Structure and Detailed Syllabus

of the Undergraduate Course (B.Sc.) in Physics under CBCS

Department of Physics

Presidency University

PRESIDENCY UNIVERSITY
KOLKATA

Department of Physics
(Faculty of Natural and Mathematical Sciences)
Presidency University
Hindoo College (1817-1855), Presidency College (1855-2010)
86/1, College Street, Kolkata - 700 073
West Bengal, India

Content

Semester-wise Modules of the Undergraduate Course in Physics (Major) under CBCS
Department of Physics, Presidency University, Kolkata

Semester	Course Type				
	Core Course	Department Specific Elective	Generic Elective	Skill Enhancement Course	Ability Enhancement Course
First	Mathematical Physics-I		(i) Mechanics or (ii) Space, Time and Universe		ENVS/ English Communications
	Mechanics				
Second	Electricity and Magnetism		(i) Waves and Optics or (ii) Physics of Everyday Life		ENVS/ English Communications
	Waves and Optics				
Third	Mathematical Physics-II		(i) Thermal Physics or (ii) The Nuclear Age	Statistical and Computational Methods	
	Thermal Physics				
	Analog Systems and Applications				
Fourth	Mathematical Physics-III		Elements of Modern Physics	Modern Experimental and Theoretical Techniques	
	Elements of Modern Physics				
	Digital Systems and Applications				
Fifth	Quantum Mechanics and Applications	Any two of: (i) Advanced Mechanics (5+1), (ii) Astronomy & Astrophysics (4+2) and (iii) Quantum Optics & Quantum Information (4+2)			
	Statistical Mechanics				
Sixth	Solid State Physics	Any two of: (i) Nuclear & Particle Physics (5+1), (ii) Soft Matter Physics (4+2) and (iii) Dissertation (6)			
	Electromagnetic Theory				

Academic Session: Each Semester shall contain at least 16 Teaching Weeks

Odd Semesters: Semesters One and Three - July to December
Even Semesters: Semesters Two and Four - January to June

Presidency University
Kolkata

Credit Allocation and Marks Distribution for the Undergraduate Course in Physics (Major) under CBCS
Department of Physics, Presidency University, Kolkata

Semester	Course Type	Paper Code	Course Name	Credits				Marks			
				Theory	Practical	Tutorial	Total	Theory	Practical	Tutorial	Total
First	Core Course	PHYS01C1	Mathematical Physics-I	4	2		6	70	30		100
First	Core Course	PHYS01C2	Mechanics	4	2		6	70	30		100
First	Generic Elective	PHYS01GE1	Any one of: (i) Mechanics (Credit 4+2, Marks 70+30) or (ii) Space, time and Universe (Credit 5+1, Marks 80+20)								100
First	Ability Enhancement Course	PHYS01AEC1	ENVS/ English Communication	4			4	100			100
Second	Core Course	PHYS02C3	Electricity and Magnetism	4	2		6	70	30		100
Second	Core Course	PHYS02C4	Waves and Optics	4	2		6	70	30		100
Second	Generic Elective	PHYS02GE2	Any one of: (i) Waves and Optics (Credit 4+2, Marks 70+30) or (ii) Physics of Everyday Life (Credit 5+1, Marks 80+20)								100
Second	Ability Enhancement Course	PHYS02AEC2	ENVS/ English Communication	4			4	100			100
Third	Core Course	PHYS03C5	Mathematical Physics-II	4	2		6	70	30		100
Third	Core Course	PHYS03C6	Thermal Physics	4	2		6	70	30		100
Third	Core Course	PHYS03C7	Analog Systems and Applications	4	2		6	70	30		100
Third	Generic Elective	PHYS03GE3	Thermal Physics	4	2		6	70	30		100
Third	Skill Enhancement Course	PHYS03SEC1	Statistical and Computational Methods	4			4	100			100
Fourth	Core Course	PHYS04C8	Mathematical Physics-III	4	2		6	70	30		100
Fourth	Core Course	PHYS04C9	Elements of Modern Physics	4	2		6	70	30		100
Fourth	Core Course	PHYS04C10	Digital Systems and Applications	4	2		6	70	30		100
Fourth	Generic Elective	PHYS04GE4	Elements of Modern Physics	4	2		6	70	30		100
Fourth	Skill Enhancement Course	PHYS04SEC2	Modern Experimental & Theoretical Techniques	4			4	100			100
Fifth	Core Course	PHYS05C11	Quantum Mechanics and Applications	4	2		6	70	30		100
Fifth	Core Course	PHYS05C12	Statistical Mechanics	4	2		6	70	30		100
Fifth	Department Specific Elective	PHYS05DSE1	Any two of: (i) Advanced Mechanics (Credit 5+1, Marks 80+20), (ii) Astronomy & Astrophysics (Credit 4+2, Marks 70+30) and (iii) Quantum Optics & Quantum Information (Credit 4+2, Marks 70+30)								100
Fifth	Department Specific Elective	PHYS05DSE2									100
Sixth	Core Course	PHYS06C13	Solid State Physics	4	2		6	70	30		100
Sixth	Core Course	PHYS06C14	Electromagnetic Theory	4	2		6	70	30		100
Sixth	Department Specific Elective	PHYS06DSE3	Any two of: (i) Nuclear & Particle Physics (Credit 5+1, Marks 80+20), (ii) Soft Matter Physics (Credit 4+2, Marks 80+20) and (iii) Dissertation (Credit 6, Marks 100)								100
Sixth	Department Specific Elective	PHYS06DSE4									100
				Total Credit			**148**	**Total Marks**			**2600**

First Semester

Core Courses

PHYS01C1: MATHEMATICAL PHYSICS-I
Credits: 6 (Theory-04, Practical-02)

Theory
Credit: 4
Contact Hours per Week: 4

Ordinary Differential Equations [10]: First-Order homogeneous and nonhomogeneous equations with variable coefficients, Superposition principle, Second-Order homogeneous and nonhomogeneous equations with constant and variable coefficients, Second-Order homogeneous equations with variable coefficients.

Functions of Several Variables [6]: Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Differentiation of composite functions. Implicit functions. Taylor series expansion of function of more than one variable. Maxima and minima. Applications to error. Constrained Maximization using Lagrange Multipliers.

Vector Calculus [27]: Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Vector identities.

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes's Theorems and their applications. Irrotational field.

Orthogonal Curvilinear Coordinates [5]: Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Matrices and Vector spaces [12]: Linear vector spaces, basis for a space, basis transformation, linear transformations, dual space, representations of transformations by matrices, Norm and inner products. Special types of square matrix, Eigenvalues and eigenvectors, Change of basis and similarity transformation, Diagonalization of matrices**.**

Reference Books:

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

2. Differential Equations, George F. Simmons, 2007, McGraw Hill.

3. Mathematical methods for Scientists and Engineers, D.A. Mc Quarrie, 2003, Viva Book

4. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.

5. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Pres.

Practical
Credit: 2
Contact Hours per Week: 4

Introduction and Overview: Computer architecture and organization, memory and Input/output devices

Basics of scientific computing: Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods

Graphics and visualization with Python: Graphs. Scatter plots. Density plots. 3D graphics. Animation

Introduction to programming in python: Introduction to programming, constants, variables and data types, dynamical typing, operators and expressions, modules, I/O statements, iterables, compound statements, indentation in python, the if-elif-else block, for and while loops, nested compound statements, lists, tuples, dictionaries and strings, basic ideas of object oriented programming, Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search

Random number generation: Area of circle, area of square, volume of sphere, value of pi (π)

Introduction to Numerical computation using numpy and scipy: Introduction to the python numpy module. Arrays in numpy, array operations, array item selection, slicing, shaping arrays. Basic linear algebra using the linalg submodule. Introduction to online graph plotting using matplotlib. Introduction to the scipy module, Introduction to OCTAVE

PHYS01C2: MECHANICS
Credits: 6 (Theory-04, Practical-02)

Theory
Credit: 4
Contact Hours per Week: 4

Fundamentals of Dynamics [6]: Reference frames. Inertial frames; Review of Newton’s Laws of Motion. Galilean transformations; Galilean invariance. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable- mass system: motion of rocket.

Work and Energy [6]: Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Qualitative study of one-dimensional motion from potential energy curves. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

Collisions [3]: Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

Rotation [6]: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Gravitation and Central Force Motion [10]: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere, Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler’s Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).

Oscillations [6]: SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

Non-Inertial Systems [8]: Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

Special Theory of Relativity [15]: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.

Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.

2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.

3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.

4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.

5. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education

6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.

7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Additional Books for Reference

8. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000

University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley

9. Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning

10. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Practical
Credit: 2
Contact Hours per Week: 4

1. Linear air track I: Uniform motion, Accelerated motion, Verification of laws of kinematics.

2. Linear air track II: Collision, Conservation of linear momentum and energy.

3. Determination of rigidity modulus of a material using torsional pendulum. Measurement of moment of inertia of a cylinder, Time period.

4. Computer interfacing of the simple and torsional pendulum experiments.

Automated detection of motion and measurement of time interval, Expeyes kit.

5. Determination of the period of a driven pendulum using resonance: Change of time period with length of string, Detection of resonance.

6. Determination of Young's modulus of the material of a metallic bar by the bending of a beam

7. Measurement and plotting of load vs depression,

8. Regression fitting to get Young's Modulus and its uncertainty

Generic Elective Course **PHYS01GE1:** Any one of the following two

1. MECHANICS
Credits: 6 (Theory-04, Practical-02) Same as PHYS01C1

Theory Credit: 4, Contact Hours per Week: 4

Practical Credit: 2, Contact Hours per Week: 4

2. SPACE, TIME AND THE UNIVERSE (Interdisciplinary)
Credits: 6 (Theory-05, Tutorials-01)

Theory
Credit: 5
Contact Hours per Week: 5

Historical and cultural perspective of our view of the Universe [15]: Traditional astronomy in ancient culture, Greek Astronomy, Astronomy in literature, music and arts, the Copernican revolution and its impact, Science Fiction and its impact

Our changing concept of Space and Time [25]: Macroscopic concept of space and time: Newton and Galileo, Concept of inertia, Newtons laws of motions and their scientific and philosophical implications, Newtons law of gravitation, Concept of unification of physical laws, Kepler's laws and planetary motions, Galilean invariance, Arrow of time and the concept of entropy, Maxwell's electromagnetism and the concept of special relativity, postulates of special relativity, length contraction and time dialation, changing concept of space and time, Inertial and gravitational mass, equivalence principle, general theory of relativity, gravitational time-dialation, Microscopic concept of space and time: Failure of classical physics, Wave particle duality, uncertainty principle, road to quantum mechanics, Copenhagen interpretation, Einstein-Bohr debate, Quantum Reality, zero point energy relativity and quantum mechanics, concepts of fields, vacuum energy, fundamental interactions, unification and the standard model, Higgs Boson and the fundamental notion of mass, Quantum Mechanics and General Relativity

Modern view of the Universe [15]: Physical basis of Einstein's field equations, cosmological principle, geometry of the universe, scale factor, redshift, expansion of the universe, idea of cosmological constant, Hubble's law, Big Bang theory, Cosmic microwave background, content of the Universe, Dark Matter and Dark energy,

Observational Status and modern day Astrophysics [20]: Astronomical observations, multi-wavelength astronomy: optical, radio, X-ray, Gamma Ray Telescopes and their design, Stellar evolution and stellar spectra, end stages of stellar evaluation: white dwarves, neutron stars, Pulsars and their importance in astronomy concept of astrophysical black holes, solar system and extra-solar system of planets, galaxies and active galaxies, distance scales in astronomy, gravitational waves and a new window of astronomy

Second Semester

Core Courses

PHYS02C3: ELECTRICITY AND MAGNETISM
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Electrostatics [12]: Electric field, Divergence and curl of electric filed, Gauss's law and its applications, Electric potential, Electrostatic energy, Conductors in an electrostatic Field, Multipole expansion, the uniqueness theorem, the method of image, Poisson and Laplace equation, Boundary value problems.

Dielectrics [8]: Dielectric materials in external electric field**,** Polarization, Force and torque on electric dipole in external electric filed, Electric field of polarized materials, Electric field in dielectrics, Electrical Susceptibility and Dielectric Constant. Displacement vector **D**, Gauss' Law in dielectrics, Capacitors.

Magnetostatics [16]: Magnetic effect of steady current, Equation of continuity and steady current, Lorentz force and concept of magnetic induction, force on linear current element, Biot-Savart's law, Ampere's circuital law and its applications, Magnetic vector potential, calculation of vector potential and magnetic induction in simple cases, Magnetic dipole moment for rotating charge bodies, Gyro-magnetic ratio, Force & torque on a magnetic dipole.

Magnetic Properties of Materials [6]: Free current and bound current; surface and volume density of current distribution; magnetisation vector; non-uniform magnetisation of matter; Introduction of H; Magnetostatic boundary conditions. Magnetic scalar potential; Field due to uniformly, magnetised sphere. Magnetic Susceptibility and permeability, Ferromagnetism, Hysteresis and iron loss.

Electromagnetic Induction [4]: Faraday's and Lenz's law. Motional e.m.f.-simple problems. Calculation of self and mutual inductance in simple cases. Energy stored in magnetic field. Energy of a magnetic dipole.

