SYLLABUS OFCOURSES FOR STUDENTS OPTING PHYSICS AS THEIR MAJOR SUBJECT

SEMESTER-I

Course Title : Introduction to Mathematical Physics

Course Code : PHY-I.C-1

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives:To develop basic competence in certain areas of mathematics required for understanding several important topics in physics.

Learning outcome: After successful completion of this course, student will comprehend some of the important mathematical concepts and should be able to use these methods to solve several problems in Physics.

Theory:

1. **Vector Analysis** **[6 h]**
   Scalars and vectors, Basis vectors and components, Multiplication of Vectors. Equation of lines and planes. Using vectors to find distances. Reciprocal vectors. Differentiation and Integration of vectors.

   [Riley 7.1, 7.3-7.9, Boas 6.4 , 6.8]

2. **Infinite Series and Power Series** **[6 h]**
   Geometric Series and other infinite series. Convergent and Divergent Series. Testing series for convergence. Power series. Expanding functions in power series. Techniques for obtaining power series expansion.

   [Boas 1.1-1.7, 1.10-1.13]

3. **Complex Numbers** **[6 h]**
   Real and imaginary Parts of a complex number. Complex plane. Complex algebra. Euler's formula. Powers and roots of complex numbers. Exponential and trigonometric functions.

   [Boas 2.1-2.5, 2.9-2.11]

4. **Matrices** **[6 h]**
   Matrix Analysis and Notation, Matrix Operations, Properties of matrices. Transpose matrix. Complex Conjugate Matrix, Hermitian Matrix, Unit matrix, Diagonal matrix, Adjoint and self-adjoint matrix, symmetric matrix, anti-symmetric matrix, unitary matrix, orthogonal matrix, trace of a matrix, inverse matrix.

   [Harper 2.3, 2.4, 2.5 and 2.6]

5. **Partial Differentiation** **[7 h]**
Definition of the partial derivative. Total differentials. Exact and inexact differentials. Theorems of partial differentiation. Chain rule. Thermodynamic relations. Differentiation of Integrals.

[Riley 4.1-4.5, 4.10-4.11]

6. **Ordinary Differential Equation** **[8 h]**
Introduction. Linear differential equation of the first order. Homogenous and inhomogeneous linear differential equation of the second order.

[Boas 8.1-8.6 and Harper 5.1-5.2]

7. **Coordinate Systems** **[6 h]**
Plane polar coordinates. Cylindrical and Spherical polar coordinates.

[Harper 1.6.6, Riley 8.9]

Experiments: (Minimum Six)

1. Least count of Instruments (Vernier Caliper, Screw Gauge, Travelling Microscope and Spectrometer).
2. Error Analysis
3. Application of Error Analysis
4. Plotting of various algebraic and trigonometric functions using Excel.
5. Fitting of given data using Excel.
6. Interpretation of graphs.
7. Solving Integration, Ordinary Differential Equation and Matrices using Mathematica.
8. Tutorial
9. Tutorial

References:

1. K. F. Riley, M. P. Hobson and S. J. Bence, *Mathematical Methods for Physics and Engineering* (Cambridge University Press, 1998)
2. Mary L. Boas, *Mathematical Methods in Physical Sciences* (John Wiley and Sons, 3rd Edition)
3. Charlie Harper, *Introduction to Mathematical Physics*- (Prentice Hall)

Additional References:

1. B. D. Gupta, *Mathematical Physics* (Vikas Publishing House, 2004)
2. M. Spiegel, S. Lipschutz, D. Spellman, *Schaum's Outline of Vector Analysis,* (McGraw Hill Education, 2009)

Course Title : Mechanics I

Course Code : PHY-II.C-2

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives: This course provides an introduction to topics in mechanics, which are essential for advanced work in physics. An objective of this course is to train students to think about some of the physical phenomenon in mathematical terms.

Learning outcome: After successful completion of this course, Students will develop qualitative and quantitative understanding of Newtonian mechanics in one and two dimensions, its conservation laws, Gravitation fields and potentials and their applications to basic physical problems familiar from the everyday world.

Theory:

1. **Newton's Laws of Motion** **[10 h]**
   Brief description of classical view of Space and Time (vector operations). The concept of Mass and Force. Newton's First and Second Laws; Inertial frames. Equations of motion. Interpretation of Newtons third Law as Conservation of Momentum. Newton's Second Law in Cartesian coordinates and in two dimensional Polar coordinates. Applications of Newtons Laws: Atwood Machine, Free fall near surface of the earth, simple harmonic motion and time dependent force.

   [Taylor 1.1-1.7, Kleppner 2.4]

2. **Projectiles and Charged Particles** **[10 h]**
   Motion of projectile in air resistance/drag (function of velocity.) Linear Air Resistance. Horizontal and vertical motion with linear drag, Trajectory and Range in a Linear Medium. Quadratic Air Resistance. Horizontal motion with quadratic drag (ignoring gravity), Motion of a charged particle with a velocity perpendicular to the direction of a uniform constant (1) electric field, (2) magnetic field and (3) electric and magnetic field (crossed) in mutually perpendicular directions. Lorentz force.

   [Taylor 2.1 - 2.7, Symon 3.17]

3. **Momentum and Angular Momentum** **[7 h]**
   Principle of conservation of momentum (Elastic and Inelastic collision), Analysis of Rocket motion. The Centre of Mass, Angular Momentum for a Single Particle. Kepler's second law as a consequence of conservation of angular momentum.

   [Taylor 3.1-3.5]

4. **Work and Energy** **[10 h]**
   Kinetic Energy and Work: Work energy theorem. Potential Energy and Conservative Forces. Force as a Gradient of Potential Energy, Time dependent potential energy (one dimension). Energy for Linear One-Dimensional Systems. Curvilinear one-dimensional systems. Energy of interaction of two particles in one dimension.

   [Taylor 4.1-4.3, 4.5-4.7, 4.9]

5. **Gravitation Field and potentials** **[8 h]**
   Newton's Law of Gravitation. Gravitational field. Gravitational potential energy. Equipotential surface. Gravitational potential and field due to a (1) thin spherical shell, (2) uniform hollow sphere and (3) thin circular plate.

   [Brijlal 5.5-5.8, 5.10, 5.11]

Experiments: (Minimum Six)

1. Dimensions of different solid body
2. Moment of Inertia of a flywheel
3. Atwood Machine
4. Verification of Newton's Second Law using Air Track
5. Conservation of linear momentum using Air Track
6. Spring Mass System: Determining the Spring Constant
7. Simple Pendulum
8. Log Decrement
9. Determining "**g**" using time of flight method using Python

References:

1. John Taylor, *Classical Mechanics*, (University Science Books, 2004)
2. Kleppner and Kolenkow, *Introduction to Mechanics,*(Cambridge University Press, 2013)
3. K. R. Symon, *Mechanics* (Addison Wesley, 1971)
4. Brij Lal and N. Subrahmanyam, *Mechanics and Electrodynamics*, (S. Chand and Company LTD , 2005)

Additional References:

1. Kittle and Knight, Mechanics (Berkeley Physics Course, Vol. 1), (McGraw Hill Education, 2011)
2. D. S. Mathur, *Mechanics* (S. Chand & Co., 2005)
3. R. G. Takawale and P. S. Puranik, *Introduction to Classical Mechanics*, (Tata McGraw-Hill, 1997)
4. Javier E. Hasbun, *Classical Mechanics* (Jones and Bartlett India Pvt. Ltd. 2010)
5. Atam Arya, *Introduction to Newtonian Mechanics,* (Addison-Wesley, 1997))
6. R. G. Takawale and P. S. Puranik, *Introduction to Classical Mechanics* (Tata McGraw-Hill, 1997)
7. Javier E. Hasbun, *Classical Mechanics* (Jones and Bartlett India Pvt. Ltd. 2010)

SEMESTER-II

Course Title : **Heat and Thermodynamics**

Course Code : **PHY-II.C-3**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Course Objectives **:** To acquaint students with fundamental concepts of Thermal Physics and explain the usefulness of these concepts for wide range of applications that include heat engines, refrigerators and air conditioners.

Learning outcome **:** At the end of this course students would understand the movement of heat (energy) and how energy instills movement. More precisely students would be able to relate the effects of changes in temperature, pressure and volume on physical systems at macroscopic scale by analyzing collective motion of their particles.

Theory:

1. **Principle of Thermometry** **[5 h]**

   Review of concept of heat and temperature, Thermometry, Types of thermometers, Centrigrade, Fahrenheit, Rankine Scales and relations between them, Platinum resistance thermometer, Thermocouple (thermoelectric) thermometers.

   [Ref. No. 1: 13.1 – 13.5, 13.15, 13.23]

2. **Laws of Thermodynamics** **[14 h]**

   Thermodynamic system, Thermodynamic variables, Thermodynamic equilibrium, and Thermodynamic processes, Zeroth law of thermodynamics, Concept of work and internal energy, First law of thermodynamics, Isothermal and adiabatic changes, Work done in isothermal and adiabatic changes, Relation between pressure, volume and temperature in adiabatic process, Reversible and irreversible processes, Carnot Heat engine, Carnot cycle for perfect gas, efficiency, Second law of thermodynamics (Kelvin – Planck Statement, Clausius Statement)

   [Ref. No. 1: 4.1, 4.4 – 4.7, 4.10.4, 4.11 - 4.13, 4.20 – 4.24, 4.28]

3. **Equations of State** **[6 h]**

   Equation of state, Andrew's experiment, Amagat's experiment, Van der Waal's equation of State, Critical constants, Reduced equation of state, Boyle temperature.

   [Ref. No. 2: 10.1 -10.6], [Ref. No. 1: 2.6, 2.14]

4. **Applications of First and Second Law of Thermodynamics** **[14 h]**

   Otto cycle and Otto engine, Diesel cycle and Diesel engine, Efficiencies, Introduction to refrigeration, Principle and coefficient of performance, Principle of air conditioning, comfort chart A.C. machine, factors affecting size and capacity of A.C. machines.

