**Syllabus**

**Choice based credit system (CBCS)**

**Department of Physics**

**North Lakhimpur College (Autonomous)**

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**Undergraduate programme**

**(Courses effective from Academic year 2019-20 onwards)**

**Approved by the Meeting of the Board of Studies, Deptt. of Physics**

**Semester wise course structure for B.Sc. in Physics (Major)**

COURSE STRUCTURE AND ALLOTMENT OF PAPERS FOR EACH

SEMESTER EXAMINATON TO BE CONDUCTED BY

THE NORTH LAKHIMPUR COLLEGE (Autonomous)

1. **Core course**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Semester** | **Course** | **Course Code** | **Course Title** | **Teaching scheme** | **Credit** |
| **I** | **Core Course**  **(I&II)** | PHY-CC-T4-101 | Mathematical Physics-I | Theory | 4 |
| PHY-CC-P2-101 | Mathematical Physics-I Lab | Practical | 2 |
| PHY-CC-T4-102 | Mechanics | Theory | 4 |
| PHY-CC-P2-102 | Mechanics Lab | Practical | 2 |
| **II** | **Core Course**  **(III & IV)** | PHY-CC-T4-201 | Electricity and Magnetism | Theory | 4 |
| PHY-CC-P2-201 | Electricity and Magnetism Lab | Practical | 2 |
| PHY-CC-T4-202 | Waves and Optics | Theory | 4 |
| PHY-CC-P2-102 | Waves and Optics Lab | Practical | 2 |
| **III** | **Core Course**  **(V-VII)** | PHY-CC-T4-301 | Mathematical Physics-II | Theory | 4 |
| PHY-CC-P2-301 | Mathematical Physics-II Lab | Practical | 2 |
| PHY-CC-T4-302 | Thermal Physics | Theory | 4 |
| PHY-CC-P2-302 | Thermal Physics Lab | Practical | 2 |
| PHY-CC-T4-303 | Digital Systems and Applications | Theory | 4 |
| PHY-CC-P2-303 | Digital Systems & Applications Lab | Practical | 2 |
| **IV** | **Core Course**  **(VIII-X)** | PHY-CC-T4-401 | Mathematical Physics III | Theory | 4 |
| PHY-CC-P2-401 | Mathematical Physics-III Lab | Practical | 2 |
| PHY-CC-T4-402 | Elements of Modern Physics | Theory | 4 |
| PHY-CC-P2-402 | Elements of Modern Physics Lab | Practical | 2 |
| PHY-CC-T4-403 | Analog Systems and Applications | Theory | 4 |
| PHY-CC-P2-403 | Analog Systems & Applications Lab | Practical | 2 |
| **V** | **Core Course**  **(XI & XII)** | PHY-CC-T4-501 | Quantum Mechanics & Applications | Theory | 4 |
| PHY-CC-P2-501 | Quantum Mechanics Lab | Practical | 2 |
| PHY-CC-T4-502 | Solid State Physics | Theory | 4 |
| PHY-CC-P2-502 | Solid State Physics Lab | Practical | 2 |
| **Discipline Specific Elective**  **(I & II)** | PHY-DS-T4-501 | Classical Dynamics | Theory | 5 |
| Tutorial | 1 |
| PHY-DS-T4-502 | Astronomy and Astrophysics | Theory | 5 |
| Tutorial | 1 |
| **VI** | **Core Course**  **(XIII & XIV)** | PHY-CC-T4-601 | Electro-magnetic Theory | Theory | 4 |
| PHY-CC-P2-601 | Electro-magnetic Theory Lab | Practical | 2 |
| PHY-CC-T4-602 | Statistical Mechanics | Theory | 4 |
| PHY-CC-P2-601 | Statistical Mechanics Lab | Practical | 2 |
| **Discipline Specific Elective**  **(III & IV)** | PHY-DS-T4-601 | Nuclear and Particle Physics | Theory | 5 |
| Tutorial | 2 |
| PHY-DS-T4-602 | Nano materials and applications | Theory | 4 |
| Nanomaterials & applications Lab | Practical | 2 |
| **Total Credit** | | | |  | **108** |

1. **Other course**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Semester** | **Course** | **Course Code** | **Course Title** | **Teaching scheme** | **Credit** |
| **I** | **AECC-I** |  | English communication | Theory | 2 |
| **GE-I** |  | Mechanics | Theory | 4 |
| Practical | 2 |
| **II** | **AECC-II** |  | Environmental science | Theory | 4 |
| **AECC-III** |  | MIL | Theory | 2 |
| **GE-II** |  | Electricity and magnetism | Theory | 4 |
| Practical | 2 |
| **III** | **AEEC-I** |  | Basic instrumentation skills | Theory | 2 |
| **GE-III** |  | Thermal physics and statistical mechanics | Theory | 4 |
| Practical | 2 |
| **IV** | **AEEC** |  | Electrical circuit and network skills | Theory | 2 |
| **GE-IV** |  | Waves and optics | Theory | 4 |
| Practical | 2 |
| **Total Credit** | | | |  | 36 |

**B. Sc PHYSICS (HONOURS)**

**Semester I**

**CORE COURSE PHY-CC-T4-101**

**MATHEMATICAL PHYSICS-I**

**Full marks: 70 (Th-56+IA-14) Credit:4**

**Calculus**:

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, Approximation: Taylor and binomial series (statements only) **(02 Lectures, 03 marks)**

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral **(13 Lectures, 13 marks)**

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(06 Lectures, 07 marks)**

**Vector Calculus**:

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. **(05 Lectures, 04 marks)**

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities. **(08 Lectures, 07 marks)**

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 Theorems and their applications (no rigorous proofs). **(14 Lectures, 08 marks)**

**Orthogonal Curvilinear Coordinates:**

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(06 Lectures, 07 marks)**

**Introduction to probability**, **Dirac Delta function and its properties**:

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson with examples. Mean and variance. Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. **(06 Lectures, 07marks )**

**Reference Books:**

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

 An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning

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

 Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.

 Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book

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

 Mathematical Physics, Goswami, 1st edition, Cengage Learning

 Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press

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

 Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press

**B. Sc PHYSICS (HONOURS)**

**Semester I**

**CORE COURSE PHY-CC-P2-101**

**MATHEMATICAL PHYSICS-I**

**Full marks: 30 Credit: 2**

**PHYSICS LAB- C I LAB: 60 Lectures 30 Marks**

*The aim of this Lab is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.*

 *Highlights the use of computational methods to solve physical problems*

 *The course will consist of lectures (both theory and practical) in the Lab*

 *Evaluation done not on the programming but on the basis of formulating the problem*

 *Aim at teaching students to construct the computational problem to be solved*

 *Students can use any one operating system Linux or Microsoft Windows*

|  |  |
| --- | --- |
| **Topics** | **Description with Applications** |
| 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 |
| Errors and error Analysis | Truncation and round off errors, Absolute and relative errors, Floating point computations. |
| Review of C & C++ Programming  fundamentals | Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If*‐*statement. If*‐*else Statement.* *Nested if Structure. Else*‐*if Statement. Ternary Operator.* *Go to Statement. Switch Statement. Unconditional and* *Conditional Looping. While Loop. Do-While Loop. FOR* *Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects |
| Programs: | 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)** |
| Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods | Solution of linear and quadratic equation, solving |
| Interpolation by 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 (Forward and Backward difference formula) and Integration (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 |
| Solution of Ordinary Differential Equations (ODE)  First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second | First order differential equation  Radioactive decay  Current in RC, LC circuits with DC source  Newton’s law of cooling  Solve the coupled differential equations  for four initial conditions  x(0) = 0, y(0) = -1, -2, -3, -4.  Plot x Vs y for each of the four initial conditions on  the same screen for 0 t 15  The differential equation describing the motion of a  pendulum is 􀯗􀰮􀰣  􀯗􀯧􀰮 􀵌 􀵆 sin􁈺􀟴􁈻. The pendulum is released  from rest at an angular displacement , i. e. 􀟴􁈺0􁈻 􀵌  􀟙 􀜽􀝊􀝀 􀟴􁈺0􁈻 􀵌 0. Solve the equation for = 0.1, 0.5  and 1.0 and plot 􀟴 as a function of time in the range 0 t  8. Also plot the analytic solution valid for small  􀟴 􁈺sin􁈺􀟴􁈻 􀵌 􀟴 |

**Referred Books:**

 Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.

 Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw‐Hill Pub.

 Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn. 2007, Cambridge University Press.

 Elementary Numerical Analysis, K.E. Atkinson, 3 r d Edn. , 2007 , Wiley India Edition.

 Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.

 An Introduction to computational Physics, T.Pang, 2nd Edn. , 2006,Cambridge Univ. Press

 Computational Physics, Darren Walker, 1st Edn., 2015, Scientific International Pvt. Ltd.

**B. Sc PHYSICS (HONOURS)**

**Semester I**

**CORE COURSE PHY-CC-T4-102**

**MECHANICS**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Fundamentals of Dynamics:** Reference frames. Inertial frames; Review of Newton’s Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. **(06 Lectures, 06 marks)**

**Work and Energy:** Work and Kinetic Energy Theorem. Conservative and nonconservative forces. Potential Energy. Energy diagram. 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. **(04 Lectures, 04 marks)**

**Collisions:** Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames. **(03 Lectures, 03 marks)**

**Rotational Dynamics**: 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. **(12 Lectures, 10 marks)**

**Elasticity:** Relation between Elastic constants. Twisting torque on a Cylinder or Wire. **(03 Lectures, 04 marks)**

**Fluid Motion:** Kinematics of Moving Fluids: Poiseuille’s Equation for Flow of a Liquid through a Capillary Tube. **(02 Lectures, 03 marks)**

**Gravitation and Central Force Motion:** Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. **(03 Lectures, 04 marks)**

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) **(06 Lectures, 06 marks)**

**Oscillations:** 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. **(07 Lectures, 06 marks)**

**Non-Inertial Systems:** Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. **(04 Lectures, 03 marks)**

**Special Theory of Relativity:** 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. **(10 Lectures, 07 marks)**

**Reference Books:**

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

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

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

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

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

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

 University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole

* Concept of modern physics, A. Beiser, TataMcGraw-Hill
* Special theory of relativity, A. Ghatak

**Additional Books for Reference**

 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

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

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

**B. Sc PHYSICS (HONOURS)**

**Semester I**

**CORE COURSE PHY-CC-P2-102**

**MECHANICS**

**Full marks: 30 Credit: 2**

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.

2. To study the random error in observations.

3. To determine the height of a building using a Sextant.

4. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c)Modulus of rigidity.

5. To determine the Moment of Inertia of a Flywheel.

6. To determine **g** and velocity for a freely falling body using Digital Timing Technique

7. To determine Coefficient of Viscosity of water by Capillary Flow Method(Poiseuille’s method).

8. To determine the Young's Modulus of a Wire by Optical Lever Method.

9. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.

10. To determine the elastic Constants of a wire by Searle’s method.

11. To determine the value of g using Bar Pendulum.

12. To determine the value of g using Kater’s Pendulum.

**Reference Books**

 Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House

 Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

 A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal

 Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

**B. Sc PHYSICS (HONOURS)**

**Semester II**

**CORE COURSE PHY-CC-T4-201**

**ELECTRICITY AND MAGNETISM**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Electric Field and Electric Potential**

Electric field: Electric field lines. Electric flux. Gauss’ Law with applications to charge distributions with spherical, cylindrical and planar symmetry. **(06 Lectures, 05 marks)**

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace’s and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. **(06 Lectures, 06 marks)**

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. **(10 Lectures, 08 marks)**

**Dielectric Properties of Matter:** Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations between **E**, **P** and **D**. Gauss’ Law in dielectrics. **(08 Lectures, 05 marks)**

**Magnetic Field:** Magnetic force between current elements and definition of Magnetic Field**B**. Biot-Savart’s Law and its simple applications: 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 (1) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field **(09 Lectures, 08 marks)**

**Magnetic Properties of Matter:** Magnetization vector (**M).** Magnetic Intensity(**H).** Magnetic Susceptibility and permeability. Relation between **B, H, M**. Ferromagnetism.B-H curve and hysteresis. **(04 Lectures, 04 marks)**

**Electromagnetic Induction:** Faraday’s Law. Lenz’s Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell’s Equations. Charge Conservation and Displacement current. **(06 Lectures, 07 marks)**

**Electrical Circuits:** AC Circuits: Kirchhoff’s laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. **(04 Lectures, 05 marks)**

**Network theorems:** Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. **(04 Lectures, 04 marks)**

**Ballistic Galvanometer:** Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR **(03 Lectures, 04 marks)**

**Reference Books:**

 Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury,

2012, Tata McGraw

 Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education

 Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

 Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education

 Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.

 Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

**B. Sc PHYSICS (HONOURS)**

**Semester II**

**CORE COURSE PHY-CC-P2-201**

**ELECTRICITY AND MAGNETISM**

**Full marks: 30 Credit: 2**

**PHYSICS LAB-C III LAB 60 Lectures 30 marks**

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 B and its variation in a solenoid (determine dB/dx)

7. To verify the Thevenin and Norton theorems.

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

9. To determine self inductance of a coil by Anderson’s bridge.

10. 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.

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 self-inductance of a coil by Rayleigh’s method.

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

**Reference Books**

 Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

 A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

 Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

 Engineering Practical Physics, S.Panigrahi and B.Mallick, 2015, Cengage Learning.

 A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub.

**B. Sc PHYSICS (HONOURS)**

**Semester II**

**CORE COURSE PHY-CC-T4-202**

**WAVES AND OPTICS**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Superposition of Collinear Harmonic oscillations**: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences. **(05 Lectures, 06 marks)**

**Superposition of two perpendicular Harmonic Oscillations**: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses. **(02 Lectures, 04 marks)**

**Wave Motion:** 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. **(04 Lectures, 05 marks)**

**Velocity of Waves:** Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton’s Formula for Velocity of Sound. Laplace’s Correction. **(06 Lectures, 06 marks)**

**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. **(07 Lectures, 08 marks)**

**Wave Optics:** Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **(03 Lectures, 02 marks)**

**Interference and Interferometer:** 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.**,** 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. **(15 Lectures, 10 marks)**

**Diffraction:** Kirchhoff’s Integral Theorem, Fresnel-Kirchhoff’s Integral formula. (Qualitative discussion only) Fraunhofer diffraction in 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. **(15 Lectures, 11 marks)**

**Holography**: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. **(03 Lectures, 04 marks)**

**Reference Books**

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

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

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

 Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

 The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.

 The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.

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

**B. Sc PHYSICS (HONOURS)**

**Semester II**

**CORE COURSE PHY-CC-P2-202**

**WAVES AND OPTICS**

**Full marks: 30 Credit: 2**

**PHYSICS LAB- C IV LAB 60 Lectures 30 marks**

1. To determine the frequency of an electric tuning fork by Melde’s experiment and verify λ2 –T law.

2. To investigate the motion of coupled oscillators.

3. To study Lissajous Figures.

4. Familiarization with: Schuster`s focusing; determination of angle of prism.

5. To determine refractive index of the Material of a prism using sodium source.

6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.