Maxwell's Equations [6]: Displacement Current, Maxwell's Equations in vacuum in presence of source charges and currents, plane wave solutions, energy & momentum relations in electromagnetic field - Poynting's theorem, Scalar & vector potentials, gauge transformation.

Electrical Circuits [4]: AC Circuits, Kirchhoff's laws for AC circuits, Complex Reactance and Impedance, Series LCR Circuit, Parallel LCR Circuit.

Network theorems [4]: Ideal Constant-voltage and Constant-current Sources, Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits

Practical
Credit: 2
Contact Hours per Week: 4

1. To study the characteristics of a series RC Circuit.

2. To verify the Thevenin and Norton theorems.

3. To verify the Superposition, and Maximum power transfer theorems.

4. To determine self inductance of a coil by Anderson's bridge.

5. To study 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.

6. To study the response curve of a parallel LCR circuit and determine its (a) Antiresonant frequency and (b) Quality factor Q.

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

PHYS02C4: WAVES & OPTICS
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Basics of Waves [12]: Linearity and Superposition Principle. Superposition of two collinear oscillations, Graphical and Analytical Methods. Lissajous Figures and their uses, Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave, Energy Transport, Intensity of Wave, Water Waves: Ripple and Gravity Waves.

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings.

Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.

Geometrical Optics [14]: Fermat's principle, Matrix method, Thick lens, Optical instruments, Aberration: spherical and chromatic

Wave Optics [3]: Electromagnetic nature of light. Definition and properties of wave front, Huygens Principle. Temporal and Spatial Coherence.

Interference [8]: Division of amplitude and 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 (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

Interferometer [3]: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer

Diffraction [20]: Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula and its application to rectangular slit. Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

Fresnel's Assumptions. 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's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

Practical
Credit: 2
Contact Hours per Week: 4

1. Prism Spectrometer: To get familiar with spectrometer, Determination of the refractive index of a prism for variouswavelengths of Sodium spectrum

2. Interference by Newton's ring: To determine the the radius of curvature of a plano-convex lens by using Newton's rings.

3. Diffraction by double slit: To study diffraction of light by using double slits and determination of unknown wavelengths.

4. Inteference Using Fresnel Biprism: To understand the use of Fresnel biprism to divide the wavefront of a monochromatic, coherent beam of light producing an interference pattern and measurement of wavelength

5. Diffraction Grating Spectrometer: To get familiar with the use of diffraction grating spectrometer.

6. To Measure certain wavelengths of spectral lines of mercury vapour using diffraction grating spectrometer

Generic Elective Course **PHYS02GE2**: Any one of the following two

1. WAVES & OPTICS
Credits: 6 (Theory-04, Practical-02) Same as PHYS02C4

Theory Credit: 4, Contact Hours per Week: 4

Practical Credit: 2, Contact Hours per Week: 4

2. PHYSICS OF EVERYDAY LIFE (Interdisciplinary)
Credits: 6 (Theory-05, Tutorials-01)

Theory
Credit: 5
Contact Hours per Week: 5

Art of Estimation and Fermi Problems [20] : The need for making approximations, Making quantitative estimates in real-life situations, introduction to a variety of Fermi problems in real life, Order of magnitude problems in different areas of physics, error estimation, significant digits, use of dimensional analysis to solve physics problems

Understanding your Electric Bill [5]: Basics of electricity and magnetism, Ohms law, power consumption, Joule heating, Energy Conservation and the use and generation of electricity, Saving electricity

Your Car and your Refrigerator [15]: The laws of thermodynamics, microscopic and macroscopic view Zeroth Law of Thermodynamics and Concept of Temperature, Concept of Work & Heat, Work Done during Isothermal and Adiabatic Processes, Reversible and Irreversible process with examples, Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence, Concept of Entropy and disorder

How do Microwave ovens work [5]: Electric and Magnetic fields, potentials, concept of electromagnetic waves, design of microwave ovens, precaution needed, basics of materials design

The Physics of Digital Cameras [14]: History of photography. Comparison of human eye and camera. Film photography. Color photographs. Charge coupled device (CCD). Operating principles of CCD camera. Color in CCD image. Filters. Bayer pattern. CCD vs film. Photo-electric effect. Wave and particle nature of light.

The use of the Global Positioning System (GPS) [6]: Navigation before GPS: position of astronomical objects in the sky. Operating principles of GPS. Atomic clocks. Gravitational time dilation. Accuracy and errors in GPS navigation.

Mobile phone communication [10]: Digital Electronics: Number systems: Decimal, binary. Conversion from decimal to binary and vice versa. How numbers are stored and manipulated in computers. Logic gates: OR, AND, NOT, XOR, NAND. Flip-flop circuit.

Memory Devices: History of memory devices: printing, recording of audio and video. Why binary number system is used for modern memory devices. Operating principles of compact disk, magnetic hard disk drive, solid state memory devices. MOSFET. Tunneling. Advantages and disadvantages of CD, magnetic disk, and solid state memory.

Third Semester

Core Courses

PHYS03C5: MATHEMATICAL PHYSICS-II
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Fourier Series [15]: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity. Complex representation of Fourier series Generalized Fourier Series and the Dirac Delta function and its properties. Summation of Fourier series. The Gibbs phenomenon.

Frobenius Method and Special Functions [25]: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and $J_1(x)$) and Orthogonality. Hermite functions.

Some Special Integrals [5]: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral)

Partial Differential Equations [15]: Classification of PDEs. Some examples of PDEs. Solution of PDEs with separation of variables and eigenfunctions. Boundary and initial conditions – vibration of a string. Laplace's equation and its solution in Cartesian, spherical polar with axially symmetric coordinate system and cylindrical polar with infinite cylinder coordinate system. Solution of 1- D and 2 – D wave equations. Solution of heat conduction equation in 1-D.

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7^{th} Edn., Elsevier.
2. Differential Equations, George F. Simmons, 2007, McGraw Hill.
3. Mathematical methods for Scientists and Engineers, D.A. Mc Quarrie, 2003,Viva Book

4. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
5. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press.

Practical
Credit: 2
Contact Hours per Week: 4

Interpolation: Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation: Evaluation of trigonometric functions e.g. sin θ, cos θ, tan θ, etc.