   [Ref. No. 2: 4.16 – 4.19], [Ref. No. 1: 4.26, 4.27, Chapter 17]

5. **Concept of Entropy** **[6 h]**

   Changes of entropy during reversible and irreversible process, Temperature – Entropy diagram, Temperature – Entropy diagram of Carnot's cycle, Physical significance of Entropy, Entropy of a perfect gas, Principle of increase of entropy, Third Law of Thermodynamics.

   [Ref. No. 2: 6.9, 6.12], [Ref. No. 1: 5.1 – 5.8]

Experiments: (Minimum Six)

1. Latent heat of ice
2. Calibration of Si diode as a thermometer.
3. Constant volume air thermometer.
4. Constant pressure air thermometer.
5. Thermal conductivity by Lee's method.
6. Thermal conductivity of copper.
7. Temperature coefficient of resistance of copper.
8. Temperature coefficient of resistance of Platinum thermometer using PT-100.

References:

1. Brijlal, Subramanyam N., Hemne P.S., Heat Thermodynamics and Statistical Physics, S. Chand (2007)

2. Saha M.N., Shrivastava B.N., Treatise on Heat, The Indian Press 5th Ed. (1965)

Additional References:

1. Roberts J. K., Miller A.R., Thermodynamics, E.L.B.S. (1960)

2. Zemansky M.W., Ditman R.H., Heat and Thermodynamics, McGraw Hill, 8th Ed. (5th reprint), 2013

Course Title : **Electricity and Magnetism**

Course Code : **PHY-II.C-4**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Course Objectives : The objective of this course is to introduce fundamentals of electricity and magnetism to the students, which is an essential preparation for more advanced courses like Electromagnetic theory.

Learning Outcome : On successful completion of this course, the students will be able to:

- Comprehend basic concepts like: laws of electrostatics and magnetostatics and also related applications.
- Understand the interrelated concepts of Electricity and Magnetism.
- Understand the working of transient circuits and alternating current circuits.
- Correlate the theoretical basis of various concepts of electricity and magnetism while performing experiments.

Theory:

1:Electrostatics **[8 h]**

Coulomb's law: Statement, Vector form of Coulomb's law for like and unlike charges, Variation of force with distance (F.vs.r graph),
Concept of electric field and Electric Field Lines:
Electric field, Electric field due to (i) a Point Charge, (ii) an Electric Dipole, (iii) a Line of Charge and a Charged Disk,
Concept of electric flux: Gauss' Law of electrostatics (Conceptual explanation),
Applications of Gauss law: Coulomb's Law from Gauss' Law, Electric Field due to (i) an isolated uniformly charged sphere, (ii) an uniform distribution of charge throughout the sphere and (iii) an uniformly charged hollow cylinder,
Electric Field near (i) a charged infinite cylindrical conductor or a cable and (ii) a plane of sheet charge
Concept of Electric Potential: Electric Potential Energy, Equipotential Surfaces, Calculating the Potential from the Field
Potential due to (i) a Point Charge, (ii) a Group of Point Charges and (iii) an Electric Dipole
Calculating the Field from the Potential

[Ref. No.1: 22.4, 23.2-23.7, 24.1-24.5, 25.1-25.7, 25.9] [Ref. No.2: 2.4(1-6)]

2 :Capacitors and Dielectrics **[5 h]**

Capacitance: Calculation of capacitance of (i) a Parallel-Plate Capacitor, (ii) a Cylindrical Capacitor and (iii) a Spherical Capacitor; Energy stored in an electric field, Capacitor with a Dielectric, Dielectrics: An Atomic View, Dielectrics and Gauss' Law, Relation between three electric vectors (E, D and P)(Without derivation, qualitative discussion only)

[Ref. No.1: 26.1- 26.3, 26.5-26.8]

3 :Magnetostatics **[7 h]**

Concept of magnetic field: Definition and properties of magnetic field

Biot–Savart's law and its applications: (i) a long straight wire and (ii) a current carrying circular loop (for a point on the axis only)

Ampere's circuital law and its applications: (i) Field of solenoid and (ii) Field of toroidal solenoid

Magnetic Field lines and Magnetic flux; Gauss' law for magnetism

[Ref. No.1: 29.1, 29.2, 30.1, 30.3, 30.4, 32.2][Ref. No.3:27.2, 27.3]

4:Self and Mutual Inductance **[6 h]**

Self induction; Calculation of self inductance of (i) a long solenoid, (ii) long parallel wires and (iii) a coaxial cable

Mutual inductance, Coefficient of coupling; Calculation of mutual inductance between two coaxial solenoids, Mutual inductance of two coils in series

Energy stored in a magnetic field and Energy density of a magnetic field

[Ref. No.4: 5.1, 5.2, 5.8, 5.9] [Ref. No.1:31.8, 31.10, 31.11, 31.12]

5 :Magnetic Properties of Material **[4 h]**

Magnetic Materials, Bohr magneton.

Magnetisation (M), Magnetic Intensity (H) and magnetic induction (B)

Magnetisation, Susceptibility and Magnetic permeability

Relation between B, M and H (without derivation, qualitative discussion only)

. Diamagnetic, paramagnetic and ferromagnetic. Explanation with the help of susceptibility and permeability, Hysteresis

[Ref. No.3:28.8]

6 :Transient Circuits **[6 h]**

Transient currents

Growth and Decay of current in an inductive (L-R) circuit, Physical meaning of time constant

Charging and Discharging of a capacitor through resistor in C-R circuit, Physical meaning of time constant

Charging and Discharging of a capacitor through resistor and inductor in L-C-R circuit: Over damped, Critically damped and Under damped conditions of L-C-R circuit

[Ref. No.4:5.3, 5.4, 5.13, 5.14]

7:Alternating Current Circuits **[9 h]**

Inductive and Capacitive reactance, Variation of inductive reactance and capacitance reactances with frequency

Introduction to vector or phasor diagrams method and its application to A.C. circuits(Series L-R, Series C-R, Series L-C-R and Parallel L-C-R)

Introduction to j-operator method and its application to A.C. circuits(Series L-C-R and Parallel L-C-R)

Physical significance of Series resonance, Parallel resonance, Quality factor and Bandwidth, Graphical representation of resonance

A.C. bridges: Maxwell's inductive bridge, Maxwell's L/C bridge, de Sauty's capacitance bridge, Wien's frequency bridge.

[Ref. No.2:22.3, 22.4, 22.6, 22.7, 22.8, 22.9, 22.10, 22.13, 22.14]
[Ref. No.2: 22.19, 22.20, 22.21(b), 22.22]
[Ref. No.4:6.5, 6.6, 6.7(c), 6.9, 6.14, 6.20, 6.21, 6.22, 6.24]

Experiments: (Minimum Six)

1.Measurement of Dielectric constant of a liquid using two co-axial metal tubes.
2. Susceptibility measurement of a parallel plate capacitor in a dielectric medium
3. Step Response of RC circuit
4 .Transient response of L-C-R circuit using square wave generator and C.R.O.
5. Response of LR and CR circuits to A.C. - phasor diagrams
6. LCR Series and parallel resonance –Resonant frequency, Q value and Bandwidth
7. Determination of Mutual Inductance using LCR series resonance
8. de Sauty's bridge / Maxwells L/C bridge

References:

1. Halliday David, Resnik Robert and Walker Jearl, Fundamentals of Physics, John Wiley & Sons, Inc., 6th Edition (2003)
2. Vasudeva D. N., Fundamentals of Magnetism and Electricity, S. Chand & Company Ltd., 12th Revised Edition (1999)
3. Young Hugh D., Freedman Roger A. and Ford A. Lewis, Sears and Zemansky's University Physics with Modern Physics, Addison-Wesley Publishers, 13th Edition(PDF) (2012)
4. Fewkes J. H. and Yarwood John, Electricity, Magnetism and Atomic Physics, Volume I, Oxford University Press Ltd., 10th Impression (1991)

Additional References:

1. Purcell Edward M., Electricity and Magnetism-Berkeley Physics Course,Volume 2, McGraw-Hill Book Company (PDF)

SEMESTER-III

Course Title : **Electromagnetic Theory – I**

Course Code : **PHY-III.C-5**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Course Objectives **:** To acquaint students with fundamental principles of Electrostatics part of the Electromagnetic Theory.

Learning Outcome **:** At the end of this course students would understand interaction between charges, the concept of electric field, electric potential in vacuum as well as in matter. Students would also learn techniques to solve electrostatic problems.

Pre-requisite: Electricity and Magnetism(PHY-II.C-4) and Introduction to Mathematical Physics(PHY-I.C-1)

Theory:

1. **Vector Analysis** **[8 h]**

   a. **Vector Algebra**: Vector Operations, Vector Algebra: Component form, Triple Products, Position, Displacement and Separation Vectors
   [Ref. No. 1 pp. 1 – 8]

   b. **Differential Calculus:** Ordinary Derivatives**,** Gradient**,** The Operator ∇**,** The Divergence and Curl**,** Product Rules**,** Second Derivatives
   [Ref. No. 1 pp. 13 – 22]

   1.3 Integral Calculus: Line, Surface and Volume Integrals, The fundamental Theorem for Divergences**,** The fundamental Theorem for Curls.
   [Ref. No. 1 pp. 28, Ref. No. 2 pp. 20, Ref. No. 2 pp. 26]

   1.4 Different Co-ordinate Systems: Cartesian Co-ordinate System, Cylindrical Co-ordinate System, Spherical Co-ordinate System, Some Useful Vector Identities with Proofs
   [Ref. No. 2 pp. 36, Ref. No. 2 pp. 30-31]

2. **Electrostatics** **[15 h]**

   a. **The Electric Field**: Coulomb's Law, The Electric Field, Continuous Charge Distributions.

   b. **Divergence and Curl of Electrostatic Fields:** Field Lines, Flux and Gauss's Law**,** The Divergence of E**,** Applications of Gauss's Law**,** The Curl of E.