7. To determine the wavelength of sodium source using Michelson’s interferometer.

8. To determine wavelength of sodium light using Fresnel Biprism.

9. To determine wavelength of sodium light using Newton’s Rings.

10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.

11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.

12. To determine dispersive power and resolving power of a plane diffraction grating.

**Reference Books**

 Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House

 A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

**B. Sc PHYSICS (HONOURS)**

**Semester III**

**CORE COURSE PHY-CC-T4-301**

**MATHEMATICAL PHYSICS-II**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Fourier series**: 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. Complex representation of Fourier series. Expansion of non-periodic functions over an interval, Even and odd functions and their Fourier expansions. **(10 Lectures, 10 marks)**

**Frobenius Method and Special Functions**: 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. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x)) and Orthogonality **(24 Lectures, 21 marks )**

**Some Special Integrals:** Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral)**(04 Lectures, 06 marks)**

**Theory of Errors:** Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line. **(06 Lectures, 07 marks)**

**Partial Differential Equations**: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation. **(14 Lectures, 12 marks)**

**Reference Books:**

 Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.

 Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.

 Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.

 Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub

**B. Sc PHYSICS (HONOURS)**

**Semester III**

**CORE COURSE PHY-CC-P2-301**

**MATHEMATICAL PHYSICS II**

**Full marks: 30 Credit: 2**

*The aim of this Lab is to use the computational methods to solve physical problems. Course will consist of lectures (both theory and practical) in the Lab. Evaluation done not on the programming but on the basis of formulating the problem*

|  |  |
| --- | --- |
| **Topics** | **Description with Applications** |
| Introduction to Numerical computation  software Scilab | Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and  developing the skills of writing a program (2) |
| Curve fitting, Least square fit, Goodness  of fit, standard deviation | Ohms law to calculate R, Hooke’s law to calculate spring constant |
| Solution of Linear system of equations  by Gauss elimination method and Gauss Seidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values 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 in Scilab | Generating and plotting Legendre Polynomials  Generating and plotting Bessel function |
| Solution of ODE  First order Differential equation Euler, modified Euler and Runge-Kutta second  order methods Second order differential equation Fixed difference method  Partial differential equations | First order differential equation   Radioactive decay   Current in RC, LC circuits with DC source   Newton’s law of cooling   Classical equations of motion  Second order Differential Equation   Harmonic oscillator (no friction)   Damped Harmonic oscillator   Over damped   Critical damped   Oscillatory   Forced Harmonic oscillator   Transient and   Steady state solution   Apply above to LCR circuits also   Solve  in the range 1 􀵑 􀝔 􀵑 3 . Plot y and 􀯗􀯬 against x in the given range on the same graph.  Partial Differential Equation:   Wave equation   Heat equation   Poisson equation   Laplace equation |
| Using Scicos / xcos | Generating square wave, sine wave, saw tooth wave   Solution to harmonic oscillator   Study of beat phenomenon   Phase space plots |

**Reference Books:**

 Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press

 Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press

 First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

 Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer

 Scilab by example: M. Affouf 2012, ISBN: 978-1479203444

Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company

 Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing

 www.**scilab**.in/textbook\_companion/generate\_book/291

**B. Sc PHYSICS (HONOURS)**

**Semester III**

**CORE COURSE PHY-CC-T4-302**

**THERMAL PHYSICS**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Introduction to Thermodynamics**

**Zeroth and First Law of Thermodynamics**: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient **(08 Lectures 08 marks)**

**Second Law of Thermodynamics**: 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. **(10 Lectures 08 marks)**

**Entropy**: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot’s Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. **(07 Lectures 07 marks)**

**Thermodynamic Potentials**: Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb’s Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations **(07 Lectures 07marks)**

**Maxwell’s Thermodynamic Relations**: Derivations and applications of Maxwell’s Relations, Maxwell’s Relations:(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. **(07 Lectures 06 marks)**

**Kinetic Theory of Gases**

**Distribution of Velocities**: Maxwell-Boltzmann Law of Distribution of Velocities in anIdeal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines andStern’sm Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Lawof Equipartition of Energy (No proof required). Specific heats of Gases. **(07 Lectures 05 marks)**

**Molecular Collisions**: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. **(04 Lectures 05 marks)**

**Real Gases:** Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew’s Experiments on CO2 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. Comparison with Experimental Curves. P-V Diagrams. Joule’s Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule- Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule- Thomson Cooling. **(10 Lectures 09marks)**

**Reference Books:**

 Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.

 A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press

 Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill

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

**B. Sc PHYSICS (HONOURS)**

**Semester III**

**CORE COURSE PHY-CC-P2-302**

**THERMAL PHYSICS**

**Full marks: 30 Credit: 2**

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 Cu by Angstrom’s Method.

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

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

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

7. To calibrate a thermocouple to measure temperature in a specified Range using

(1) Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

**Reference Books**

 Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House

 A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal

 Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

 A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, Vani Pub.

**B. Sc PHYSICS (HONOURS)**

**Semester III**

**CORE COURSE PHY-CC-T4-303**

**DIGITAL SYSTEMS AND APPLICATIONS**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Introduction to CRO:** 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. **(03 Lectures 05marks)**

**Integrated Circuits** (Qualitative treatment only): 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. **(03 Lectures 06marks)**

**Digital Circuits:** 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 **(06 Lectures 07marks)**

**Boolean algebra:** De Morgan's Theorems. Boolean Laws. Simplification of Logicm Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **(06 Lectures 07 marks)**

**Data processing circuits, Arithmetic Circuits:**: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders.Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. **(10 Lectures 07 marks )**

**Sequential Circuits and Timers:** 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. IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator. **(11 Lectures 07 marks)**

**Shift registers and Counters (4 bits):** Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits)**,** Ring Counter. Asynchronous counters, Decade Counter. SynchronousCounter. **(07 Lectures 06 marks)**

**Computer Organization**: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map. **(06 Lectures 04marks)**

**Intel 8085 Microprocessor Architecture:** 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. **(08 Lectures 07 marks)**

**Reference Books:**

 Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw

 Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.

 Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.

 Digital Electronics G K Kharate ,2010, Oxford University Press

 Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning

 Logic circuit design, Shimon P. Vingron, 2012, Springer.

 Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.

 Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill

 Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

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**B. Sc PHYSICS (HONOURS)**

**Semester III**

**CORE COURSE PHY-CC-P2-303**

**DIGITAL SYSTEMS AND APPLICATIONS**

**Full marks: 30 Credit: 2**

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

2. To test a Diode and Transistor using a Multimeter.

3. To design a switch (NOT gate) using a transistor.

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

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

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

7. To minimize a given logic circuit.

8. Half Adder, Full Adder and 4-bit binary Adder.

9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.

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 make 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 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.

**Reference Books:**

 Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.

 Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.

 Microprocessor Architecture Programming and applications with 8085, R.S. Goankar, 2002, Prentice Hall.

 Microprocessor 8085:Architecture, Programming and interfacing, A. Wadhwa, 2010, PHI Learning.

**B. Sc PHYSICS (HONOURS)**

**Semester IV**

**CORE COURSE PHY-CC-T4-401**

**Mathematical Physics- III**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Unit I: Complex Analysis**

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of 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. **(28 Lectures26 Marks)**

**Unit II: Integrals Transforms**

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, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. **(16 Lectures 15 Marks)**

**Unit III: Laplace Transforms**

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. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. **(16 Lectures 15 Marks)**

**Reference Books:**

* Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
* Mathematics for Physicists, P. Dennery and A.Krzywicki, 1967, Dover Publications
* Complex Variables, A.S.Fokas&M.J.Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
* Complex Variables, A.K. Kapoor, 2014, Cambridge Univ. Press
* Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
* First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlet

**B. Sc PHYSICS (HONOURS)**

**Semester IV**

**CORE COURSE PHY-CC-P2-401**

**Mathematical Physics-III**

**Full marks: 30 Credit: 2**

### Scilab/C++/Mathematica based simulations experiments based on Mathematical Physics problems like

1. Solve differential equations:
2. Dirac Delta Function:

Evaluate, and show it tends to 5.