Numerical differentiation and Integration: Forward and Backward difference formula and Integration by Trapezoidal and Simpson rules, Monte Carlo method,

Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop, Ohms law to calculate R, Hooke's law to calculate spring constant

Solution of ODE: First order Differential equation Euler, modified Euler and Runge-Kutta second order methods Second order differential equation Fixed difference method, First order differential equation:

1. Radioactive decay
2. Current in RC, LC, LRC circuits with DC source
3. Newton's law of cooling
4. Classical equations of motion Second order Differential Equation
5. Harmonic oscillator (no friction)
6. Damped Harmonic oscillator
7. Over damped solution
8. Critical damped solution
9. Oscillatory solution
10. Forced Harmonic oscillator
11. Transient and Steady state solution

PHYS03C6: THERMAL PHYSICS
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Zeroth and first law of Thermodynamics [7]: Extensive and intensive ThermodynamicVariables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, Internal Energy, First Law of Thermodynamics and its applications: General Relation between specific heats at constant pressure and constant volume, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

Second law of Thermodynamics [8]: Reversible and Irreversible process with examples, Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence, Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.

Entropy [8] : Concept of Entropy, Clausius Theorem. Clausius Inequality,

Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Temperature–Entropy diagrams for Carnot's Cycle, Third Law of Thermodynamics. Unattainability of Absolute Zero.

Thermodynamic Potential [7]: Enthalpy, Helmholtz Free Energy, Gibb's

Free Energy - Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Joule-Thompson porous plug experiment, Adiabatic demagnetization, First and second order Phase Transitions, Clausius-Clapeyron Equation and Ehrenfest criterion.

Maxwell's Thermodynamic Relations [5] : Derivations and applications of Maxwell's Relations such as (1) Clausius-Clapeyron equation, (2) Values of Cp-Cv,

(3) Tds Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

Kinetic theory of gases [8]: Preliminaries: Basic postulates of kinetic theory, Pressure of an ideal gas, Maxwell-Boltzmann Law of Distribution of velocities and energy of an Ideal Gas and its Experimental Verification - Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy and its applications, Specific heats of Gases.

Molecular collisions [10]: Mean Free Path, Collision Probability, Distribution of Mean Free Paths, Mean free path of ideal gases obeying Maxwell's velocity distribution, Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion, Perrin's experiment, Random walk, Fluctuation-dissipation theorem, Langevin theory of translational Brownian motion, Einstein-Smoluchwoski relation.

Real gases [7] : Behavior of Real Gases, Deviations from the Ideal Gas Equation. The Virial equation. Andrew's Experiments on Carbon-dioxide Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Survey of other equations of state for real gases.

Practical
Credit: 2
Contact Hours per Week: 4

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.

2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.

3. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.

4. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).

5. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.

6. To calibrate a thermocouple to measure temperature in a specified Range using Null Method.

7. Direct measurement of temperature using Op-Amp difference amplifier and to determine Neutral Temperature.

PHYS03C7: ANALOG SYSTEMS AND APPLICATIONS
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Semiconductor Diodes [8]: p- and n-type semiconductors. Energy Band Diagram. Conductivity and Mobility, Concept of Drift velocity. p-n Junction Fabrication (Simple Idea). Barrier Formation in p-n 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.

Two-terminal Devices and their Applications [8]: (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Average and RMS Current and Voltage, 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.

Bipolar Junction transistor and Field-Effect Transistors [10]: 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. Brief Idea on JFET and MOSFET

Amplifiers [7]: Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Simple Network Theorems, 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.

Coupled Amplifier [3]: Two stage RC-coupled amplifier and its frequency response.

Feedback in Amplifiers [4]: Concept of Feedback, Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise.

Sinusoidal and Non-Sinusoidal Oscillators [4]: Barkhausen Criterion for self-sustained oscillations. RC Phase shift oscillator. Hartley Oscillator. Colpitts Oscillator. Multivibrator

Operational Amplifiers [3]: Characteristics of an Ideal and Practical Op-Amp. IC 741. Open-loop and Closed-loop Gain. Frequency Response. CMRR. Offset. Slew Rate.

Applications of Op-Amps [8]: (1) Inverting and non-inverting amplifiers, Concept of Virtual Ground and Virtual Short (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector and Schmitt Trigger (8) Wein bridge oscillator.

Introduction to CRO [3]: Block Diagram of CRO. Electron Gun. Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference.

Integrated Circuits [2]: Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital lCs.

Reference Books:

1. Integrated Electronics: Analog and Digital Circuits and Systems, J. Millman and C.C. Halkias, 2nd Edn. 2017, McGraw Hill Education.

2. Electronic Principles, A. Malvino and D. J. Bates, 8th Edn. 2015, McGraw-Hill Education.

3. Solid State Electronic Devices, B.G. Streetman and S.K. Banerjee, 6th Edn. 2009, PHI.

4. Op-Amps and Linear Integrated Circuits, R. A. Gayakwad, 4th Edn. 2000, Pearson.

5. Electronic Devices and Circuit Theory, R. L. Boylestad and L. Nashelsky, 11th Edn. 2016, Pearson.

6. Modern Electronic Instrumentation and Measurement Techniques, A. D. Helfrick and W. D. Cooper, 2011, PHI.

7. Schaum’s Outline Series: Theory and Problems of Electronic Devices and Circuits, J. J. Cathey, McGraw-Hill.

8. Microelectronic Circuits, A. S. Sedra, and K. C. Smith, 5th Edition, Oxford University Press.

Practical
Credit: 2
Contact Hours per Week: 4

1. To measure (a) Voltage and (b) Time period of a periodic waveform using CRO.

2. Use of multimeter and familiarity with electronic components, such as resistor color code, capacitors, diodes and transistors

3. To study the current-voltage characteristics of p-n junction diode and Light emitting diode.

4. To study the current-voltage characteristics of Zener diode and its use as voltage regulator.

5. To study the characteristics of a Bipolar Junction Transistor in CE configuration.

6. To study the biasing configuration of BJT and to design a CE amplifier of a given gain.

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 Op-Amp.

9. To design an astable multivibrator of given specifications using BJT.

10. To design a digital-to-analog converter (DAC) of given specifications using Op-Amp.

11. To study the analog to digital converter (ADC) IC.

12. To design an inverting amplifier using Op-amp (741) of given gain and to study its dc and ac response.

13. To design non-inverting amplifier using Op-amp (741) and to study its dc and ac response.

14. To study the zero-crossing detector and Schmitt Trigger.

15. To add dc voltages using Op-amp in inverting and non-inverting mode.

16. To design a precision Differential amplifier of given I/O specification using Op-Amp.

17. To investigate the use of Op-Amp as an Integrator.

18. To investigate the use of Op-Amp as a Differentiator.

Generic Elective Course **PHYS03GE3:** Any one of the following two

1. THERMAL PHYSICS
Credits: 6 (Theory-04, Practical-02) Same as PHYS03C6

Theory Credit: 4, Contact Hours per Week: 4

Practical Credit: 2, Contact Hours per Week: 4

2. THE NUCLEAR AGE (Interdisciplinary, crosslisted with Department of History)

Credits: 6 (Theory-05, Tutorials-01)
Theory
Credit: 5
Contact Hours per Week: 5

Preliminaries [8]: Basic quantum phenomena- discrete energy levels, tunnelling, Atoms and their constituents, Spectroscopy, Origin of natural radioactivity, Radioactive decay processes – half-life and mean-life, Discovery of the nucleus, Elementary aspects of nuclear physics, Binding energy, Energy release in nuclear processes, Alpha, beta, gamma emission.