   c. **Electric Potential:** Introduction to Potential**,** Poisson's Equation and Laplace's Equation**,** Potential of a Localised Charged Distribution**,** Summary: Electrostatic Boundary Condition.

d. **Work and Energy in Electrostatics:** Work Done to Move a Charge**,** The Energy of a Point Charge Distribution**,** The Energy of a Continuous Charge Distribution**,** Comments on Electrostatic Energy.

e. **Conductors:** Basic Properties of Conductor, Induced Charges, Surface Charge and the Force on a Conductor,Capacitors.
[Ref. No. 1, pp. 58 – 103]

3. **Techniques to Solve Electrostatic Problems** **[8 h]**
   a. **Poisson's Equation**
   b. **Laplace's Equation**: Laplace's Equation in One Dimension, Laplace's Equation in Two Dimensions, Laplace's Equation in Rectangular Co-ordinates, Solution to Laplace's Equation in Spherical Co-ordinates (Zonal Harmonics).

   c. **Conducting Sphere ina Uniform Electric Field**

   d. **Electrostatic Images:** Point Charge and Conducting Sphere**,** Line Charge and Line Images.
   [Ref. No. 3 pp. 51 – 67]

4. **Electrostatic Field in Matter** **[8 h]**
   Polarization, Gauss's Law in a Dielectric, Electric Displacement Vector, Electric Susceptibility and Dielectric Constant, Boundary Conditions on the Field Vectors, Boundary Value Problems Involving Dielectric, Dielectric Sphere in a Uniform Electric Field
   [Ref. No. 3 pp. 75 – 93]

5. **Microscopic Theory of Dielectrics** **[6 h]**
   Molecular field in a dielectric: ClausiusMossotti Relation, Polar and Non-Polar Molecules, Induced Dipoles,Langevin's Debye Formula, Permanent Polarization, Ferroelectricity.
   [Ref. No. 3 pp. 101 – 109]

Experiments: (Minimum Six)
1. Vandegraff Generator.
2. Measurement of dielectric constant and susceptibility of liquid using parallel metal plates.
3. Measurement and Study of variation of dielectric constant of $BaTiO_3$ ferroelectric and determination of its Curie temperature.
4. E and D measurement for a parallel plate capacitor and calculation of dielectric constant.
5. Law of Capacitance using Dielectric Constant Measurement Kit.
6. Absolute capacity by ballistic galvanometer.
7. C_1/C_2 by De-Sauty's method using ballistic galvanometer.
8. Dipole Moment and Polarizability of Benzene.

References:
1. Griffiths D. J., Introduction to Electrodynamics, Prentice Hall of India, 3rd Ed. (2011)
2. Harper Charlie, Introduction to Mathematical Physics, Prentice Hall of India, 5th reprint, (1993)
3. Reitz J. R., Milford F. J., Christy R. W., Foundations of Electromagnetic Theory, Addison-Wesley Publishing Company, 3rd Ed., (1979)

Additional Reference:

1. Mukherji U., Electromagnetic Field Theory and Wave Propagation, Narosa Publishing House, (2008)

Course Title : Optics

Course Code : PHY-III.CE-1

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives: The course aims to enable the students to develop understanding towards the different phenomena exhibited by light.

Learning Outcome: On completion of this course, the students will be able to:

- understand the image formation for various optical systems.
- differentiate between optical phenomena like Interference, Diffraction and Polarization.
- correlate the theoretical basis of various concepts of Geometrical Optics and Physical Optics while performing experiments.

Pre-requisite: Nil.

Theory:

Unit-I **[13 h]**

Geometrical Optics: (5 h)

Fundamentals of Reflection and Refraction:Refractive index and optical path, Fermat's Principle of least time, Derivation of the laws of reflection and refraction using Fermat's Principle.
Lenses: thin and thick lenses, Lens equation, Lens maker's formula, Cardinal points of an optical system, Combination of coaxially placed two thin lenses (equivalent lenses) (including derivation for focal length and cardinal points).

[Ref.1: Chapter.1: 1.6, 1.7; Ref.2: Chapter.1: 1.2, 1.3, 1.4; Ref.1: Chapter.4: 4.8, 4.9, 4.10, 4.11, 4.12, 4.15, 4.17; Chapter.5: 5.2, 5.2.1, 5.2.2, 5.2.3, 5.3, 5.10, Chapter.6: 6.1, 6.2]

Lens Aberrations: (4 h)

Introduction, Types of aberrations: monochromatic and chromatic aberration, Monochromatic aberration and its reduction: Spherical aberration, Types of chromatic aberration: Achromatism (lenses in contact and separated by finite distance).

[Ref.1: Chapter.9: 9.1, 9.2, 9.5, 9.5.1, 9.10, 9.11, 9.12, 9.13]

Optical Instruments: (4 h)

Objective and Eyepiece, Huygen's eyepiece, Ramsden's eyepiece, Telescopes, Refracting and Reflecting type of telescopes and Constant deviation Spectrometer.

[Ref.1: Chapter.10: 10.8, 10.10, 10.10.1, 10.11, 10.11.1,10.12, 10.15, 10.15.1, 10.16, 10.16.1, 10.17]

Unit-II **[10 h]**

Interference: (6 h)

Introduction: Superposition of waves, Interference, Coherence, Conditions for Interference, Techniques of obtaining Interference, Young's Double Slit Experiment, Phase Change on reflection: Stoke's law.

[Ref.1: Chapter.14: 14.3, 14.4, 14.4.2, 14.4.4, 14.6, 14.7, 14.8 and Ref.2: Chapter6: 6.3]

Interference in Thin Films: Thin Film, Plane Parallel Film, Interference due to Transmitted light, Haidinger Fringes, Wedge-shaped Film, Newton's Rings.
[Ref.1: Chapter.15: 15.1, 15.2, 15.2.1 to 15.2.5, 15.3, 15.4, 15.5, 15.5.1 to 15.5.4, 15.6, 15.6.1 to 15.6.9]

Interferometry: (4 h)
Michelson's Interferometer: Principle, Construction, Working, Circular Fringes, Localised Fringes, White Light Fringes, Application of Michelson's Interferometer: Measurement of Wavelength and Determination of the difference in the wavelength of two waves.
[Ref.1: Chapter.15: 15.7, 15.7.1 to 15.7.5, 15.8, 15.8.1, 15.8.2]

Unit-III [12 h]

Diffraction: (5h)
Difference between Interference and Diffraction, Types of diffraction: Fresenel Class and Fraunhoffer Class.
[Ref.1: Chapter.17: 17.6, 17.7 and Ref.2: Chapter7: 7.5, 7.6]
Diffraction of Light (Fresnel Class):
Division of cylindrical wave-front into Fresnel's half period strips, Diffraction at straight edge, Diffraction at a narrow wire.
[Ref.2: Chapter.7: 7.9, 7.10, 7.11]

Diffraction of Light (Fraunhoffer Class): (7 h)
Diffraction at a single slit (Central maximum, Secondary maxima and Secondary minima), Diffraction at double slit, Distinction between single slit and double slit diffraction patterns, Missing orders in a double slit diffraction pattern, Diffraction at N slits(only conceptual), Determination of wavelength of a spectral line using Plane Transmission Grating.
Resolving Power, Rayleigh's criterion, Resolving power of telescope and Resolving Power of Prism.
[Ref.1: Chapter.18: 18.2, 18.2.1, pg.431 to 433, 18.4, 18.4.1, 18.4.2, 18.4.3, 18.7, 18.7.1, 18.7.2, 18.7.6 and Chapter.19: 19.1, 19.2, 19.6, 19.7, 19.11]

Unit-IV [10 h]

Polarization:
Polarized Light, Natural Light, Production of Linearly Polarised Light, Anisotropic Crystal, Calcite Crystal, Huygens Theory of Double Refraction in Uniaxial crystal, Nicol prism- its fabrication, working and use, Effect of Polarizer on Natural Light, Effect of Analyser on Plane Polarized Light, Types of Polarized Light, Retardation plates - Quarter wave plate and Half wave plate, Production of Elliptically and Circularly Polarized Lights, Detection of plane, circularly, elliptically polarized lights, Analysis of polarized light, Optical activity, Specific rotation, Simple Polarimeter, Laurent's Half-Shade Polarimeter.
[Ref.1: Chapter.20: 20.3, 20.4, 20.5, 20.5.1 to 20.5.5, 20.7, 20.8, 20.8.1 to 20.8.3, 20.9, 20.9.1, 20.9.2, 20.6.1, 20.6.3, 20.15, 20.17.1, 20.17.2, 20.18, 20.18.1, 20.19, 20.19.1, 20.20, 20.24, 20.24.1, 20.25, 20.26]

Experiments:(Minimum six)

1) Cardinals points of Two lenses
2) Prism Spectrometer: Optical levelling, Angle of Prism
3) Dispersive power of prism

4) Newton's Rings
5) Single Slit Diffraction
6) Diffraction Gratings
7) Brewster's Law
8) Polarimeter
9) Lloyd's Mirror/Biprism (Demonstration)
10) Cylindrical Obstacle (Demonstration)

References:

1. Subhramanyam N., Lal Brij, Avadhanulu M. N., A Text book of Optics, S. Chand & Company Ltd., New Delhi, Firstmulticolour Edition (2006).
2. Singh S. P. and Agarwal J. P., Optics, PragatiPrakashan, 8th Edition (2001).

Additional References:

1. Mathur B. K., Principles of Optics, New Global Printing Press, Kanpur.
2. GhatakAjoy, Optics, Tata McGraw-Hill Publicashing Company Ltd. (1977)
3. Jenkins F. A. and White H. E., Fundamentals of Optics, Tata McGraw-Hill Publishing Company Ltd., (1981)

Course Title **: Modern Physics**

Course Code **: PHY-III.CE-2**

Marks **: 75 (Theory) + 25 (Practical)**

Credits **: 3 (Theory) + 1 (Practical)**

Course Objective:
Modern Physics involves the study of radiation and matter at atomic levels and velocities close to the speed of light. This course will focus on the early development of the theory of atomic structure, wave particle duality, elementary nuclear physics and Lasers. Lectures will help you clarify concepts of modern physics through various conceptual questions and problems.