1. Fourier Series:

Program to sum

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

1. Frobenius method and Special functions:

Show recursion relation

1. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
2. Calculation of least square fitting manually without giving weightage to error, Confirmation of least square fitting of data through computer program
3. Evaluation of trigonometric functions e.g.,*sin θ,* Given Bessel’s function at N points find its value at an intermediate point. Complex analysis: Integrate 1/(x2+2) numerically and check with computer integration.
4. Compute the nth roots of unity for *n* = 2, 3, and 4.
5. Find the two square roots of −5+12*j.*
6. Integral transform: FFT of
7. Solve Kirchhoff’s Current law for any node of an arbitrary circuit using Laplace’s transform.
8. Solve Kirchhoff’s Voltage law for any loop of an arbitrary circuit using Laplace’s transform.
9. Perform circuit analysis of a general LCR circuit using Laplace’s transform.

**Reference Books:**

* Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
* Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
* Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB:

Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896

* A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
* Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
* Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand& Company
* Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing
* https://web.stanford.edu/~boyd/ee102/**laplace**\_ckts.pdfocw.nthu.edu.tw/ocw/upload/12/244/12handout.pdf

**B. Sc PHYSICS (HONOURS)**

**Semester IV**

**CORE COURSE PHY-CC-T4-402**

**ELEMENTS OF MODERN PHYSICS**

**Full marks: 70 (Th-56+IA-14) Credit:4**

**Unit I:**

Planck’s quantum theory, 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. **(11 Lectures, 10 Marks)**

**Unit II:**

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. **(07 Lectures, 07 Marks)**

**Unit III:**

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; 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. **(09 Lectures, 08 Marks)**

**Unit IV:**

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. **(11 Lectures, 10 Marks)**

**Unit V:**

Size and structure of atomic nucleus and its relationship 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 **(06 Lectures, 06 Marks)**

**Unit VI:**

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, 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. **(06 Lectures, 06 Marks)**

**Unit VII:**

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). **(03 Lectures, 03 Marks)**

**Unit VIII: Lasers**

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. **(06 Lectures, 06 Marks)**

**Reference Books:**

* Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
* Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
* Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
* Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill
* Quantum Mechanics: Theory & Applications, A.K.Ghatak&S.Lokanathan, 2004, Macmillan

**Additional Books for Reference**

* Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
* Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W.

Savin, 2ndEdn, Tata McGraw-Hill Publishing Co. Ltd.

* Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
* Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rdEdn., Institute of Physics Pub.
* Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

**B. Sc PHYSICS (HONOURS)**

**Semester IV**

**CORE COURSE PHY-CC-P2-402**

**ELEMENTS OF MODERN PHYSICS**

**Full marks: 30 Credit: 2**

1. Measurement of Planck’s constant using black body radiation and photodetector
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 value of e/m by (a) Magnetic focusing or (b) Bar magnet.
8. To show the tunneling effect in tunnel diode using I-V characteristics.
9. To determine the wavelength of laser source/Na light/Hg light using diffraction of single slit
10. To determine the wavelength of laser source//Na light/Hg light using diffraction of double slits.
11. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating

**Reference Books**

* Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
* Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
* A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Edn, 2011,Kitab Mahal

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**B. Sc PHYSICS (HONOURS)**

**Semester IV**

**CORE COURSE PHY-CC-T4-403**

**ANALOG SYSTEMS AND APPLICATIONS**

**Full marks: 70 (Th-56+IA-14) Credit:4**

**Unit I:**

**Semiconductor Diodes:** 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.

**Two-terminal Devices and their Applications:** (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. **(13Lectures, 12 Marks)**

**Unit II:**

**Bipolar Junction transistors:** 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. **(07 Lectures, 07 Marks)**

**Unit III:**

**Amplifiers:** Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage DividerBias.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 andPower Gains.Classification of Class A, B & C Amplifiers.

**Coupled Amplifier:** Two stageRC-coupled amplifier and its frequency response.

**Feedback in Amplifiers:** Effects of Positive and Negative Feedback on Input Impedance,

Output Impedance, Gain, Stability, Distortion and Noise.  **(18 Lectures 16 Marks)**

**Unit IV:**

**Sinusoidal Oscillators:** Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.Wein bridge oscillator. **(04 Lectures 06Marks)**

**Unit V:**

**Operational Amplifiers (Black Box approach):** 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. **Applications of Op-Amps:** (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector. **(13 Lectures 12 Marks)**

**Unit VI:**

**Conversion:** Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation). **(03 Lectures 03 Marks)**

**Reference Books:**

* Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
* Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
* Solid State Electronic Devices, B.G.Streetman&S.K.Banerjee, 6th Edn.,2009, PHI Learning
* Electronic Devices & circuits, S.Salivahanan&N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
* OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
* Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6thEdn., Oxford University Press.
* Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
* Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
* Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
* Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

**B. Sc PHYSICS (HONOURS)**

**Semester IV**

**CORE COURSE PHY-CC-P2-403**

**ANALOG SYSTEMS AND APPLICATIONS**

**Full marks: 30 Credit: 2**

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 & efficiency.
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.
21. To design a circuit to simulate the solution of a 1st/2nd order differential equation.

**Reference Books:**

* Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
* OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
* Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
* Electronic Devices & circuit Theory, R.L. Boylestad& L.D. Nashelsky, 2009, Pearson

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**B. Sc PHYSICS (HONOURS)**

**Semester V**

**CORE COURSE PHY-CC-T4-501**

**QUANTUM MECHANICS AND APPLICATIONS**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Unit: I**

**Time dependent Schrodinger equation**: 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, Normalization, Linearity and Superposition Principles.Eigenvalues and Eigen functions. Position, momentum, and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum, Wave Function of a Free Particle  **(8 Lectures 8 Marks)**

**Unit: II**

**Time independent Schrodinger equation**-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 **(11 Lectures 10 Marks)**

**Unit: III**

**General discussion of bound states in an arbitrary potential**- 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.  **(11 Lectures 10 Marks)**

**Unit: IV**

**Quantum theory of hydrogen-like atoms**: 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. **(08 Lectures 08Marks)**

**Unit: V**

**Atoms in Electric & Magnetic Fields**: 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** Normal and Anomalous Zeeman Effect.Paschen Back and Stark Effect (Qualitative Discussion only). **(11 Lectures 10 Marks)**

**Unit: VI**

**Many electron atoms**: 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.). **(11 Lectures 10 Marks)**

**Reference Books:**

* A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
* Quantum Mechanics, Robert Eisberg and Robert Resnick, 2ndEdn., 2002, Wiley.
* Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
* Quantum Mechanics, G. Aruldhas, 2ndEdn. 2002, PHI Learning of India.
* Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
* Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
* Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

**Additional Books for Reference**

* Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
* Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
* Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

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**B. Sc PHYSICS (HONOURS)**

**Semester V**

**CORE COURSE PHY-CC-P2-501**

**QUANTUM MECHANICS AND APPLICATIONS**

**Full marks: 30 Credit: 2**

### Use C/C++/Scilab/Mathematica for solving the following problems based on Quantum Mechanics like

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

Here, m is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 (eVÅ)1/2, ħc = 1973 (eVÅ) and m =0.511x106 eV/c2.

1. Solve the s-wave radial Schrodinger equation for an atom:

where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 (eVÅ)1/2, m = 0.511x106 eV/c2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

1. Solve the s-wave radial Schrodinger equation for a particle of mass m:

For the anharmonic oscillator potential

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c2, k = 100 MeV fm-2, b = 0, 10, 30 MeV fm-3In these units, cħ = 197.3 MeV fm. The ground state energy I expected to lie between 90 and 110 MeV for all three cases.