Nuclear Fission and Nuclear Reactors [22]: Overview of nuclear reactions, Reaction cross-sections, Neutron reactions in different energy regimes, Cross-sections in the resonance region and the continuous region, Discovery of nuclear fission, Products of fission and their mass distribution, Energetics, Decay of fission fragments, Chain reaction, Criticality and the multiplication factor, Role of moderators, Nuclear reactors, Classification of reactors and their components, Conversion ratio and production of plutonium in thermal reactors, Fast breeder reactors, Nuclear reactor safety, Introduction to risk management, Characterisation of nuclear fuel cycle – uranium enrichment, fuel fabrication and reprocessing, Introduction to radioactive waste management, Deep geologic waste disposal and its alternatives, Calculation of electricity generation cost by nuclear fission based technology.

Nuclear Weapons [10]: Uncontrolled chain reaction, nuclear fusion, Introduction to fission and fusion based nuclear weapons, Biological effects of exposure to high radiation doses, Types of effects – deterministic and stochastic, Effects of low radiation doses, Concentration of radionuclides in the environment, Radiation measurement tools, Prescribed safe radiation standards.

History of the Quantum Revolution [5]: Contributions by Planck, Einstein, Bohr, Pauli, Heisenberg, Schrodinger, Born, Oppenheimer; Wave mechanics vs Matrix mechanics, Brief mention of the timelines and parallel development in different geographical locations such as Goetingen, Zurich, Copenhagen etc.

The beginning of nuclear physics [10]: History of natural and artificial radioactivity, The Curie family, Rutherford at Montreal and Manchester, Bethe, History of discovery of nuclear fission, Hahn, Strassmann, Meitner; Herbert Anderson at Columbia University, Bohr-Wheeler collaboration.

The Manhattan Project [15]: Capsule history of World War II, The Allies and the Axis, Pearl Harbor, Fermi and the Chicago Atomic Pile, Brief elucidation of the history of launching the Manhattan Project, Einstein's peace initiatives, Immigration of important German scientists of Jewish origin to the United States, Szilard and Teller, Relevant American wartime industry, Los Alamos, Robert Oppenheimer and General Leslie Groves, Technical challenges in building the first atomic bomb, Dropping of the Allied Atomic *Fission* bomb in Japan.

The Nazi Atomic Bomb [5]: Brief discussion of the Nazi wartime effort in building the atomic bomb under the leadership of Heisenberg, Analysis of the reasons behind failure of the Nazi effort.

Skill Enhancement Course

PHYS03SEC1: STATISTICAL AND COMPUTATIONAL METHODS
Credit: 4
Contact Hours per Week: 4

Computer Programming (Fortran/C/C++) [16]: Basic programming concepts. Constants, variables and arrays. Control Statements. Input/Output facilities. Operators and expressions. Loops. Nested loops. Function. Subroutine, Libraries.

Introduction to Softwares [14]: Basic 2D and 3D graph plotting - plotting functions and data files, fitting data using gnuplot's fit function, polar and parametric plots, modifying the appearance of graphs, Surface and contour plots, exporting plots as eps, pdf, png, jpg files, Intro to softwares: XMAXIMA, OCTAVE, MATLAB, MATHEMATICA, origin Word processing in word and latex

Propagation and reporting of uncertainties [5]: Characterisation of uncertainties present in various basic instruments in the lab. Effect of uncertainties in the final result.

Probability Distributions [10]: Probability theory, PDF, CDF, Moments of a distribution, Binomial, Poisson. Gaussian/Normal.

Classification of experimental uncertainties [4]: Instrumental, random, and systematic uncertainties in various experiments in labs. Concept of different moments: mean, standard deviation. Standard deviation on the mean.

Least-Square Fit [4]: Straight line. Polynomial. Arbitrary function. Uncertainties from fit.

Goodness of Fit [7]: Confidence intervals. Chi-squared test. Degrees of freedom. Reduced Chi-square. Correlation and covariance. F test. Monte-Carlo test.

Fourth Semester

Core Courses
PHYS04C8: MATHEMATICAL PHYSICS-III
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Complex Analysis [20]: Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

Tensor Analysis [15]: Cartesian tensors: first and zero order Cartesian tensors, second and higher order Cartesian tensors. Algebra of tensors: summation, multiplication, contraction, inner product, the quotient law. The tensors δ_{ij} and ε_{ijk}. Isotropic tensors, improper rotation and pseudo-tensors, dual tensors. Non-Cartesian tensors, the metric tensors. General coordinate transformation and tensors. Applications (e.g., electromagnetic field tensors, stress-strain tensors, moment of inertia tensors).

Integrals Transforms [25]: Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Parseval's theorem. Convolution theorem. Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave, Diffusion and Heat Flow Equations.

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of Derivatives and Integrals, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2^{nd} order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1^{st} order. Solution of heat flow along infinite bar using Laplace transform.

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. Differential Equations, George F. Simmons, 2007, McGraw Hill.
3. Mathematical methods for Scientists and Engineers, D.A. Mc Quarrie, 2003, Viva Book
4. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
5. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ Press.

Practical
Credit: 2
Contact Hours per Week: 4

Solution of Algebraic and Transcendental Equations: Bisection method, Newton Raphson and Secant methods, Solution of linear and quadratic equation.

Solution of Linear System of Equations: Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen value problems , Solution of mesh equations of electric circuits (3 meshes), Solution of coupled spring mass systems (3 masses)

Generation of Special functions using User defined functions: Generating and plotting Legendre Polynomials Generating and plotting Bessel function, Evaluation of trigonometric functions e.g. sin θ, Given Bessel's function at N points find its value at an intermediate point.

Fourier Series and Fourier Transform: Fourier analysis: Sawtooth function, half wave function, summation of Fourier series, discrete Fourier transform, aliasing, fast Fourier transform

PHYS04C9: ELEMENTS OF MODERN PHYSICS
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Quantum Theory [17]: Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: 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.

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Energy-time uncertainty principle- application to virtual particles and range of an interaction, Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude;

Bohr Atom, Atomic spectra: Frank Hertz experiment, semi-classical theory: Wilson

Sommerfield quantization: applications in simple systems.