Learning Outcome:
After completion of this course, students will develop a comprehension of broad knowledge in modern physics. Students will also acquire the necessary skills for critical thinking and problem solving.

Pre-requisite: Nil.

Theory:

1. **Electrons, Nucleus and Atoms:** **[5 h]**
   Determination of e/m for cathode rays. Thomson's model of the atom and qualitative discussion of alpha scattering experiment.Rutherford's model of the atom.Determining upper limit to nuclear dimension. Electron orbits. Failure of Classical Physics.
   [Rajam: Pages 33-36, 44-50, Beiser: 5.1, 5.3, 5.5-5.7]

2. **Brief review of Atomic models:** **[6 h]**
   Atomic Spectra. Frank-Hertz experiment. The Bohr Atom: Quantization of energy. Bohr-Sommerfeld model.Nuclear motion and reduced mass.Bohr's Correspondence Principle.
   [**Beiser: 6.1, 6.3-6.8]**

3. **Particle Properties of waves:** **[4 h]**
   Concepts of Blackbody radiation.The Photoelectric effect.Compton Effect.Experimental verification of the Photoelectric effect.
   [Singh: 1.1-1.3, Beiser: 3.1,3.2, 3.5, Muregeshan: 8.5]

4. **Wave Properties of Particles:** **[6 h]**
   De Broglie's hypothesis. Electron Diffraction experiment of G. P. Thomson. Experiments with bullets, waves and electrons.The interference of electron waves. Watching the electrons. The uncertainty principle and its application.
   [Beiser 4.1, Feynman 1.1-1.8,Muregeshan11.3, 11.4]

5. **Properties of the Nucleus: [3 h]**
   Nuclear sizes. Nuclear spin.Binding energy, B.E versus A plot. Saturation of nuclear forces.
   [Beiser: 21.2, 21.4-21.6]

6. **Nuclear Forces and Models: [5 h]**
   Main characteristics of Nuclear Forces.Meson theory of Nuclear forces.Yukawa potential.Brief discussion of the Liquid drop Model and Shell Model.
   [Beiser: 22.4-22.6]

7. **Radioactivity and Radioactive Decay: [8 h]**
   The law of Radioactivity Decay. Mean lifetime. Half life and Decay constant. Successive radioactive transformation (A-B-C) type, Ideal transient and secular equilibrium.Radioactive series. Carbon dating. Artificial radioactivity.Brief qualitative discussion on apha decay, beta decay and gamma decay.
   [Patel: 2.3, 2.6-2.9, 2.11, 2.13, Beiser: 23.3, 23.6-23.10]

8. **Nuclear Fission and Nuclear Fusion: [4 h]**
   Nuclear fission.The chain reaction. Transuranic elements. Thermonuclear energy
   [Beiser: 24.7-24.10]

9. **Lasers: [4 h]**
   Attenuation of light in an optical media. Thermal Equilibrium. Interaction of light with matter. Einstein's A and B coefficients and their relations. Population inversion. Principal pumping schemes. Ruby Laser and He-Ne Laser. Applications of Laser.
   [Subrahmanyam: 22.1-22.11, 22.16.1, 22.16.3, 22.7]

Experiments: (Minimum Six)

1. Determination of e/m of electrons using Thomson's method.
2. Measurement of k/e.
3. Measurement of diameter of Lycopodium powder.
4. To determine wavelength of Laser source by diffraction of single slit.
5. To determine wavelength of Laser source by diffraction of double slit.
6. Frank Hertz Experiment.
7. Photoelectric effect.
8. Geiger Muller Counter (Demonstration).

References:

1. Beiser, A. 1969, *Perspectives of Modern Physics*, McGraw-Hill Book Company, Singapore.
2. Feynman, R. 2012, *Feynman Lectures on Physics: Quantum Mechanics (Volume - 3)*, Pearson Education, India.
3. Kakani, S. 2011, *Modern Physics*, Viva Books private limited, New Delhi.
4. Murugeshan, R 2009, *Modern Physics*, S. Chand and Company limited, New Delhi.
5. Patel, S. 2011, *Nuclear Physics: An Introduction*, 2nded. New Age Inernational Limited, New Delhi.
6. Rajam, J. 2000, *Atomic Physics*, S. Chand and Company limited, New Delhi.

7. Subrahmanyam, N., Lal, B. and Avadhanulu, M. 2004, *A Textbook of Optics*, S. Chand and Company limited, New Delhi.
8. Singh, K. And Singh, S. 2013, *Elements of Quantum Mechanics*, S. Chand, New Delhi.

Additional References:

1. Ghatak 2012, *Optics*,Mcgraw Hill Education, India.
2. Richtmyer, F., Kennard, E., Cooper, J. 2001, *Introduction to Modern Physics*, 6^{th} ed. McGraw-Hill Book Company, New Delhi.
3. Tipler, P. 2012, *Modern Physics*, WH Freeman, New York.

Course Title : Oscillations, Waves and Sound

Course Code : PHY-III.CE-3

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Prerequisite: Introduction to Mathematical Physics (PHY-I.C-1)

Course Objectives:Simple harmonic motion is one of the fundamental types of motion that exists in nature. The objective of this course is to cover the fundamental physical concepts of Simple harmonic motion, waves and sound.

Learning Outcome: After successful completion of this course, students will be able to

- Understand the behavior of oscillations and waves in nature
- Understand systems of single and multiple harmonic oscillators and appreciate the role of driving and damping harmonic systems.
- Demonstrate understanding of nature of sound waves and the Doppler Effect.

Theory:

1. **Undamped free oscillation [15 h]**

   Different type of equilibria (Stable, unstable and neutral equilibrium). Periodic oscillations and potential well.
   [Mathur: 5.9]

   Differential equation for simple harmonic oscillator and its solutions.Energy of the harmonic oscillator.
   [Taylor: 5.1-5.2]

   Examples of simple harmonic oscillations: spring and mass system, simple and compound pendulum, torsional pendulum, bifilar oscillations, Helmholtz resonator.
   [Mathur: 7.7.1-7.7.5]

   Superposition of two simple harmonic motions of the same frequency along the same line. Superposition of two mutually perpendicular simple harmonic vibrations of the same frequency. Superposition of two mutually perpendicular simple harmonic vibrations and having time periods in the ratio 1:2. Uses of Lissajous' figures.
   [Subrahmanyam: 2.1, 2.2, 2.4, 2.6, 2.9]

2. **Damped Oscillations [8 h]**

Introduction.Differential equation of damped harmonic oscillator and its solution, discussion of different cases (Strong, weak and Critical damping).Logarithmic decrement.Energy equation of damped oscillations.Power dissipation.Quality factor.
[Taylor: 5.4 and Mathur: 8.2-8.4]

3. **Driven Damped Oscillations** **[6 h]**
   Introduction, Differential equation of forced oscillation and its solution (transient and steady state).Resonance.Width of the resonance; the Q factor.The phase at resonance.Velocity resonance.
   [Taylor: 5.5-5.6 and Mathur: 8.9]

4. **Waves and Sound** **[10 h]**
   Transverse vibrations in strings.Velocity of longitudinal waves in gases.Newton's formula for velocity of sound.Velocity in a homogeneous medium.Laplace's correction.Kundt's tube-determination of velocity of sound in a gas and in solids.Intensity level and Bel and Decibel.
   Production and detection of Ultrasonic waves and its applications
   [Khanna 4.2, 5.3-5.5, 11.1, 11.3, 12.1-12.4, 19.6 and Subrah.: 11.23 11.25,11.27]

5. **Doppler Effect:** **[6 h]**
   Explanation of Doppler effect in sound. Observer in rest and source in motion.Source at rest and observer in motion.When both source and observer are in motion.Effect of wind velocity. Doppler effect in light. Applications of Doppler effect.
   [Subrahmanyam: 8.1-8.6]

Experiments: (Minimum Six)

1. To determine the equivalent length of the Kater's pendulum and the acceleration due to gravity using a resonance pendulum.
2. To determine the damping constant using Damped harmonic oscillator
3. To determine the velocity of Sound using Helmholtz resonator
4. To determine the value of acceleration due to gravity using a bar pendulum.
5. To determine the frequency of AC mains using Sonometer.
6. Bifilar suspension: Dependence of the time period on the geometry of non-parallel bifilar suspension.
7. Log Decrement.
8. Velocity of Sound using CRO.
9. Lissajous Figures (Demonstration).

References:

1. Khanna, D. and Bedi, R. 1992, *A Textbook of Sound*, Atma Ram and sons, Delhi.
2. Mathur, D. 2012, *Mechanics*, S. Chand, New Delhi.
3. Taylor, J. 2005, *Classical Mechanics*, University Science Books, USA
4. Subrahmanyam, N. and Lal, B. 1994, Waves and Oscillation, Vikas Publishing House, Noida

Additional References:

1. French, AP 2003, Vibration and Waves, CBS Publisher, India.
2. Halliday, D., Resnick, R. and Walker, J. 2003, Fundamentals of Physics, 6th edition, John Wiley and Sons, USA.
3. Pain, J. 2005, *The Physics of Vibration and Waves*, 6th Edition, Wiley.

Course Title	**: Properties of Matter and Acoustics**
Course Code	**: PHY-III.CE-4**
Marks	**: 75 (Theory) + 25 (Practical)**
Credits	**: 3 (Theory) + 1 (Practical)**

Course Objectives: This course provides an introduction to dynamics of rigid bodies and calculation of moment of inertia, properties of matter and acoustics of rooms. An objective of this course is to build up an understanding of fundamental physical principles which are required for most of other physical sciences.

Learning Outcome: After successful completion of this course,

- Students will gain an introductory knowledge of dynamics of rigid bodies, and its applications to basic physical problems.
- They will have knowledge of acoustics of rooms and musical scales.
- Students will be able to comprehend the phenomenon of elasticity, surface tension, viscosity and their application.

Pre-requisite: Nil.