1. Solve the s-wave radial Schrodinger equation for the vibrations of hydrogen molecule:

Where is the reduced mass of the two-atom system for the Morse potential.

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take: m = 940x106eV/C2, D = 0.755501 eV, α = 1.44, ro = 0.131349 Å

**Laboratory based experiments:**

1. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
2. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
3. To show the tunneling effect in tunnel diode using I-V characteristics.
4. Quantum efficiency of CCDs

**Reference Books:**

* Schaum's outline of Programming with C++. J.Hubbard, 2000,McGraw‐Hill Publication Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rd Edn., 2007, Cambridge University Press.
* An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
* Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández.2014 Springer.
* Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
* A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
* Scilab Image Processing: L.M.Surhone.2010 Betascript PublishingISBN:978-6133459274

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**B. Sc PHYSICS (HONOURS)**

**Semester V**

**CORE COURSE PHY-CC-T4-502**

**SOLID STATE PHYSICS**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Unit: I**

**Crystal Structure:** 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. **(11 Lectures 10 Marks)**

**Unit: II**

**Elementary Lattice Dynamics:** 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 **(07 Lectures 07 Marks)**

**Unit: III**

**Magnetic Properties of Matter:** 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. **(09 Lectures 08 Marks)**

**Unit: IV**

**Dielectric Properties of Materials:** Polarization. Local Electric Field at an Atom.Depolarization Field.Electric Susceptibility.Polarizability.ClausiusMosotti 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. **(11 Lectures 10 Marks)**

**Unit: V**

**Ferroelectric Properties of Materials:** Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. **(06 lectures 06 Marks)**

**Unit: VI**

**Elementary band theory:** 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. **(07 Lectures 07 Marks)**

**Unit: VII**

**Superconductivity:** 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 **(09 Lectures 08 Marks)**

**Reference Books:**

* Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.
* Elements of Solid-State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India
* Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
* Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning
* Solid-state Physics, H. Ibach and H. Luth, 2009, Springer
* Solid State Physics, Rita John, 2014, McGraw Hill
* Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
* Solid State Physics, M.A. Wahab, 2011, Narosa Publications

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**B. Sc PHYSICS (HONOURS)**

**Semester V**

**CORE COURSE PHY-CC-P2-502**

**SOLID STATE PHYSICS**

**Full marks: 30 Credit: 2**

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To study the PE Hysteresis loop of a Ferroelectric Crystal.
6. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
7. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 oC) and to determine its band gap.
8. To determine the Hall coefficient of a semiconductor sample.
9. To determine the band gap of a semiconductor by P-N junction.

**Reference Books**

* Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
* Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
* A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
* Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.

**B. Sc PHYSICS (HONOURS)**

**Semester VI**

**CORE COURSE PHY-CC-T4-601**

**ELECTROMAGNETIC THEORY**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Unit: I**

**Maxwell’s Equations:** 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. **(13 Lectures 12 Marks)**

**Unit: II**

**EM Wave Propagation in Unbounded Media:** 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. **(11 Lectures 10 Marks)**

**Unit: III**

**EM Wave in Bounded Media:** 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). **(11 Lectures 10 Marks)**

**Unit: IV**

**Polarization of Electromagnetic Waves:** Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. 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. **(13 Lectures 12 Marks)**

**Unit: V**

**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. **(04 Lectures 04 Marks)**

**Unit V:**

**Wave Guides:** 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 Fibers:** Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only). **(08 Lectures 08 Marks)**

**Reference Books:**

* Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
* Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
* Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
* Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
* Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
* Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

**Additional Books for Reference**

* Electromagnetic Fields & Waves, P.Lorrain&D.Corson, 1970, W.H.Freeman& Co.
* Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
* Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

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**B. Sc PHYSICS (HONOURS)**

**Semester VI**

**CORE COURSE PHY-CC-P2-601**

**ELECTROMAGNETIC THEORY**

**Full marks: 30 Credit: 2**

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.
3. To analyze elliptically polarized Light by using a Babinet’s compensator.
4. To study dependence of radiation on angle for a simple Dipole antenna.
5. To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6. To study the reflection, refraction of microwaves
7. To study Polarization and double slit interference in microwaves.
8. To determine the refractive index of liquid by total internal reflection using Wollaston’s air-film.
9. To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
11. To verify the Stefan`s law of radiation and to determine Stefan’s constant.
12. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

**Reference Books**

* Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
* Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
* A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Ed., 2011, Kitab Mahal
* Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

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**B. Sc PHYSICS (HONOURS)**

**Semester VI**

**CORE COURSE PHY-CC-T4-602**

**STATISTICAL MECHANICS**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Unit: I**

**Classical Statistics:** 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, 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.

**(17 Lectures 16 Marks)**

**Unit: II**

**Classical Theory of Radiation:** 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’sIonization Formula. Rayleigh-Jean’s Law.Ultraviolet Catastrophe. **(10 Lectures 09 Marks)**

**Unit: III**

**Quantum Theory of Radiation:** 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. **(05 Lectures 05 Marks)**

**Unit: IV**

**Bose-Einstein Statistics:** 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. **(14 Lectures 13 Marks)**

**Unit: V**

**Fermi-Dirac Statistics:** 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, White Dwarf Stars, Chandrasekhar Mass Limit. **(14 Lectures 13 Marks)**

**Reference Books:**

* Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
* Statistical Physics, Berkeley Physics Course, F. Reif, 2008, Tata McGraw-Hill Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
* Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
* An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

**B. Sc PHYSICS (HONOURS)**

**Semester VI**

**CORE COURSE PHY-CC-P2-602**

**ELEMENTS OF MODERN PHYSICS**

**Full marks: 30 Credit: 2**

### Use C/C++/Scilab/Mathematica/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
   1. Study of local number density in the equilibrium state (i) average; (ii) fluctuations
   2. Study of transient behavior of the system (approach to equilibrium)
   3. Relationship of large N and the arrow of time
   4. Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
   5. Computation and study of mean molecular speed and its dependence on particle mass
   6. Computation of fraction of molecules in an ideal gas having speed near the most probable speed
2. Computation of the partition function Z(β) for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
   1. Study of how Z(β), average energy <E>, energy fluctuation ∆E, specific heat at constant volume Cv, depend upon the temperature, total number of particles N and the spectrum of single particle states.
   2. Ratios of occupation numbers of various states for the systems considered above
   3. Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.
3. Plot Planck’s law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and low temperature.
4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.
5. Plot the following functions with energy at different temperatures
   1. Maxwell-Boltzmann distribution
   2. Fermi-Dirac distribution
   3. Bose-Einstein distribution

**Reference Books:**

* Elementary Numerical Analysis, K.E.Atkinson, 3rd Edn. 2007, Wiley India Edition Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
* Introduction to Modern Statistical Mechanics, D. Chandler, Oxford University Press, 1987
* Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
* Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer
* Statistical and Thermal Physics with computer applications, Harvey Gould and Jan Tobochnik, Princeton University Press, 2010.
* Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. VandeWouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
* Scilab by example: M. Affouf, 2012. ISBN: 978-1479203444
* Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 9786133459274

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**Discipline Specific Elective (DSE)**

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**B. Sc PHYSICS (HONOURS)**

**Semester V**

**CORE COURSE PHY-DS-T6-501**

**CLASSICAL DYNAMICS**

**Full marks: 100 (Th-80+IA-20) Credit: 6**

*The emphasis of the course is on applications in solving problems of interest to physicists. Students are to be examined based on problems, seen and unseen.*

**Unit: I**

**Classical Mechanics of Point Particles**: Review of Newtonian Mechanics; Application to the motion of a charge particle in external electric and magnetic fields- motion in uniform electric field, magnetic field- gyroradius and gyrofrequency, motion in crossed electric and magnetic fields. Generalized coordinates and velocities, Hamilton’s principle, Lagrangian and the Euler-Lagrange equations, one-dimensional examples of the Euler-Lagrange equations- one-dimensional Simple Harmonic Oscillations and falling body in uniform gravity; applications to simple systems such as coupled oscillators Canonical momenta & Hamiltonian. Hamilton's equations of motion.

