding energy, nuclear shell model (qualitative discussions) and magic numbers.

Unit VI: Radioactivity (Lecture 08)

Stability curve and stability of nuclei, Law of radioactive decay, disintegration constant, half life and mean life. Activity unit. Alpha decay – Range energy relation, Fine structure of alpha energy spectrum. Beta decay energy released, continuous beta spectrum and Pauli's prediction of neutrino. Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

Unit VII : Detection of nuclear radiation (Lecture 04)

Method of energy loss by charged particles and gamma photons. Photoelectric, Compton and Pair-production processes Gas filled detectors – principle and construction of a gas filled detector, Ionization, proportional, GM and spark region.

Unit VIII: Fission and Fusion (Lecture 04)

Energy consideration in Nuclear Reaction, Q-value of nuclear reaction, Mass deficit, Einstein's mass-energy equivalence principle and generation of nuclear energy. Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235. Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

Unit IX: Lasers (Lecture 04)

Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. Basic lasing.

Reference Books

[1] Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.

[2] Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill

[3] Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.

[4] Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.

[5] Modern Physics, G. Kaur and G. R. Pickrell, 2014, McGraw Hill

[6] Quantum Mechanics: Theory & Applications, A. K. Ghatak & S. Lokanathan, 2004, Macmillan

Lab

A minimum of six experiments to be done.

1. Measurement of Planck's constant using black body radiation and photo-detector.
2. Photo-electric effect
   Photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light.
3. To determine work function of material of filament of directly heated vacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of $H - \alpha$ emission line of hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of iodine vapour.
8. To determine the value of e/m by (a) magnetic focusing or (b) bar magnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using $I - V$ characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating.

PHY-HC-4036
Analog Systems & Applications
Total Lectures: 60 Credits: 6 (Theory: 04, Lab: 02)

Course Outcome: *On successful completion of the course students will be able to understand about the physics of semiconductor p-n junction and devices such as rectifier diodes, zener diode, photodiode etc. and bipolar junction transistors, transistor biasing and stabilization circuits, the concept of feedback in amplifiers and the oscillator circuits, students will also have an understanding of operational amplifiers and their applications.*

Theory

Unit I: Semiconductor Diodes (Lectures 10)

P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity. PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. Drift Velocity. Derivation for Barrier Potential, Barrier Width and Current for Step Junction. Current flow mechanism in Forward and Reverse Biased Diode.

Unit II: Two-terminal Devices and their Applications (Lectures 06)

(1) Rectifier Diode: Half- wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode and (3) Solar Cell.

Unit III: Bipolar Junction Transistors (Lectures 06)

$n-p-n$ and $p-n-p$ Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions.

Unit IV: Amplifiers (Lectures 10)

Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class *A, B* & *C* Amplifiers.

Unit V: Coupled Amplifier (Lectures 04)

Two stage RC-coupled amplifier and its frequency response.

Unit VI: Feedback in Amplifiers (Lectures 04)

Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

Unit VII: Sinusoidal Oscillators (Lectures 04)

Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

Unit VIII: Operational Amplifiers (Black Box approach) (Lectures 04)

Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground.

Unit IX: Applications of Op-Amps (Lectures 09)

(1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator.

Unit X: Convversion (Lectures 03)

Resistive network (Weighted and $R-2R$ Ladder). Accuracy and Resolution. A/D Conversion (successive approximation).

Reference Books

[1] Integrated Electronics, J. Millman and C. C. Halkias, 1991, Tata Mc-Graw Hill.

[2] Electronics: Fundamentals and Applications, J. D. Ryder, 2004, Prentice Hall.

[3] Solid State Electronic Devices, B. G. Streetman & S. K. Banerjee, 6th Edn.,2009, PHI Learning

[4] Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

[5] OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall

[6] Microelectronic circuits, A. S. Sedra, K.C. Smith, A. N. Chandorkar, 2014, 6th Edn., Oxford University Press.

[7] Electronic circuits: Handbook of design & applications, U. Tietze, C. Schenk,2008, Springer

[8] Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd Ed., 2002, Wiley India

[9] Microelectronic Circuits, M. H. Rashid, 2nd Edition, Cengage Learning

[10] Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

Lab

A minimum of eight experiments to be done.