Dynamics of Rigid bodies: [11 h]

Rigid bodies, Rotational Kinetic energy, Moment of inertia and its physical significance, Angular acceleration, angular moment, law of conservation of momentum, Analogy between translatory and rotatory motion, Theorem of perpendicular axis, Theorem of parallel axis, Moment of inertia of thin uniform bar, Moment of Inertia of a bar about an axis passing through one end and perpendicular to its length, Moment of Inertia of a bar about an axis perpendicular to its at a distance 'a' from one end, Moment of inertia of rectangular lamina, Moment of inertia of solid uniform bar of rectangular cross section, Moment of inertia of ring, Moment of inertia of disc, ,Moment of inertia of Annular disc, Moment of inertia of hollow cylinder, Moment of inertia of solid sphere, ,Moment of inertia of hollow sphere, Moment of inertia of spherical shell, ,Moment of inertia of a uniform elliptical lamina, Moment of inertia of a uniform triangular lamina, Moment of inertia of a solid cone.

[Reference#1 : Section 3.1-3.25]

Properties of Matter Elasticity: [12 h]

Modulii of elasticity, Poisson's ratio and relationship between them.Bending of beams-bending moment, flexural rigidity. Cantilever (rectangular bar). Depression of a beam supported at the ends and loaded at the center. A vibrating cantilever.Torsion in a string-couple per unit twist, Torsional Pendulum.

[Reference # 2, Section 8.8, 8.9, 8.12, 8.13, 8.14, 8.15, 8.16, 8.17, 8.18, 8.22, 8.26, 8.29, 8.30(a(i)), 8.32, 8.33(i)]

Surface Tension: **[6 h]**

Brief review of molecular theory of surface tension.Relation between surface tension and surface energy. Excess pressure inside a spherical Liquid drop, difference of pressure across a curved surface,Angle of contact. Capillarity-rise of liquid in a capillary tube.

[Reference # 2, Section 14.1, 14.2, 14.3, 14.4 14.6, 14.8, 14.14, 14.15 and 14.17]
[Reference #1 section 8.7 -8.9]

Viscosity **[9 h]**

Equation of continuity: Euler's equation for liquid flow, Bernoulli's theorem and its applications. Streamline flow, Turbulent flow, Critical velocity, Coefficient of viscosity, Poiseuille's formula for flow of liquid through a capillary tube. Criticism of Poiseuille's equation

[Reference # 2, Section 12.1 - 12.12 (12.8 upto equation b)]

Acoustics of Rooms and Musical Scales **[7 h]**

Reverberation of Sound, Reverberation time, Absorption coefficient, Sabine's formula for reverberation time (discussions only) , Acoustic requirements of an auditorium. Musical interval, harmony, melody.Diatonic scale.Tempered scale. (only concepts)

[Reference # 3,Section: 23.1-23.17, Section:17.1-17.12]

Experiments: (Minimum Six)

1) Cantilever : Determination of Young's modulus by vertical vibrations of a cantilever.
2) Torsional Pendulum : Determination of Rigidity Modulus of the material of a wire.
3) Jagger's Method : Determination of Surface Tension
4) Viscosity of a liquid by Poiseuilles method
5) Bending of beams: determination of Young's modulus
6) Capillarity: determination of Surface tension
7) Flat Spiral Spring: determination of elastic constants by vertical and torsional oscillations of a loaded spring
8) Young's Modulus of Brass by Flexural Vibrations of Bar.
9) Rigidity Modulus of Brass.

References:

1) Properties of matter by Brij Lal N. Subrahmanyam, Eurasia Publishing House New Delhi (1999)
2) Elements of Properties of Matter, by D. S. Mathur, S. Chand and Company, New Delhi.
3) Text book of Sound. D. R. Khanna and R.S. Bedi, Atma Ram, New Delhi (1994).

Additional References:

1) Sound. F. G. Mee, Heinemann Ltd., London (1967)
2) Newman and Searle, General properties of Matter
3) C. J. Smith, Properties of Matter

<u>**SEMESTER-IV**</u>

Course Title : Quantum Mechanics

Course Code :PHY-IV.C-6

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1(Practical)

Course Objectives: The objective of this course is to provide an introduction to quantum mechanics and its application.

Learning Outcome: On successful completion of this course, the students will be able to

1. develop a knowledge of the origin of Quantum Physics.
2. understand the wavelike properties of matter and interpret experiments displaying it.
3. understand the concepts and principles of quantum mechanics.
4. solve the Schrödinger equation to obtain wave functions for some important types of potential in one dimension.

Pre-requisite: Nil

Theory:

1. Review of Particle-like Properties of Radiation: [3 h]

Black body radiation and Plank's constant. Einstein's quantum theory of the Photoelectric effect. Compton effect. The dual nature of electromagnetic radiation.

[Singh: 1.1-1.3], [Eisberg: 2.1-2.5]

2. De Broglie's Postulate - Wavelike properties of Particles: [12 h]

2.1. Dual nature of matter: Experiments with bullets, waves and electrons. The interference of electron waves. Watching the electrons.

[Feynman: 1.1-1.6]

2.2. Matter Waves: De Broglie's postulate. Davisson and Germer experiment. Electron diffraction experiment of G. P. Thomson. Review of the Bohr's postulate about stationary states in the light of De Broglie's concepts.

[Eisberg: 3.1], [Singh: 2.8]

2.3. Properties of Matter waves: Wave and group velocities. Relation between the group velocity and phase velocity. Velocity of De Broglie wave. Wave packet and its motion in one dimension.

[Singh: 2.3-2.5, 2.9]

2.4. **The Philosophy of Quantum Theory**: Copenhagen interpretation of Bohr and Heisenberg; points of view of Einstein and De Broglie.

[Eisberg: 3.6]

3. Heisenberg's Uncertainty Principle: [5 h]

Uncertainty principle. Elementary proof of Heisenberg's uncertainty relation between position and momentum. Elementary proof of Heisenberg's uncertainty relation between energy and time. Illustration of Heisenberg's uncertainty principle with thought-experiments. Consequences of the uncertainty relation.

[Singh: 3.1-3.5]

4. Schrödinger's Theory of Quantum Mechanics: [10 h]

4.1 **Max Born's Interpretation of the wave function**: Wavefunction. Complex character of the wave function. Wave function as computational devices. Probability density. Acceptable wave function.Normalisation of wave function.

[Beiser: 4.2], [Eisberg: 5.3, 5.6]

4.2 **Schrödinger's Wave Equation:** One dimensional time-dependent Schrödinger's wave equation. One Dimensional Time-Independent Schrödinger's Wave Equation. Operators in quantum mechanics: position, momentum, kinetic energy, Hamiltonian, total energy, angular momentum. Eigen function, Eigenvalue and Eigenvalue equation. Expectation values. Postulates of quantum mechanics.

[Singh: 4.1 – 4.6]

5. **Applications of Schrödinger's Steady state equation: [15 h]**

5.1 Free particle.

5.2 One dimensional infinite rectangular potential well (Particle in a one dimensional box). Concept of parity, parity operator and its eigen values.

5.3 Particle in a three dimensional rigid box. Degree of degeneracy.

5.4 One dimensional step potential of finiteheight (Energy less than step height and energy greater than step height)

5.5 One dimensional potential barrier. Tunnel effect. Tunnel diode. Qualitative discussion of alpha decay,

5.6 One dimensional finite rectangular potential well(placed symmetric to origin). Parity and parity operators,

5.7 One dimensional harmonic oscillator (Algebraic method using raising and lowering operators and analytical method.)

[Singh: 5.2],[Eisberg: 6.2 – 6.9], [Griffiths: 2.3]

Experiments:

1. Stefan's law
2. Photo-electric effect
3. Tunnel Diode I-V Characteristics: Tunnel Effect
4. Tutorial based on De Broglie's hypothesis and Dual nature of radiation/ matter
5. Tutorial based on Concepts of Wave Packets: Group Velocity and Phase Velocity
6. Tutorial based on Concepts of Uncertainty Principle
7. Tutorial based on Concepts of Wave function: Normalisation, Probability distribution and Expectation Values
8. Tutorial based on Quantum mechanical Operators
9. Tutorial-I based on Application of One dimensional Time-Independent Schrodinger's Wave Equation
10. Tutorial-II based on Application of One dimensional Time-Independent Schrodinger's Wave Equation

References:

1. Beiser, A. 1969, *Perspectives of Modern Physics*, McGraw-Hill Book Company, Singapore.
2. Eisberg, R. And Resnick, R. 2010, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles*, 2nd Edition, Wiley India Pvt Ltd.
3. Feynman, R. 2012, *Feynman Lectures on Physics: Quantum Mechanics (Volume - 3)*, Pearson Education, India.
4. Griffiths, D. 2015, *Introduction to Quantum Mechanics*, Pearson Education, India.
5. Singh, K. And Singh, S. 2013, *Elements of Quantum Mechanics*, S. Chand, New Delhi.

Additional References:

1. Flugge, S. 2008, *Practical Quantum Mechanics*, Springer (SIE).
2. Rajasekar, S. and Veluswamy, R. 2014, *Quantum Mechanics I: The Fundamentals*, CRC Press, New York.
3. Richtmyer, F., Kennard, E., Cooper, J. 2001, *Introduction to Modern Physics*, 6th ed. Tata McGraw-Hill Book Company, New Delhi.
4. Verma, H. 2012, *Quantum Physics*, TBS, Calicut.
5. Wichmann, E. 2010, *Quantum Physics: Berkeley Physics Course Vol 4*, Tata McGraw-Hill Book Company, New Delhi.

Course Title : **Electronics-I**

Course Code : **PHY-IV.CE-5**

Marks : **75 (Theory) + 25 (Practical)**

Credits :**3 (Theory) + 1 (Practical)**

Course Objectives: The general goal of this course is to allow the students to understand the fundamentals of semiconductor behavior and the operation of basic semiconductor devices. This course lays the foundations for the understanding of more advanced semiconductor devices such as those covered in more advanced courses.