Wave Mechanics [20]: Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension, 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 & rectangular potential barrier, varied potential problems,

Nuclear Model [15]: 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. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers, Radioactive decay, Alpha and beta decay, neutrino hypothesis, Fission and fusion- mass deficit, relativity and generation of 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).

Lasers [8]: 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, Modern applications: Light matter interaction

Reference Books:

1. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, 2ed Paperback – 2006 by Robert Eisberg and Robert Resnick, Wiley student edition

2. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education

3. Concepts of Modern Physics (SIE) 6th Edition (English, Paperback, Arthur Beiser, Shobit Mahajan), 2009, McGraw Hill Education (India) Private Limited

4. University Physics Plus Modern Physics Plus Mastering Physics with eText -- Access Card Package, 13th Edition, Hugh D. Young and Roger A. Freedman,

2012 , Pearson

Practical
Credit: 2
Contact Hours per Week: 4

1. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light

2. Animation of simple solution of Schrodinger equation.

3. Solving Schrodinger equation and evaluating the time evolution of probability waves

4. Analysis of Planck's law for Black Body radiation and Wein's Law

5. Animation of laser properties

6. Measurement of Planck's constant using black body radiation and photo-detector

7. To determine the wavelength of H-alpha emission line of Hydrogen atom.

8. To show the tunneling effect in tunnel diode using I-V characteristics.

9. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

10. To verify discrete atomic level using the Frank-Hertz experiment

PHYS04C10: DIGITAL SYSTEMS AND APPLICATIONS
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Digital Circuits [8]: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers.

Boolean Algebra [8]: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (i) Sum of Products and Product of Sums Method and (ii) Karnaugh Map.

Data processing circuits [4]: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits [6]: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor.

Sequential Circuits [6]: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop.

Timers [3]: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.

D/A and A/D Conversions [3]: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (introductory)

Shift registers [3]: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

Counters (4 bits) [3]: Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter

Computer Organization [4]: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

Intel 8085 Microprocessor Architecture [4]: Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI.

Introduction to Assembly Language [8]: 1 byte, 2 byte & 3 byte instructions, simple 8085 programs.

Reference Books:

1. Digital Principles and Applications, A.P. Malvino, D.P. Leach and G. Saha, 8th Edn. McGraw-Hill Education.

2. Digital Systems: Principles & Applications, R.J. Tocci, N.S. Widmer, 10th Edn. Pearson

3. Integrated Electronics: Analog and Digital Circuits and Systems, J. Millman and C.C. Halkias, 2nd Edn. 2017, McGraw Hill Education.

4. Schaum's Outline of Theory and Problems of Digital Principles, R. L. Tokheim, 3rd Edn. McGraw-Hill.

5. Microprocessor Architecture, Programming and Applications with the 8085, R.S. Gaonkar, 5th Edn. Penram (India).

Practical
Credit: 2
Contact Hours per Week: 4

1. To design AND and OR gates using diodes and resistors.

2. To design NOT gate using transistor and resistors.

3. To design AND, OR, NOT and XOR gates using NAND gates.

4. To design a combinational logic system for a specified Truth Table.

5. To convert a Boolean expression into logic circuit and design it using logic gate ICs.

6. To minimize a given logic circuit.

7. To fabricate Half Adder and Full Adder circuits for single bit addition using NAND gates.

8. To fabricate Half Subtractor and Full Subtractor circuits for single bit. Realizing Adder-Subtractor using Full Adder IC.

9. To build 1-bit comparator for equality and inequality of two bits.

10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.

11. To build JK Master-slave flip-flop using Flip-Flop ICs

12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.

13. To build a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.

14. To design an astable multivibrator of given specifications using 555 Timer.

15. To design a monostable multivibrator of given specifications using 555 Timer.

16. Write at least the following programs using 8085 Microprocessor

a) Addition and subtraction of numbers using direct addressing mode

b) Addition and subtraction of numbers using indirect addressing mode

c) Multiplication by repeated addition.

d) Division by repeated subtraction.

e) Handling of 16-bit Numbers.

f) Use of CALL and RETURN Instruction.

g) Block data handling, sorting and rearrangement of numbers.

Other programs (e.g. Parity Check, using interrupts, etc.)

Generic Elective Course

PHYS04GE4: ELEMENTS OF MODERN PHYSICS
Credits: 6 (Theory-04, Practical-02) Same as PHYS04C9

Theory Credit: 4, Contact Hours per Week: 4
Practical Credit: 2, Contact Hours per Week: 4

Skill Enhancement Course

PHYS04SEC2: MODERN EXPERIMENTAL AND THEORETICAL TECHNIQUES
Credit: 4
Contact Hours per Week: 4

Introduction to state-of-the-art research topics [20]: Research seminar and student journal club on topics in particle physics, astro-particle physics, condensed matter systems, atomic molecular physics, non-linear physics, cold-atom systems, astrophysics and astronomy, cosmology, statistical physics, atmospheric physics, fluid dynamics, material science, history and philosophy of science, sociology of physics and other interdisciplinary topics

Modern Experimental Techniques [30]: Experimental methods in materials science and engineering: characterization of material structures (using spectroscopy, microscopy and diffraction techniques), material properties (mechanical, thermal, electrical, electrochemical, etc.) and material processes (phase transformations, reactions). Laboratory demonstrations on different kinds of materials (e.g., metals, ceramics, polymers, carbons, semiconductors and composites.)

Research Lab Visits [10]: Visit of local research labs and demonstration of facilities

Fifth Semester

Core Courses

PHYS05C11: QUANTUM MECHANICS AND APPLICATIONS
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Schrodinger equation [6]: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions, Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions

General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

General discussion of bound states in an arbitrary potential [6]: continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle, operator method for quantization of the harmonic oscillator

Quantum theory of hydrogen-like atoms [9]: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells, introduction to spin

Formalism [10]: Linear Vector Spaces and linear operators, Hilbert space, Eigen functions of a Hermitian Operator, Uncertainty Principle, Dirac Notation, Heisenberg equation of motion, Symmetries in Quantum Mechanics

Atoms in Electric & Magnetic Fields [9] : Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor’s Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

Atoms in External Magnetic Fields [5]: Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect

Many electron atoms [15]: Pauli’s Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms- L-S and J-J couplings. Hund’s Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc), Molecular spectra, Raman effect, Modern applications

Reference Books:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed.,

2010, McGraw Hill

2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.

3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.

4. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.