1. To study $V - I$ characteristics of PN junction diode, and Light emitting diode.
2. To study the $V - I$ characteristics of a Zener diode and its use as voltage regulator.
3. Study of $V - I$ & power curves of solar cells, and find maximum power point & effciency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitt's oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using Op-amp (741/351) for dc voltage of given gain .
14. To design inverting amplifier using Op-amp (741/351) and study its frequency response.
15. To design non-inverting amplifier using Op-amp (741/351) & study its frequency response.
16. To study the zero-crossing detector and comparator.
17. To add two dc voltages using Op-amp in inverting and non-inverting mode.
18. To design a precision Differential amplifier of given I/O specification using Op-amp.
19. To investigate the use of an op-amp as an Integrator.
20. To investigate the use of an op-amp as a Differentiator.

Honours Generic Paper

PHY-HG-4016 (PHY-RC-4016)
Waves & Optics
Total Lectures: 60 Credits: 6 (Theory: 04, Lab: 02)

Course outcome: *Upon completion of this course, students are expected to understand Simple harmonic oscillation and superposition principle, importance of classical wave equation in transverse and longitudinal waves and solving a range of physical systems on its basis, concept of normal modes in transverse and longitudinal waves: their frequencies and configurations, interference as superposition of waves from coherent sources derived from same parent source, Demonstrate understanding of Interference and diffraction experiments, Polarization. In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment, Fresnel Biprism etc. Resolving power of optical equipment, the motion of coupled oscillators, study of Lissajous figures and behaviour of transverse, longitudinal waves.*

Theory

Unit I: Superposition of Two Collinear Harmonic Oscillations (Lectures 04)

Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

Unit II: Superposition of Two Perpendicular Harmonic Oscillations (Lectures 02)

Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

Unit III: Waves Motion (Lectures 07)

General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.

Unit IV: Fluids (Lectures 06)

Surface Tension: Synclastic and anticlastic surface – Excess of pressure – Application to spherical and cylindrical drops and bubbles – variation of surface tension with temperature – Jaegar's method. Viscosity – Rate flow of liquid in a capillary tube – Poiseuille's formula – Determination of coefficient of viscosity of a liquid – Variations of viscosity of liquid with temperature – lubrication.

Unit V : Sound (Lectures 06)

Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria.

Unit VI : Wave Optics (Lectures 03)

Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

Unit VII : Interference (Lectures 10)

Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination and Fringes of equal thickness . Newton's Rings: measurement of wavelength . Michelson's Interferometer: Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index Visibility of fringes.

Unit VIII : Michelson Interferometer (Lectures 03)

(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Refractive Index. (4) Visibility of fringes.

Unit IX : Diffraction (Lectures 14)

Fresnel and Fraunhofer diffraction . Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel diffraction pattern of a straight edge and at a circular aperture . Resolving Power of a telescope. Fraunhofer diffraction due to a Single slit , Diffraction grating . Resolving power of grating.

Unit X : Polarization (Lectures 05)

Transverse nature of light waves. Double Refraction, Plane, circular and elliptically polarized light , Production and analysis of polarized light. Retarding plates.

Reference Books

[1] Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.

[2] Fundamentals of Optics, F. A. Jenkins and H.E. White, 1981, McGraw-Hill

[3] Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.

[4] Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

[5] The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

[6] The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

[7] Fundamental of Optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand Publications.

Lab

A minimum of five experiments to be done.

1. To study the variation in liquid column height with diameter of capillary tube and determine the surface tension of the liquid.
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify Z^2 — T Law.
3. To determine the coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method)
4. To determine the focal length of a convex mirror with the help of convex lens .
5. To determine the refractive index of a liquid by using plane mirror and convex lens.
6. To determine the focal length of two lenses and their combination by displacement method .
7. Familiarization with Schuster's focussing; determination of angle of prism.
8. To determine the Refractive Index of the Material of a Prism using Sodium Light.
9. To determine wavelength of sodium light using Newton's Rings.