Learning Outcome: In this course, students will study basic circuit laws; semiconductor based analog circuits from a fundamental point of view. It extends this knowledge to descriptions of bipolar transistors and its applications. A discussion of feedback leads to the study of operational amplifier and sinusoidal oscillators.
Pre-requisite: Nil

Theory:

1. **Basic concepts and resistor circuits** **[8 h]**
   Basics of current and voltages in a circuit, Constant voltage and Constant current source, Conversion of voltage source into current source, Maximum power transfer theorem, Kirchoff's Current and voltage Law, Thevenin's theorem and Norton's theorem,Techniques for solving circuit problems.
   [Reference #1 section1.1, 1.2.1.3, 1.2.3, Reference #2 section 1.8-1.16]

2. **Semiconductor Diodes** **[10 h]**
   Semiconductor materials- intrinsic and extrinsic types, Ideal Diode, Terminal characteristics of diodes: p-n junction under open circuit condition, p-n junction under forward bias and reverse bias conditions, Diode I-V characteristic and load line for a simple diode circuit,Diodeapplications:Voltage dropper, Diode limiter, Variable diode clipper, Diode clamp, Rectification-working of Half wave and Full wave – calculation of efficiency, nature of rectifier output, comparison of rectifiers, Power supply filters (capacitor filter)
   [Reference #1 section 3.1.3, 3.1.4, 3.2.1-3.2.4, Reference #2 section 5.8-5.18,6.7-6.21]

3. **Bipolar Junction Transistors (BJTs)** **[10 h]**
   Physical structure and operation modes, Transistor action, Transistor as an amplifier, Basic BJT amplifier configuration: common emitter, common base and common collector connections and their characteristics, comparison of transistor connections, Transistor as an amplifier in C-E mode, Active region operation of transistor, D.C. analysis of transistor circuits, performance of transistor amplifier, cut off and saturation points, power rating of

transistor.Biasing the BJT: fixed bias, emitter feedback bias, collector feedback bias and voltage divider bias.
[Reference #2 section 8.1- 8.23, 9.1-9.12, Reference #1 section 4.1-4.4]

4. **Sinusoidal oscillators** **[8 h]**
   Positive and negative feedback,Voltage and current feedback, series and shunt feedback, Effect of negative feedback on gain, frequency response, input and output resistance and distortion, Positive feedback, Barkhausen criterion for oscillations, Phase shift oscillator, Wein bridge oscillator, Hartley oscillator and Colpitts oscillator.
   [Reference #2 section13.1-13.13 ,14.1-14.14, Reference #1 section 7.3-7.3.4.1]

5. **Operation Amplifier (Op-amps)** **[9 h]**
   Ideal Op-amp, operation of differential amplifier, differential and common mode signals, common mode rejection ratio (CMRR), d.c. analysis of differential amplifier , parameters of differential amplifier due to mismatch of transistors,bandwidth of an Op-amp, Slew rate limiting, Frequency response, Practical op-amp circuits: inverting amplifier, non –inverting amplifier, integrator, differentiator.
   [Reference #2 section 25.1-25.5,25.9,25.11,25.15,25.19,25.21,25.23,25.35,25.37, Reference #1 section 6.1,6.3,6.4]

Experiments: (Minimum Six)
1. Half wave rectifier using Junction Diode
2. Full wave rectifier using Junction Diode
3. Bridge rectifier with capacitor filter- Ripple factor using CRO.
4. C.E. Amplifier: Gain v/s Load
5. C.E. Amplifier :Input and Output Impedance
6. C.E. Amplifier. Fequency response. Calculation of Gain Bandwidth product
7. OP-Amp: Characteristics Input and Output impedance
8. OP-Amp: Inverting and Non-inverting amplifier
9. Colpitts Oscillator
10. Wein's Bridge Oscillator

References:
1) Dennis L. Eggleston, Basic Electronics for Scientists and Engineers, CAMBRIDGE UNIVERSITY PRESS, First edition, 2011
2) V.K.Mehta,Rohit Mehta, Principles of Electronics,S. Chand and co. Ltd.

Additional References:
1) KalSaantiram, Basic Electronics: Devices, Circuits and IT fundamentals
2) Malvino, Electronic Principles, the McGraw- Hill companies
3) Mottershead Allen, Electronics Devices and Circuits An Introduction, Prentice-Hall of India Pvt. Ltd., New Delhi, 23rd Printing, (2000)

Course Title : Solid State Devices

Course Code : PHY-IV.CE-6

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1(Practical)

Course Objectives: The objectives are to provide a clear explanation of the operation of most commonly used solid state devices.

Learning Outcome: On successful completion of this course, the students will be able to understand the performance and usages of most of the solid statedevices.

Pre-requisite: Nil

Theory:

1. Basic Semiconductor and pn-Junction Theory: [10 h]

The Atom, Electron Orbit and Energy Levels, Energy Bands, Conduction in Solids, Conventional Current and Electron Flow, Bonding Forces between Atoms, Classification of Solids, Intrinsic Semiconductor, Conduction of Electrons and Holes, *p*-Type and *n*-Type Semiconductors, Effect of Heat and Light, Drift Current and Diffusion Current, The *pn*-Junction, Reverse-biased Junction, Forward-biased Junction, Temperature Effect, Mobility and Conductivity, Hall Effect and Hall Coefficient.

[Ref.1: Chapter 1 and Ref.2: Chapter 1: 1.8 and1.9]

2.Special Diodes: [6 h]

Zener Diode, Use of Zener Diode as voltage regulator and as Peak Clipper, Meter Protection, Tunneling Effect, Tunnel Diode, Tunnel Diode as Oscillator, Varactor, PIN Diode, Schottky Diode, Step Recovery Diode.

[Ref.3: Chapter 15]

3. Optoelectronic Devices: [8 h]

Light Units, Photomultiplier tube, Photoconductive Cell, Photovoltaic Cell, Photodiode, Solar Cell, Phototransistor, PhotoFET, Spectral response of Human eye, Light Emitting Diode(LED), Liquid Crystal Display(LCD), Optoelectronic Couplers, Laser Diode, Light Dependent Resistor (LDR).

[Ref.1: Chapter 19: 19-1 to 19-7, 19-9, 19-11, 19-12 and Ref.3: 16.1 to 16.3]

4. Breakdown Devices: **[12 h]**

Silicon Controlled Rectifier(SCR), SCR Characteristic and Parameters, Simple applications of SCR: HWR, Battery-charging regulator and Temperature Controller, Silicon Controlled Switch (SCS), Gate Turn Off switch (GTO), Light Activated SCR (LASCR), Shockley Diode, The TRIAC and DIAC, Typical Diac-Triac Phase control circuit, The Unijunction Transistor(UJT), UJT Characteristics, UJT Parameter and Specification, UJT Relaxation Oscillator, UJT Control of SCR, Programmable Unijunction Transistor.

[Ref.1: Chapter 18: 18-1, 18-2, 18-4, 18-6 to 18-11; Ref.4: Chapter 21: 21.6 to 21.10 and Ref.5: Chapter 28: 28-4]

5. Field Effect Transistors: **[9 h]**

Advantage and Disadvantage of The FET, Basic Construction of JFET, Characteristics curves of The JFET, Principle of operation of The JFET, Effect of V_{DS} on Channel Conductivity, Channel Ohmic Region and Pinch-Off Rergion, Characteristic Parameters of The FET, Effect of Temperature on FET Parameters, The MOSFET, The Depletion MOSFET, The Enhancement MOSFET, The difference between JFETs and MOSFETs, Dual Gate MOSFET, FET used in Phase-Shift Oscillator Circuit, Applications of FET in its Channel Ohmic Region, FET as a VVR in Voltage controlled Attenuator and in an Automatic Gain Controlled Circuit, Field-Effect Diode and its use as CRD, Power MOSFETs.

[Ref.5: Chapter 21: 21-1 to 21-8, Chapter 22: 22-1 to 22-5, 22-9, 22-10;
Ref.1: Chapter 8: 8-9]

Experiments: **(Minimum six)**

1. Energy Gap of a Semiconductor
2. Energy Gap of a LED.
3. Zener Diode Characteristics and Voltage regulation
4. LDR Characteristics
5. LED VI Characteristics
6. Phototransistor
7. SCR characteristics and gate controlled ac half wave rectifier
8. UJT Characteristics and its use in relaxation oscillator
9. FET Characteristics
10. Solar Cell.
11. SCR, Diac, Triac Characteristics.

References:

1. Bell David A., Electronics Devices and Circuits, Prentice-Hall of India Pvt. Ltd., New Delhi, 3rd Edition (2000).
2. Singh Kamal and Singh S. P., Solid State Devices and Electronics, S. Chand & Company Ltd., New Delhi, 1st Edition (2007).
3. Theraja B. L., Basic Electronics (Solid State), S. Chand and Company Ltd., New Delhi, 1st Multicolour Edition (2005).
4. Boylestad Robert and Nashelsky Louis, Electronic Devices and Circuit Theory, Prentice-Hall of India Pvt. Ltd., New Delhi, 6th Edition (2000).
5. Mottershead Allen, Electronics Devices and Circuits An Introduction, Prentice-Hall of India Pvt. Ltd., New Delhi, 23rd Printing, (2000).

Course Title : **Computational Physics**

Course Code : **PHY-IV.CE-7**

Marks : **75 (Theory) + 25 (Practical)**

Credits : **3 (Theory) + 1 (Practical)**

Course Objectives: The course aims to enable the students to solve problems in Physicswhich involves numerical methods by using FORTRAN as aprogramming language.

Learning Outcome: On completion of this course, the students will be able to:

- Understand various numerical methods
- Use FORTRAN language for numerical calculations
- Understand various concepts of Physics using numerical methods using FORTRAN as a programming language.

Pre-requisite: Nil
Theory:
1. Concepts of programming: **[5 h]**
Definition and Properties of algorithms, Algorithm development, Flow charts- symbols and simple flowcharts.