**Applications:** Hamiltonian for a harmonic oscillator, solution of Hamilton’s equation for Simple Harmonic Oscillations; particle in a central force field- conservation of angular momentum and energy. **(23 Lectures 25 Marks)**

**Unit: II**

**Small Amplitude Oscillations:** Minima of potential energy and points of stable equilibrium, expansion of the potential energy around a minimum, small amplitude oscillations about the minimum, normal modes of oscillations example of N identical masses connected in a linear fashion to (N-1)-identical springs. **(10 Lectures 10 Marks)**

**Unit: III**

**Special Theory of Relativity:** Postulates of Special Theory of Relativity. Lorentz Transformations. Minkowski space. The invariant interval, light cone and world lines. Space-time diagrams. Time-dilation, length contraction and twin paradox. Four-vectors: space-like, time-like, and light-like. Four-velocity and acceleration. Metric and alternating tensors. Four-momentum and energy-momentum relation. Doppler effect from a relativistic prospect. Concept of four-force. Conservation of four-momentum. Relativistic kinematics. Application to two-body decay of an unstable particle.

**(28 Lectures 30 Marks)**

**Unit: IV**

**Fluid Dynamics:** Density and pressure P in a fluid, an element of fluid and its velocity, continuity equation and mass conservation, stream-lined motion, laminar flow, Poiseuille’s equation for flow of a liquid through a pipe, Navier-Stokes equation, qualitative description of turbulence, Reynolds number. **(14 Lectures 15 Marks)**

**Reference Books:**

* Classical Mechanics, H.Goldstein, C.P. Poole, J.L. Safko, 3rd Edn. 2002, Pearson Education.
* Mechanics, L. D. Landau and E. M. Lifshitz, 1976, Pergamon.
* Classical Electrodynamics, J.D. Jackson, 3rdEdn., 1998, Wiley.
* The Classical Theory of Fields, L.D Landau, E.M Lifshitz, 4thEdn., 2003, Elsevier.
* Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.
* Classical Mechanics, P.S. Joag, N.C. Rana, 1stEdn., McGraw Hall.
* Classical Mechanics, R. Douglas Gregory, 2015, Cambridge University Press.
* Classical Mechanics: An introduction, Dieter Strauch, 2009, Springer.
* Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press

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**Discipline Specific Elective (DSE)**

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**B. Sc PHYSICS (HONOURS)**

**Semester V**

**CORE COURSE PHY-DS-T6-502**

**Astronomy and Astrophysics**

**Full marks: 100 (Th-80+IA-20) Credit: 6**

**Unit: I**

**Astronomical Scales:** Astronomical Scales: Distance, Mass and Time, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities: Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. **(04 Lectures 04 Marks)**

**Unit: II**

**Basic concepts of positional astronomy:** Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits. **(18 Lectures 20 Marks)**

**Unit: III**

**Astronomical techniques**: Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes). **(06 Lectures 06 Marks)**

**Unit: IV**

**Physical principles:** Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium. **(04 Lectures 04 Marks)**

**Unit: V**

**The sun** (Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere.Corona, Solar Activity, Basics of Solar Magneto-hydrodynamics.Helioseismology).

**The solar family** (Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets. **(07 Lectures 07 Marks)**

**Unit: VI**

**Stellar spectra and classification Structure (**Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification). **(05 Lectures 05 Marks)**

**Unit: VII**

**The milky way**: Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus. **(14 Lectures 16 Marks)**

**Unit: VIII**

**Galaxies:** Galaxy Morphology, Hubble’s Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms. **(08 Lectures 08 Marks)**

**Large scale structure & expanding universe:** Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble’s Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter). **(9 Lectures 10 Marks)**

**Reference Books:**

* Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
* Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
* The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
* Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
* K.S. Krishnasamy, ‘Astro Physics a modern perspective,’ Reprint, New Age International (p) Ltd, New Delhi,2002.
* BaidyanathBasu, ‘An introduction to Astro physics’, Second printing, Prentice -

Hall of India Private limited, New Delhi,2001.

* Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

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**Discipline Specific Elective (DSE)**

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**B. Sc PHYSICS (HONOURS)**

**Semester VI**

**CORE COURSE PHY-DS-T6-601**

**Nuclear and Particle Physics**

**Full marks: 100 (Th-80+IA-20) Credit: 6**

**Unit: I**

**General Properties of Nuclei**: Constituents of nucleus and their Intrinsic properties, quantitativefacts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. **(10 Lectures 10 Marks)**

**Unit: II**

**Nuclear Models**: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.  **(11 Lectures 12 Marks)**

**Unit: III**

**Radioactivity decay**:(a) Alpha decay: basics of α-decay processes, theory of αemission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b)beta-decay: energy kinematics for beta-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays’ emission & kinematics, internal conversion. (**11 Lectures 12 Marks)**

**Unit: IV**

**Nuclear Reactions:** Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(08 Lectures 08 Marks)**

**Unit: V**

**Interaction of Nuclear Radiation with matter**: Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter **(08 Lectures 09 Marks)**

**Unit: VI**

**Detector for Nuclear Radiations:** Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT).Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector **(08 Lectures 09 Marks)**

**Unit: VII**

**Particle Accelerators:** Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons. **(05 Lectures 05 Marks)**

**Unit: VIII**

**Particle physics:** Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons.  **(14 Lectures 15 Marks)**

**Reference Books**:

* Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
* Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
* Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
* Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
* Introduction to Elementary Particles, D. Griffith, John Wiley & Sons
* Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
* Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
* Radiation detection and measurement, G.F. Knoll (John Wiley & Sons, 2000).
* Physics and Engineering of Radiation Detection, Syed Naeem Ahmed (Academic Press, Elsevier, 2007).
* Theoretical Nuclear Physics, J.M. Blatt &V.F.Weisskopf (Dover Pub.Inc., 1991)

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**Discipline Specific Elective (DSE)**

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**B. Sc PHYSICS (HONOURS)**

**Semester VI**

**CORE COURSE PHY-DS-T4-602**

**Nano Materials and Applications**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Unit: I**

**NANOSCALE SYSTEMS:** Length scales in physics, Nanostructures: 1D, 2D and 3Dnanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. **(10Lectures 10 Marks)**

**Unit: II**

**SYNTHESIS OF NANOSTRUCTURE MATERIALS:** Top down and Bottom up approach, Photolithography. Ball milling.Gas phase condensation.Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD).Sol-Gel.Electro deposition. Spray pyrolysis. Hydrothermal synthesis.Preparation through colloidal methods.MBE growth of quantum dots. **(08 Lectures 08 Marks)**

**Unit: III**

**CHARACTERIZATION:** X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. (0**8 Lectures 08 Marks)**

**Unit: IV**

**OPTICAL PROPERTIES:** Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure.Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission, and luminescence. Optical properties of heterostructures and nanostructures **(14 Lectures 12 Marks)**

**Unit: V**

**ELECTRON TRANSPORT**: Carrier transport in nanostructures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **(06 Lectures 06 Marks)**

**Unit: VI**

**APPLICATIONS:** Applications of nanoparticles, quantum dots, nanowires, and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching, and optical data storage. Magnetic quantum well; magnetic dots -magnetic data storage.Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). **(14 Lectures 12 Marks)**