5. Introduction to Quantum Mechanics, D.J. Griffiths, 2nd Ed. 2005, Pearson Education

6. Concepts of Modern Physics (SIE) 6th Edition (English, Paperback, Arthur Beiser, Shobit Mahajan), 2009, McGraw Hill Education (India) Private Limited

Practical
Credit: 2
Contact Hours per Week: 4

1. Solve the Schrodinger equation for the ground state and the first excited state of the hydrogen atom

2. Solve the radial Schrodinger equation for an atom for the screened coulomb potential

3. Solve the radial Schrodinger equation for a particle of mass in an anharmonic oscillator potential

4. Solve Schrodinger equation for vibrational spectra of hydrogen

5. Simulate the Mach Zender interferometer

6. Simulate the Stern Gerlach experiment for spin half particles

7. Simulate a two state quantum system and study its properties (e.g., spin half systems)

8. Interactive Tutorial on Foundations of Quantum Mechanics

9. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency

10. Study of Zeeman effect: with external magnetic field; Hyperfine splitting

PHYS05C12: STATISTICAL MECHANICS
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Classical Statistics [18]: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox & resolution, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature., Introduction to nonequilibrium phenomena, Purcell 's experiment, Langevin dynamics, Grand canonical ensemble and application.

Classical Theory of Radiation [9]: Properties of Thermal Radiation. Blackbody Radiation, Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jean's Law. Ultraviolet Catastrophe.

Quantum Theory of Radiation [5]: Spectral Distribution of Black Body Radiation, Planck's

Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental

Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3)

Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law

Bose-Einstein Statistics [8]: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas, Bose derivation of Planck's law.

Fermi-Dirac Statistics [15]: Fermi-Dirac Distribution Law, Thermodynamic

functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, concept of degeneracy pressure, White Dwarf Stars, Chandrasekhar Mass Limit, Thermoionic emission & Richardson equation. Pauli spin paramagnetism

Reference Books:

1. Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2 nd Ed., 1996, Oxford University Press.

2. Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill

3. Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall

4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.

5. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer

6. An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

7. An Introduction to Thermal Physics. Daniel V. Schroeder. 422 pp. Addison–Wesley, Reading, Massachusetts,. 2000

Practical
Credit: 2
Contact Hours per Week: 4

1. Study of Specific Heat of Solids in different approximations and physical regimes.

3. Numerical study of Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein distribution functions

4. Numerical estimates of metallic specific heat

5. Video demonstration of BEC

6. Numerical studies of the Partition function and its properties

7. Verification of Stirling approximation for large numbers

8. Simulating Spin systems

9. Numerical study of the ortho-para states of hydrogen

10. Numerical analysis of Bose gas confined in a harmonic trap

Department Specific Elective: **PHYS05DSE1** and **PHYS05DSE2**

[Any two of the following three: Advanced Mechanics (Credit 5+1), Astronomy & Astrophysics (Credit 4+2) and Quantum Optics & Quantum Information (Credit 4+2)]

1. ADVANCED MECHANICS
Credits: 6 (Theory-05, Tutorials-01)

Theory
Credit: 5
Contact Hours per Week: 5

Rigid Body Dynamics [15]: Demonstration of gyroscopic motion, Rotation about a fixed axis, Moment of inertia tensor, Products of inertia, Principal axis, Precession of top due to weak torque (formal derivation of gyroscopic motion), Euler's equation and its solution for symmetric rigid bodies.

Lagrangian and Hamiltonian Formalism [18]: Variational Principle in Mathematics, Principle of least action, Virtual displacement, D'Alembert's principle, Principle of virtual work, Generalised coordinates, Constraints and degrees of freedom, Lagrange's equations of motion for conservative holonomic systems, Generalised momentum, Cyclic coordinates, Application to simple cases, Construction of Hamiltonian using Legendre transformation, Hamilton's equations of motion and its application to simple cases, Relation between Hamiltonian and total mechanical energy in various cases, Noether's theorem: Symmetries and conservation principle.

Small Oscillations [7]: Secular equation for small oscillations and its solution: Double pendulum, Weakly coupled pendulum, Normal coordinates and modes.

Fluid Mechanics [23]: The equation of continuity, Euler’s equation for ideal fluids, Hydrostatics, Bernoulli’s theorem, Potential flow, Incompressible fluids, Newtonian fluids, Navier-Stokes equation and its applications. Poiseuille’s formula, Couette flow, Turbulent flow and Reynold’s number, Modern Applications

Elasticity [12]: Stress and Strain tensors, Hooke’s law, Isotropic solids and their conditions for equilibrium, Energy of deformation, Propagation of waves in an elastic medium.

Reference Books:

1. Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.

2. Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.

3. The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4th Edn., 2003, Elsevier.

4. Classical Mechanics, P.S. Joag, N.C. Rana, 1st Edn., McGraw Hall.

5. Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.

6. Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.

7. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

2. ASTROPHYSICS AND COSMOLOGY
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Introduction to Observational Astronomy [8]: Celestial sphere, Coordinate systems, Measurement of time and distance, Luminosity, Apparent and absolute magnitude, Colour index, Measurement of mass, Electromagnetic spectrum, Observational tools for multi-wavelength astronomy
Introductory Stellar astrophysics [20]: Stellar spectral classification, Saha equation, Hertzsprung-Russell diagram, Stellar structure -hydrostatic equilibrium, Polytropes, Lane-Emden equation : analytic solutions, Stellar energy generation-nucleosynthesis, Radiative transfer, Stellar evolution, Fate of massive stars: brown dwarfs, supernovae, Compact objects: white dwarfs, neutron stars and black holes.
Introductory extragalactic Astrophysics [12]: Galaxy-classification, Galactic structure, Milky Way galaxy, Active galaxies, Structure of the Universe.
Cosmology [20]: Background Smooth Universe: Observational triumphs of cosmology, Olber's paradox, Hubble's law and the expanding Universe, Big Bang theory, Redshift, Scale factor, Cosmological principle: homogeneity and isotropy, homogeneity and isotropy, Newtonian cosmology, Friedmann equation, Conservation and acceleration equations, Different components of the Universe, Multi-component Universe, Equations of state, Distance measures in cosmology, Thermal History of the Universe: Cosmic microwave background, Big Bang Nucleosynthesis, Dark matter, Dark energy, Observational signatures of the perturbed Universe

Practical
Credit: 2
Contact Hours per Week: 4

1. Numerical studies of hydrostatic equilibrium in stars
2. Studies of HR Diagram
3. Usage of FITS files with IDL
4. Determination of the solar constant
5. Basic knowledge of IRAF
6. Numerical studies of the properties of the cosmic microwave background
7. Computational studies of distance measures in cosmology
8. Solving Friedman Equations for different cosmological models

3. QUANTUM OPTICS AND QUANTUM INFORMATION
Credits: 6 (Theory-05, Tutorials-01)

Theory
Credit: 5
Contact Hours per Week: 5

Quantum Optics [30]: Coherent state representation of the electromagnetic field, Nonlinear optics, Coupled mode equations, Three and four-wave mixing, Density operators and phase space, Interaction of atoms with classical and quantized electromagnetic field, The Rabi model, Jaynes-Cummings model and its extensions, Squeezed states of light, Dissipative interactions and decoherence, Interferometry with squeezed states, Application in interferometric gravitational wave detectors.