2. FORTRAN Programming **[20 h]**
Evolution of Fortran.
Simple Fortran Programs:
Writing a Program, Input statements, Some Fortran program examples.
Numerical Constants and Variables:
Constants, Scalar Variables, Declaring Variable Names, Implicit Declaration, Named Constants.
Arithmetic Expressions:
Arithmetic Operators and Modes of Expression, Integer Expressions, Real Expressions, Precedence of Operations in Expressions, Assignment Statements, Defining Variables, Some problems due to rounding of real numbers, mixed mode expressions, Intrinsic functions, Examples of Use of Functions.
Input-Output Statements:
List-directed input statements, List-directed output statements.
Conditional Statements:
Relational Operators, The block IF construct, Example programs Using IF structure.
Implementing Loops in Program:
The block DO loop, count control DO loop, Rules to be followed in writing DO loops.
Logical expressions and More Control statements:

Introduction, Logical constants, variables and expressions, precedence rules for logical operators, Some examples of use of Logical expressions, The case statements.
Functions and subroutines:
Introduction, function subprogram, syntax rules for function subprograms, Generic functions, Subroutines, Internal Procedures.

Defining and Manipulating Arrays:
Arrays Variables, Use of multiple subscripts, Do type notation for Input/Output Statements, Initializing arrays, Terminology used for multidimensional arrays, use of arrays in DO loops, whole array operations.
[Ref.1: Chapter-1 to Chapter-10]

3. Computational Physics: [20 h]
Errors in Computation:
Inherent errors in storing, Numbers due to finite bit representation to use in Computer, Truncation error, round off errors (Explain with the help of examples)
Iterative methods:
Discussion of algorithm and flowcharts and writing FORTRAN programs for finding single root of equation using bi-section method, Newton-Raphson method.
Least Square Curve fitting:
Discussion of algorithm and flowcharts and writing FORTRAN program for straight line fit with example in physics.
Numerical Integration:
Discussion of algorithm and flowcharts and writing FORTRAN program for trapezoidal rule and Simpson's 1/3rd rule.
Solution of Differential equations:
Discussion of algorithm and flowcharts and writing FORTRAN program for Euler's method for finding solution of differential equation.

(*Derivation of formula is not expected for all the above numerical methods*)
[Ref.2: Chapters - 2, 3, 6, 8 and 9]

Experiments:
Following programs may be discussed thoroughly in theory lectures and implemented in the practicals.

1. Sum of digits of an integer
2. To find factorial of a number
3. Checking and printing of prime numbers
4. Generation of Fibonacci numbers
5. To find sin(X), cos(X) using series method
6. Sorting of Numerical data - ascending, descending.
7. Matrix operations – addition, subtraction, multiplication
8. Graphics- line, circle, arc, bar, ellipse.
9. Root of equation-Bisection method, Newton Raphson method

10. Numerical integration- Trapezoidal, Simpson’s 1/3rd rule.
11. Least square curve fitting- data for ohm’s law.
12. Freely falling body and motion of falling body including air drag. (using Euler’s method)
13. Electric field due to a point charge
14.Charging and Discharging of Capacitor in RC circuit/Growth and Decay of current in RL Circuit.

References:

1. Rajaraman V., Computer Programming in Fortran 90 and 95, Prentice-Hall of India, New Delhi, 2nd Edition (1987).
2. Rajaraman V., Computer Oriented Numerical Methods, Prentice-Hall of India, New Delhi, 2nd Printing (1999).

Additional Reference:

1. Verma P. K. and Ahluwalia and Sharma K. C., Computational Physics, New Age International Publishers, India, (1999).

Course Title : Astronomy and Astrophysics

Course Code :PHY-IV.CE-8

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1(Practical)

Course objectives: The objective of this course is to develop an understanding of the scale, constituents, and physics of stellar astronomy. A descriptive course includes the methods of astronomy and astrophysics, the motions of celestial objects and the evolution of galaxies.

Learning outcome: On completion of this course, the students will get necessary foundation in astronomy and astrophysics that will prepare them for the advanced study in Astronomy.

Pre-requisite: .

Theory:

1. **Introduction to Astronomy** **[3 h]**
   Introduction of astronomy and astrophysics.Importance and scope of astronomy.Methods of astronomy and astrophysics.The scientific method.
   [Abhyankar 1.1 - 1.5]

2. **Celestial coordinates** **[7 h]**
   Spherical coordinates. Celestial sphere.Altazimuth system.Finding right ascension and declination of a star.Equatorial, ecliptic and galactic system of co-ordinates.onversion of coordinates. Sky charts and their importance.
   [Abhyankar 2.1 – 2.8]

3. **Astronomical Scales and measurements** **[8 h]**
   Units of measurement in astronomy. Measuring distances within solar system. Measuring distances in Universe: Parallax method. Standard Candle method**.**Cepheid variable method**.**RedShift.
   [Abhyankar 4.1 – 4.3]

4. **Stellar structure , Birth and Death of stars** **[8 h]**
   Basic Properties of a Star: Star brightness, colour, magnitude. Effective temp of a star.Size, mass, and luminosity. Internal Structure of a star: The Hydrostatic Equilibrium. star formation and Proto stars. The Main Sequence (HR Diagrams).White Dwarf.Supernova.Neutron Stars and Black Holes.
   [Abhyankar 3.2, 9.1,9.2] [Maoz 4.1-4.5] [Choudhuri 3.2.1, 3.2.4, 3.6, 4.7]

5. **Galaxies** **[6 h]**
   Galaxy formation and Evolution.Radio galaxies.Seyfert galaxies.Types of galaxies.Hubble tunning fork model for galaxy classification.Elliptical galaxies.Spiral galaxy.Lenticular galaxies.Irregular galaxies.Distance, luminosity, size and mass of galaxies.
   [Schneider 3.1, 3.2, 3.3] [Abhyankar 17.1,17.2]

6. **Milky way** **[5 h]**
   Mass and size of the Milkyway Galaxy.Interstellar Medium and its composition. Structure of Milkway Galaxy from optical and radio observations. Star count. Distribution of stars in the solar neighbourhood.Motion of Stars within the Galaxy.
   [Choudhuri 6.1] [Abhyankar 14.1, 14.2,14.6,15.1]

7. **Telescopes and astronomy in different bands of electromagnetic radiation** **[8 h]**
   Types of telescopes.Optical telescopes.Radio telescopes.Infrared and Ultraviolet telescopes. X-ray telescopes. Design and construction of an optical telescope. Schmidt telescopes. Optical astronomy.Infrared astronomy.Ultraviolet astronomy.Radio astronomy.X-ray astronomy and gamma ray astronomy.
   [Abhyankar 19.1 - 19.5] [Choudhuri 1.7]

Experiments: (Minimum Six)

1. Measurement of the solar constant.
2. Resolving power of telescope.
3. Study of scattering of light (Diameter of Lycopodium powder).
4. To obtain proper motion of Barnard's star using Aladin.
5. Draw constellation map of a) Orion b) Auriga c)Taurus d)Ursa Major (Big Dipper) marking of pole star.
6. To determine the elements in sun using Fraunhofer spectra.
7. To estimate Astronomical Unit using venus transit data by parallax method.
8. Data analysis technique using virtual observatory.
9. Determine the period of revolution of sun using virtual laboratory.

References:

1. K.D. Abhyankar, *Astrophysics: Stars and Galaxies* (University Press, 2001).
2. D. Maoz, *Astrophysics in a Nutshell AKA basic astrophysics* (Princeton University Press 2007).
3. Peter Schneider, *Extragalactic Astronomy and Cosmology an introduction* (Springer 2006).
4. A. R. Choudhuri, *Astrophysics for Physicists* (Cambridge University Press 2010).

Additional References:

1. Seed Backman, *Foundations in Astronomy and Astrophysics* (Cengage Learning 2013)
2. M.Sandage and J.Kristian, *Galaxies and the Universe* (University of Chicago Press).
3. Gordon Walker, *Astronomical Observations - an Optical Perspective* (Cambridge University press).

Course Title : Instrumentation

Course Code : PHY-IV.CE-8

Marks: 75 (Theory) + 25 (Practical)

Credit: 3 (Theory) + 1(Practical)

Course Objectives: The objective of this course is to understandbasic concepts related to the various types of measuring instruments and measuring techniques.

Learning Outcome:On completion of this course, the students will get necessary knowledge of errors associated with instruments and basic principles involved in measuring instruments like Ammeter, Voltmeter, Ohmmeter and Multimeters.Students get familiar with working and use of CROs and Signal Generators. Students understand working and usage of the various types of transducers.

Pre-requisite: Nil

Theory:

1. **Fundamentals of Measurement:** **[6 h]**
   Introduction, Performance Characteristics, Static Characteristics, Errors in Measurements, Types of Static Error, Sources of Error, Dynamic Characteristics, Standard, Electrical Standards.
   [Ref.1: Chapter 1.2 to 1.7, 1.9, 1.10]

2. **Indicators and Display Devices:** **[5 h]**
   Types of Instrument, Basic Meter Movement: PMMC Movement and Practical PMMC Movement, Classification of Displays, Use of LED and LCD as Display Devices, Segmental Displays using LEDs.
   [Ref.1: Chapter 2.1, 2.2, 2.8, 2.10, 2.11, 2.12.3]

3. **Measuring Instruments:** **[12 h]**
   DC Ammeter, MultirangeAmmeter, Universal Shunt, Requirements of a Shunt, Extending of Ammeter Ranges. Basic Meter as a DC Voltmeter, DCVoltmeter,MultirangeVoltmeter, Extending Voltmeter Ranges, Loading,Transistor Voltmeter(TVM), FET DC Voltmeter. ACVoltmeter using Rectifiers,Multirange AC Voltmeter, AC current measurements using AC Voltmeter and a series Resistor. Ohmmeter: Series type and Shunt type, Multimeter.
   Digital voltmeter: Ramp Technique, Digital Multimeters and Frequency meter (with help of Block Diagrams), Q meter.