**Reference books:**

* C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
* S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
* K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHI Learning Private Limited).
* Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
* M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).
* Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
* Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

**Discipline Specific Elective (DSE)**

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**B. Sc PHYSICS (HONOURS)**

**Semester VI**

**CORE COURSE PHY-DS-P2-602**

**Nano Materials and Applications**

**Full marks: 30 Credit: 2**

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

**Reference Books:**

* C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
* S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
* K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).
* Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

**Generic Elective Papers (GE) (Minor-Physics)**

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**B. Sc PHYSICS (GENERIC ELECTIVE)**

**Semester I**

**GENERIC ELECTIVE PHY-GE-T4-101**

**MECHANICS**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Vectors:** Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. **(4 Lectures 4 marks)**

**Ordinary Differential Equations:** 1st order homogeneous differential equations. 2nd order homogeneous differential equations with constant coefficients. **(6 Lectures 6 marks)**

**Laws of Motion:** Frames of reference. Newton’s Laws of motion. Dynamics of a\ system of particles. Centre of Mass. **(10 Lectures 8marks)**

**Momentum and Energy:** Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets. **(6 Lectures 6 marks)**

**Rotational Motion:** Angular velocity and angular momentum. Torque. Conservation of angular momentum. **(5 Lectures 5 marks)**

**Gravitation:** Newton’s Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler’s Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. Basic idea of global positioning system (GPS). Weightlessness. Physiological effects on astronauts **(8 Lectures 8 marks)**

**Oscillations:** Simple harmonic motion, Differential equation of SHM and its solutions, Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations **(6 Lectures 5 marks)**

**Elasticity:** Hooke’s law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson’s Ratio-Expression for Poisson’s ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire – Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion – Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, *η* and  by Searles method. **(8 Lectures 8 marks)**

**Special Theory of Relativity:** Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities **(7 Lectures 6 marks)**

***Note:*** *Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate*

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**Reference Books:**

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

Addison-Wesley

 Mechanics Berkeley Physics, v.1: Charles Kittel, et. al. 2007, Tata McGraw-Hill.

 Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley

 Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford

University Press

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

**Generic Elective Papers (GE) (Minor-Physics)**

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**B. Sc PHYSICS (GENERIC ELECTIVE)**

**Semester I**

**GENERIC ELECTIVE PHY-GE-P2-101**

**MECHANICS**

**Full marks: 30 Credit: 2**

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.

2. To determine the Height of a Building using a Sextant.

3. To determine the Moment of Inertia of a Flywheel.

4. To determine the Young's Modulus of a Wire by Optical Lever Method.

5. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.

6. To determine the Elastic Constants of a Wire by Searle’s method.

7. To determine g by Bar Pendulum.

8. To determine g by Kater’s Pendulum.

9. To study the Motion of a Spring and calculate (a) Spring Constant, (b) g.

**Reference Books:**

 Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.

 Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

 Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

 A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

**Generic Elective Papers (GE) (Minor-Physics)**

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**B. Sc PHYSICS (GENERIC ELECTIVE)**

**Semester II**

**GENERIC ELECTIVE PHY-GE-T4-102**

**ELECTRICITY AND MAGNETISM**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Vector Analysis**: Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only) **(12 Lectures 10 marks)**

**Electrostatics:** Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric **(22 Lectures 21 marks)**

**Magnetism:** Magnetostatics: Biot-Savart's law and its applications- straight conductor, circularcoil, solenoid carrying current. Divergence and curl of magnetic field. Magneticvector potential. Ampere's circuital law.Magnetic properties of materials: Magnetic intensity, magnetic induction, magnetic susceptibility. Brief introduction of dia, para and ferromagneticmaterials **(10 Lectures 11 marks)**

**Electromagnetic Induction:** Faraday's laws of electromagnetic induction, Lenz's law, self & mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field **(6 Lectures 6 marks)**

**Maxwell`s equations and Electromagnetic wave propagation:** Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization. **(10 Lectures 8 marks)**

**Reference Books:**

 Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education

 Electricity & Magnetism, J.H. Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press

 Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.

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

 D.J.Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

**Generic Elective Papers (GE) (Minor-Physics)**

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**B. Sc PHYSICS (GENERIC ELECTIVE)**

**Semester II**

**GENERIC ELECTIVE PHY-GE-P2-102**

**ELECTRICITY AND MAGNETISM**

**Full marks: 30 Credit: 2**

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.

2. Ballistic Galvanometer:

(i) Measurement of charge and current sensitivity

(ii) Measurement of CDR

(iii) Determine a high resistance by Leakage Method

(iv) To determine Self Inductance of a Coil by Rayleigh’s Method.

3. To compare capacitances using De’Sauty’s bridge.

4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)

5. To study the Characteristics of a Series RC Circuit.

6. To study a series LCR circuit LCR circuit and determine its (a) Resonant frequency, (b) Quality factor

7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and

(b) Quality factor Q

8. To determine a Low Resistance by Carey Foster’s Bridge.

9. To verify the Thevenin and Norton theorems

10. To verify the Superposition, and Maximum Power Transfer Theorems

**Reference Books**

 Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.

 Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

 A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed.2011, Kitab Mahal

**Generic Elective Papers (GE) (Minor-Physics)**

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**B. Sc PHYSICS (GENERIC ELECTIVE)**

**Semester III**

**GENERIC ELECTIVE PHY-GE-T4-103**

**THERMAL PHYSICS AND STATISTICAL MECHANICS**

**Full marks: 70 (Th-56+IA-14) Credit: 4**

**Laws of Thermodynamics:** Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law and Entropy, Carnot’s cycle & theorem, Entropy changes in reversible &m irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. **(20 Lectures 15 marks)**

**Thermodynamical Potentials:** Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell’s relations and applications - Joule-Thompson Effect, Clausius- Clapeyron Equation, Expression for (CP – CV), CP/CV, TdS equations. **(10 Lectures 10 marks)**

**Kinetic Theory of Gases:** Derivation of Maxwell’s law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases **(10 Lectures 10 marks)**

**Theory of Radiation:** Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien’s distribution law, Rayleigh- Jeans Law, Stefan Boltzmann Law and Wien’s displacement law from Planck’s law. **(8 Lectures 8 marks)**

**Statistical Mechanics:** Phase space, Macrostate and Microstate, Entropy and Thermodynamic probability, Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics. **(12 Lectures 13 marks)**

**Reference Books:**

 Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.

 A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.

 Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.

 Heat and Thermodynamics, M.W.Zemasky and R. Dittman, 1981, McGraw Hill

 Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and

G.L. Salinger. 1988, Narosa

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

 Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. chand Publications.

**Generic Elective Papers (GE) (Minor-Physics)**

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**B. Sc PHYSICS (GENERIC ELECTIVE)**

**Semester III**

**GENERIC ELECTIVE PHY-GE-T4-103**

**THERMAL PHYSICS AND STATISTICAL MECHANICS**

**Full marks: 30 Credit: 02**

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

2. Measurement of Planck’s constant using black body radiation.

3. To determine Stefan’s Constant.

4. To determine the coefficient of thermal conductivity of Cu by Searle’s Apparatus.

5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom’s Method.

6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton’s disc method.

7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.

8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.

9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system

10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off- Balance Bridge

**Reference Books:**

 Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.

 Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

 A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

**Generic Elective Papers (GE) (Minor-Physics)**

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**B. Sc PHYSICS (GENERIC ELECTIVE)**

**Semester IV**

**GENERIC ELECTIVE PHY-GE-T4-401**

**WAVES AND OPTICS**

**Full marks: 70 (Th-56+IA-14) Credit: 04**

**Unit: I**

**Superposition of Two Collinear Harmonic oscillations**: Linearity & Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). **(5 Lectures 5 Marks)**

**Unit:II**

**Superposition of Two Perpendicular Harmonic Oscillations**: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and theiruses. **(5 Lectures 5 Marks)**

**Unit:III**

**Waves Motion- 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. **(5 Lectures5 Marks)**

**Unit:IV**

**Fluids:** 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. **(5 Lectures 5 Marks)**

**Unit:V**

**Sound:** 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. **(12 Lectures10 Marks)**

**Unit: VI**

**Wave Optics:** Electromagnetic nature of light.Definition and Properties of wave front.Huygens Principle.

**Interference:** Interference: 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 (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton’s Rings: measurement of wavelength and refractive index.

**Michelson’s Interferometer:** Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes

**(14 Lectures 12 Marks)**

**Unit: VII**

**Diffraction:** Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate.Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. (**10 Lectures 10 Marks**)

**Unit: VIII**

**Polarization:** Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **(4 Lectures 4 Marks)**

**Reference Books:**

* Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
* Principles of Optics, B.K. Mathur, 1995, Gopal Printing
* Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publications
* University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley

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**Generic Elective Papers (GE) (Minor-Physics)**

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**B. Sc PHYSICS (GENERIC ELECTIVE)**

**Semester IV**

**GENERIC ELECTIVE PHY-GE-T4-104**

**WAVES AND OPTICS**

**Full marks: 30 Credit: 02**

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde’s Experiment and to verify λ2 – T Law.
3. To study Lissajous Figures 4.Familiarization with Schuster`s focusing; determination of angle of prism.
4. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille’s method).
5. To determine the Refractive Index of the Material of a Prism using Sodium Light.
6. To determine Dispersive Power of the Material of a Prism using Mercury Light
7. To determine the value of Cauchy Constants.
8. To determine the Resolving Power of a Prism.
9. To determine wavelength of sodium light using Fresnel Biprism.
10. To determine wavelength of sodium light using Newton’s Rings.
11. To determine the wavelength of Laser light using Diffraction of Single Slit.
12. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction Grating
13. To determine the Resolving Power of a Plane Diffraction Grating.
14. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

**Reference Books:**

* Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
* Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
* A Text Book of Practical Physics, InduPrakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

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**Ability Enhancement Elective course (skill enhancement course)**

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**BASIC INSTRUMENTATION SKILLS**

**(Credits: 02)**

**Theory: 30 Lectures Marks: 24**

*This course is to get exposure with various aspects of instruments and their usage through hands-on mode. Experiments listed below are to be done in continuation of the topics.*

**Basic of Measurement:** Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. **Multimeter:** Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance. **(4 Lectures)**

**Electronic Voltmeter:** Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance. **AC millivoltmeter:** Type of AC millivoltmeters: Amplifier- rectifier, and rectifier- amplifier. Block diagram ac millivoltmeter**,** specifications and their significance. **(4 Lectures)**

**Cathode** Ray **Oscilloscope:** Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence & chemical composition. Time base operation, synchronization. Front panel controls. Specifications of a CRO and their significance, **(6 Lectures)**

Use of CRO for the measurement of voltage (dc and ac frequency, time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working. **(3 Lectures)**

**Signal Generators and Analysis Instruments:** Block diagram, explanation and specifications of low frequency signal generators. pulse generator, and function generator. Brief idea for testing, specifications. Distortion factor meter, wave analysis. **(4 Lectures)**

**Impedance Bridges & Q-Meters:** Block diagram of bridge. working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram & working principles of a Q- Meter. Digital LCR bridges. **(3 Lectures)**

**Digital Instruments:** Principle and working of digital meters. Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter. **(3 Lectures)**

**Digital Multimeter:** Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution. **(3 Lectures)**

**The test of lab skills will be of the following test items:**

1. Use of an oscilloscope.

2. CRO as a versatile measuring device.

3. Circuit tracing of Laboratory electronic equipment,

4. Use of Digital multimeter/VTVM for measuring voltages

5. Circuit tracing of Laboratory electronic equipment,

6. Winding a coil / transformer.

7. Study the layout of receiver circuit.

8. Trouble shooting a circuit

9. Balancing of bridges

**Laboratory Exercises:**

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.

2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.

3. To measure Q of a coil and its dependence on frequency, using a Q- meter.

4. Measurement of voltage, frequency, time period and phase angle using CRO.

5. Measurement of time period, frequency, average period using universal counter/ frequency counter.

6. Measurement of rise, fall and delay times using a CRO.

7. Measurement of distortion of a RF signal generator using distortion factor meter.

8. Measurement of R, L and C using a LCR bridge/ universal bridge.

**Open Ended Experiments:**

1. Using a Dual Trace Oscilloscope

2. Converting the range of a given measuring instrument (voltmeter, ammeter)

**Reference Books:**

 A text book in Electrical Technology - B L Theraja - S Chand and Co.

 Performance and design of AC machines - M G Say ELBS Edn.

 Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.

 Logic circuit design, Shimon P. Vingron, 2012, Springer.

 Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.

 Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012,

Tata Mc-Graw Hill

 Electronic circuits: Handbook of design and applications, U.Tietze, Ch.Schenk,

2008, Springer

 Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

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**Semester IV**

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**ELECTRICAL CIRCUITS AND NETWORK SKILLS**

**Course Code: PHYSICS-SE-T2-401**

**Theory: 30 Lectures Marks: 56**

**Distribution of credits: Theory: 02**

*The aim of this course is to enable the students to design and trouble shoots the electrical circuits, networks and appliances through hands-on mode*

**Unit: I**

**Basic Electricity Principles**: Voltage, Current, Resistance and Power, Ohm's law, Series, parallel, and series-parallel combinations, AC Electricity and DC Electricity, Familiarization with multimeter, voltmeter, and ammeter. **(3 Lectures 3 Marks)**

**Unit: II**

**Understanding Electrical Circuits**: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary, and complex power components of AC source.Power factor.Saving energy and money.

**(4 Lectures 6 Marks)**

**Unit: III**

**Electrical Drawing and Symbols**: Drawing symbols. Blueprints.Reading Schematics. Ladder diagrams. Electrical Schematics.Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop. **(4 Lectures 6 Marks)**

**Unit: IV**

**Generators and Transformers**: DC Power sources. AC/DC generators.Inductance, capacitance, and impedance.Operation of transformers. **(3 Lectures 3 Marks)**

**Unit: V**

**Electric Motors**: Single-phase, three-phase & DC motors. Basic design.Interfacing DC or AC sources to control heaters & motors. Speed & power of ac motor.

**(4 Lectures 6 Marks)**

**Unit: VI**

**Solid-State Devices**: Resistors, inductors and capacitors. Diode and rectifiers.Components in Series or in shunt.Response of inductors and capacitors with DC or AC sources. **(3 Lectures 3 Marks)**

**Unit: VII**

**Electrical Protection**: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection.Grounding and isolating. Phase reversal. Surge protection. Interfacing DC or AC sources to control elements (relay protection device). **(4 Lectures 6 Marks)**

**Unit: VIII**

**Electrical Wiring**: Different types of conductors and cables. Basics of wiring-Star and delta connection.Voltage drop and losses across cables and conductors.Instruments to measure current, voltage, power in DC and AC circuits.Insulation.Solid and stranded cable.Conduit.Cable trays. Splices: wirenuts, crimps, terminal blocks, split bolts, and solder. Preparation of extension board. **(5 Lectures 7 Marks)**

**Reference Books:**

* A text book in Electrical Technology - B L Theraja - S Chand & Co.
* A text book of Electrical Technology - A K Theraja
* Performance and design of AC machines - M G Say ELBS Edn.

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