PHY-SE-4064
Radiation Safety
Credits: 4 (Theory: 2, Lab: 2)
Theory: 30 Lectures

Preferred minimum qualifications of the teacher/instructor: Assistant Professor of Physics with PhD in Nuclear Physics/ Radiation Physics (preferably with a RSO degree from BRIT/BARC).

To ensure safety of the public, occupational workers and the environment, this course on the basic knowledge of radiation safety is introduced. The course is designed in such a way to acquaint the students with the sources of various natural and man-made radiation sources, risks involved in working in relatively high radiation zone, and safety measures to be taken to protect individual's health.

The students will acquire a basic knowledge of types and sources of radiations, interactions of radiations with matter, risks involved and safety measures to be taken.

Theory

Unit I: Structure of Matter (Lectures 6)

Constituents of atoms and nuclei, atomic and mass numbers, Isotopes, energy units, electron shells, atomic energy levels, Nuclear energy levels. Transitions between atomic energy levels (resulting optical photons) and nuclear energy levels (resulting gamma photons), -Ionization and excitation, Electromagnetic spectrum, Relationship between wavelengths, Frequency, Energy.

Units and Measurements of Physical Quantities: Force, Work, Power, energy temperature and heat. SI units of above parameters. (6L)

Unit II: Radioactivity (Lectures 6)

Natural and artificial radioactivity, types of nuclear radiations: alpha, beta, and gamma rays – concepts of Half life, activity, units of activity, -specific activity. Interactions of gamma ray and charged particles with matter. Absorbed Dose, Units of Dose. Radiation hazard, Safety measurements: Time, distance and shielding. Occupational dose limit.

Unit III: Radiation Quantities and Units (Lectures 7)

Particle flux and fluence, Radiation flux and fluence, cross section, energy, linear energy transfer (LET), linear and mass attenuation coefficients, mass stopping power, inverse square law, W-value, exposure (rate), Kerma (rate), Terma, absorbed dose (rate), rate constants, radiation weighting factors, tissue weighting factors, equivalent dose, effective dose, collective effective dose, Annual Limit of Intake {ALI}, Derived Air Concentration {DAC}, personnel dose equivalent, committed dose.

Unit IV: X-Ray (Lectures 5)

Electromagnetic waves, X-Rays –Production of X-rays: The X-ray tube, Physics of X-ray production, continuous spectrum, characteristic spectrum,–Basics of X-ray Circuits, measurement of high voltage –control of KV circuit –MA circuit. Loading, processing and storing of X-ray plates. Distribution of X-rays in space, Interaction of X-rays with matter, Attenuation of x-rays. Radiation effect of X-rays, safety measurements to be followed.

Unit V: Computed Tomography (Lectures 3)

Theory of tomography – multi section radiography, tomographic equipment, Computer tomography. Radiation hazard of Tomographic machine, Safety measurement to be followed.

Unit VI: MRI (Lectures 3)

Magnetic Resonance imaging – Basic principle– Imaging methods– Slice section, Image contrast, Bio-effects of MRI. Safety measurements. Counting statistics, errors in counting.

Lab

1. Measurement of alpha track density due to environmental (air) Radon (and its daughter) using SSNTD
2. Taking X-ray of a pen/pencil
3. Visit to a CT scan and MRI laboratory.
4. Study the background radiation levels using Radiation meter

Characteristics of Geiger Muller (GM) Counter:

5. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
6. Study of counting statistics using background radiation using GM counter.
7. Study of radiation in various materials (e.g. KSO_4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
8. Study of absorption of beta particles in Aluminum using GM counter.
9. Detection of α particles using reference source & determining its half life using spark counter
10. Gamma spectrum of Gas Light mantle (Source of Thorium)
11. Studying α particles in air using SSNTDs technique

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 and electric potential	Electrostatic field, electric flux. Gauss's law. Application of Gauss's law to charge distributions with planar, spherical and 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.	13	Credit - 2
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			
	At least four from the following:		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.

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Theory Credit: 03 (Three)

Practical Credit: 01 (One)

No. of Required Classes: 45

No. of Contact Classes: 45

No. of Non-Contact Classes:

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