Quantum Measurement [20]: The interpretation of quantum mechanics and the measurement process, The probabilistic interpretation and collapse of the wave function, Decoherence parameter, Density matrix description of the measurement process, Measurement theories -von Neumann-Wigner approach, Neutron interferometry and quantum Zeno effect, Non-classical states of electromagnetic wave as tools for quantum measurement, Quantum non-demolition measurements.

Quantum Information [25]: Classical information, Shannon entropy, Entangled states, Bloch sphere, von Neumann entropy, Applications of entanglement to quantum information processing, Einstein-Podolsky-Rosen paradox, Bell's inequality, Greenberger-Horne-Zeilinger equality, Optical test of local realistic theories, Quantum teleportation, Quantum cryptography.

Sixth Semester

Core Courses

PHYS06C13: SOLID STATE PHYSICS
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

Crystal Structure [12]: Solids Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg’s Law. Atomic and Geometrical Factor.

Elementary Lattice Dynamics [10]: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit’s Law, Einstein and Debye theories of specific heat of solids. T3 law

Magnetic Properties of Matter [8]: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie’s law, Weiss’s Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

Dielectric Properties of Materials [8]: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.

Ferroelectric Properties of Materials [6]: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

Elementary band theory [10]: Kronig Penny model. Band Gap. Conductor, Semiconductor (P and N type) and insulator. Conductivity of Semiconductor, mobility, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient.

Superconductivity [6]: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation)

Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
5. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
6. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
7. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Practical
Credit: 2
Contact Hours per Week: 4

1. Determination of resistivity and band gap of a semiconductor by four probe method.
2. Determination of the concentration of majority carriers of a semiconductor using Hall effect.
3. Measurement of susceptibility of paramagnetic salt
4. To measure the resistivity of GE semiconductor
5. To measure hysteresis loop of Ferroelectric crystal
6. Experiment on lattice dynamics (diatomic molecule)

PHYS06C14: ELECTROMAGNETIC THEORY
Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4

Contact Hours per Week: 4

Maxwell Equations [8]: Review of Maxwell’s equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density

EM Wave Propagation in Unbounded Media [9]: Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere.

EM Wave in Bounded Media [8]: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence)

Polarization of Electromagnetic Waves [12]: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel’s Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light

Rotatory Polarization: Optical Rotation. Biot’s Laws for Rotatory Polarization. Fresnel’s Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel’s theory. Specific rotation. Laurent’s half-shade polarimeter

Wave Guides [8]: Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission, Optical Fibres:- Numerical Aperture. Step and Graded Indices (Definitions Only).

Electrodynamics and Special Relativity [15]: Relativity Pre-Einstein, Inconsistency with electromagnetic theory, Velocity Addition and Lorentz Transformations, Relativistic Energy momentum, Four vectors and transformation properties, Simple applications to particle decay and elastic collision, Aberration, Doppler effect: examples in modern research, Incompleteness of special relativity, Non-inertial reference frame and the equivalence principle.

Reference Books:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.

2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.

3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning

4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill

5. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning

6. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

7. Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.

8. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.

9. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

Practical
Credit: 2
Contact Hours per Week: 4

1. Verification of Cauchy's relation by plotting a dispersion curve using a Prism Spectrometer

2. Study of Optical Activity with Polarimeter: To calibrate a polarimeter and determine the specific rotation of an optically active substance

3. Polarization by Reflection: Introduction to the method of producing linearly polarized light and testing the electromagnetic theory of reaction of polarized light from a dielectric surface, as expressed in Fresnel's equations

4. Study of Magnetic Hysteresis: To study the phenomena of magnetic hysteresis and determination of ferromagnetic constants.

Department Specific Elective: **PHYS06DSE3** and **PHYS06DSE4**

[Any two of the followings: Nuclear & Particle Physics (Credit 5+1), Soft Matter Physics (Credit 4+2) and Dissertation (Credit 6)]

1. NUCLEAR AND PARTICLE PHYSICS
Credits: 6 (Theory-05, Tutorials-01)

Theory
Credit: 5
Contact Hours per Week: 5

Nuclear properties and models [14]: Properties of nuclei – size, shape, charge distribution,binding energy, spin, electric and magnetic moment, parity. Nature of the nuclear force. Form of nucleon-nucleon potential, charge independence and charge symmetry of nuclear forces. Deuteron problem. Nuclear stability – liquid drop model and semi-empirical mass formula. Evidence for nuclear shell structure, single particle shell model, magic numbers, Fermi gas model, concept of mean field.

Unstable nuclei [10]: Alpha decay, Geiger-Nuttal law, Straggling. Beta decay: Kurie plot, neutrino hypothesis, selection rules. Gamma decay: spectroscopy, isomeric states, internal conversion, Mossbauer effect.

Nuclear reaction and Nuclear Astrophysics [16]: Conservation principles, Q value and threshold, Classification of nuclear reactions. Bohr's postulate of compund nucleus formation. Fission -energy and mass distribution of fragments, Bohr-Wheeler theory of fission. Chain reactions. Nuclear reactors. Fusion – explanation from liquid drop model. Primordial nucleosynthesis, Stellar nucleosynthesis. Heavy element production, r- and s- processes.

Accelerators and Detectors [12]: Interaction of particles and radiation with matter. Bethe-Block formula, Cerenkov detector, Ionisation chamber and GM counter, Scintillation detectors, Semiconductor detectors. Basic principle of calorimetry for detection of highly energetic particles. Basic acceleration mechanisms and introduction to particle accelerators.

Particle Physics [23]: Four fundamental interactions. Quantum numbers – spin, isospin, strangeness, parity, hypercharge. Conservation laws. Particle classification – hadron and lepton. Quark model of hadron – baryon and meson. Gell-Mann plot. Elementary discussion of key experiments that led to the current understanding of unified electro-weak interaction and strong interaction. Standard Model. Elementary exposition of diagrammatic techniques (without actual calculation) used to evaulate cross-sections of production processes and decay rates. Introduction to physics beyond the Standard Model – Flavour oscillation of massive neutrinos in vacuum. Solar neutrino problem.

2. SOFT MATTER PHYSICS

Credits: 6 (Theory-04, Practicals-02)

Theory
Credit: 4
Contact Hours per Week: 4

----- To be Provided Later -----

3. DISSERTATION: Directed Study, Supervised Project etc.