[Ref.1: Chapter 3.1 to 3.5, 4.2 to 4.7,4.12to 4.15, 4.21, 4.22, 4.25, 5.2, 6.2,6.3,10.7 and Ref.2: Chapter 22: 22-9]

4. Oscilloscope: [6 h]

Basic Principle, Block Diagram of Oscilloscope, Simple CRO, VerticalAmplifier, Horizontal Deflecting System, sweep generator, Delay line.

[Ref.1: Chapter 7.2.1, 7.4, 7.5, 7.5.1, 7.6, 7.7.1, 7.10]

5. Signal Generator: [4 h]

Standard Signal Generator, AF Sine and Square Wave Generator, FunctionGenerator.

[Ref.1: Chapter 8.4, 8.5, 8.7, 8.8]

6. Transducers: [12 h]

Introduction, Electrical Transducer, Selecting a Transducer, Strain Gauges, Resistance Wire Gauge, Types of Strain Gauges(Wire), Foil Strain Gauge, Semiconductor Strain Gauge,InductiveTransducer, Differential Output Transducers, Linear Variable Differential Transducers (LVDT), Capacitive Transducer, PiezoElectric Transducer, Semiconductor DiodeTemperature Sensor, Temperature Transducers: Resistance Temperature Detectors, Thermistors, Thermocouples.

[Ref.3: Chapter 36.1 to 36.3, 36.12 to36.15] [Ref.1: Chapter 13.1 to 13.3, 13.6, 13.6.1 to 13.6.4, 13.9,13.9.1, 13.9.2, 13.10, 13.11,13.13, 13.15, 13.20.7]

Experiments: **(Minimum six)**

1. Use of CRO and Function Generator (AC/DC voltage measurement,frequency measurement).
2. To measure displacement (linear and angular) using potentiometer/variable inductor/variablecapacitor.
3. Construction and design of analog two ranges Voltmeter.
4. Construction and design of analog two ranges Ohmmeter.
5. Crystal Oscillator: Determination of velocity of ultrasonic waves in a liquidmedium.
6. Study of strain Gauges
7. Study of LVDT (including calibration) and its use in any one application.
8. Calibration of Thermocouple
9. Thermistor as a temperature sensor.

References:

1. Kalsi H S, Electronics Instrumentation, Tata McGraw Hill Education Pvt. Ltd. New Delhi, 3rd Edition (2010).
2. Mottershead Allen, Electronics Devices and Circuits An Introduction, Prentice-Hall of India Pvt. Ltd., New Delhi, 23rd Printing, (2000).
3. Theraja B. L., Basic Electronics (Solid State), S. Chand and Company Ltd., New Delhi, 1stMulticolour Edition (2005).

Additional References:

1. Boylestad Robert and Nashelsky Louis, Electronic Devices and Circuit Theory, Prentice-Hall of India Pvt. Ltd., New Delhi, 6^{th} Edition (2000).

SEMESTER-V

Course Title: Electromagnetic Theory – II

Course Code: PHY-V.C-7

Marks: 75 (Theory) + 25 (Practical)

Credits: 3 (Theory) + 1 (Practical)

Course Objectives: To acquaint students with fundamental principles of Magnetostatics part of the Electromagnetic Theory.

Learning Outcome: At the end of this course, students would be able:

a) to calculate magnetic field using Biot-Savart law and Ampere's law.
b) understand the link between electrostatics and magnetostatics using Maxwell's equations.
c) learn about the propagation of electromagnetic waves.

Pre-requisite: Electromagnetic Theory – I (PHY-III.C-5)

Theory:

1. Magnetostatics **[12 h]**

Lorentz force law: Magnetic fields, Magnetic forces, Currents, Biot-Savart law: Steady currents, Magnetic fields of a steady current, Divergence and Curl of **B**: Straight-line currents, divergence and curl of **B**, applications of Ampere's law, comparison of magnetostatics and electrostatics, Magnetic vector Potential: Vector potential, magnetostatic boundary conditions, multipole expansion of the vector potential.
[Griffiths: 5.1: 5.1.1 – 5.1.3, 5.2: 5.2.1 – 5.2.2, 5.3: 5.3.1 – 5.3.4, 5.4: 5.4.1 – 5.4.3]

2. Magnetic Fields in Matter **[14 h]**

Magnetization: Diamagnets, paramagnets and ferromagnets, torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits, magnetization, the field of a magnetized object: Bound currents, physical interpretation of bound currents, magnetic field inside matter, The auxiliary field H: Ampere's law in magnetized materials, a deceptive parallel, boundary conditions, Linear and nonlinear media: Magnetic susceptibility and permeability, Energy in magnetic fields.

[Griffiths: 6.1: 6.1.1 – 6.1.4, 6.2: 6.2.1 – 6.2.3, 6.3: 6.3.1 – 6.3.3, 6.4: 6.4.1 – 6.4.2, 7.2.4]

3. Microscopic Theory of Magnetism **[5 h]**

Molecular field inside matter, origin of diamagnetism, origin of paramagnetism, theory of ferromagnetism, ferromagnetic domains, ferrites

[Reitz: 10.1 – 10.2]

4. Maxwell's Equations **[4 h]**

Generalization of Ampere's law, displacement current, Maxwell's equations and their ampirical basis, electromagnetic energy, Poynting theorem.

[Reitz: 16.1 – 16.3]

5. Propagation of Electromagnetic Waves **[10 h]**

The wave equation, plane monochromatic waves in non-conducting media, polarization, plane monochromatic waves in conducting media, reflection and refraction at the boundary of two non-conducting media: normal incidence and oblique incidence, Brewster's angle, critical angle.

[Reitz: 16.4, 17.1, 17.2, 17.4, 18.1, 18.2]

Experiments: (Minimum Six)

1. Hysteresis by magnetometer.
2. B-H curve in a hard magnetic material and in a soft ferrite.
3. Core losses and copper losses in a transformer.
4. Measurement of mutual inductance using ballistic galvanometer.
5. Calibration of lock-in-amplifier and determination of mutual inductance.
6. Determination of magnetic susceptibility of $FeCl_3$ by Quincke's method.
7. M/C using ballistic galvanometer

References:

1. Griffiths D. J., 2011, *Introduction to Electrodynamics*,3rd Ed. , Prentice Hall of India.

2. Reitz J. R., Milford F. J., Christy R. W., 1979, *Foundations of Electromagnetic Theory*,3rd Ed., Addison-Wesley Publishing Company.

Additional Reference:

1. Mukherji U., 2008,*Electromagnetic Field Theory and Wave Propagation*, Narosa Publishing House.

Course Title : Solid State Physics

Course Code : PHY-V.CE-9

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objective: To give the students a firm understanding of the basics of Solid State Physics. The course broadly deals with the topics related to structural aspects and the various physical properties of crystalline solids.

Learning Outcome: After completion of this course, students will develop a comprehensive broad knowledge in topic such as: Bondings in Solids, Crystal Physics, Electrical properties of solids, Origin of energy band structure in solids and Magnetic properties of materials.

Pre-requisites: Modern Physics and Quantum Mechanics

Theory:

1. Bonding in Solids: [5 h]

Introduction,Bonding in Solids, Cohesive energy, Ionic bonding, Calculation of Cohesive energy of ionic solids, Covalent bonding, Metallic bonding, Hydrogen bonding, Van der Waals (Molecular) bonding.

[Palanisamy: 1.1, 1.2, 1.3, 1.4, 1.4.1, 1.5 - 1.5.2, 1.6 - 1.9]

2. Crystal Structure: [12 h]

Introduction, Space Lattice, Unit cell, Lattice Parameter of unit cell, Bravais lattices, Crystal Symmetry, Stacking sequences in metallic crystal structure, SC, BCC, FCC and HCP structures, Crystal structures- NaCl, diamond, CsCl, ZnS, Directions in crystals, Planes in crystals- Miller indices, Distances of Separation between Successive (*hkl*) Planes.

[Palanisamy: 2.1, 2.2 - 2.2.3, 2.3 - 2.3.4, 3.1, 3.2, 3.3 -3.3.2, 3.4]

3. Diffraction of X-rays by Crystals: [5 h]

Introduction, Bragg's law, Production of X-rays, Determination of lattice parameters and X-ray Diffraction methods: Laue method and Debye Scherrer method.

[Palanisamy: 4.9 - 4.9.3, 4.10 - 4.10.2]

4. Electron Theory of Metals: **[18 h]**

Introduction, Classical free electron theory, Quantum theory of free electrons, Fermi distribution function, Density of energy states, Sources of electrical resistance, Electrons in a periodic potentials, Energy bands in Solids.

[Palanisamy: 6.1, 6.2 - 6.2.2, 6.3, 6.3.1, 6.4, 6.5, 6.6, 6.7-6.7.5, 6.8]

5. Magnetic Properties: **[5 h]**

Introduction, Classification of magnetic materials, The quantum numbers, Origin of magnetic moment, Ferromagnetism, Ferromagnetic domains, Hysteresis, Hard and soft materials.

[Palanisamy: 8.1, 8.2, 8.3, 8.4, 8.7, 8.7.3, 8.7.5, 8.7.6]

Experiments: (Minimum Six)

1. Energy band gap of a semiconductor
2. Energy band gap of LEDs
3. To determine value of Planck's constant using LEDs of at least 4 different colours.
4. Fermi energy of Copper
5. Measurement of Hysteresis loss using CRO
6. Calculation of lattice constant by of Copper – X-ray diffraction pattern is given and student calculates: d-spacing, miller indices and lattice constant
7. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 ^oC) and to determine its band gap

References:

1. Palanisamy P. K., 2004, *Solid State Physics,* Scitech Publications (India) Pvt. Ltd.
2. Pillai S. O., 1999, *Solid State Physics*, 3rd Edition, New Age International (P) Ltd, Publisher.
3. Kittel C.,2004, *Introduction to Solid State Physics*, 8th Edition,John Wiley and Sons.
4. Dekker A. J., 1998, *Solid State Physics*, Macmillan India Ltd. Publisher.

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Course Title : Thermodynamics and Statistical Mechanics

Course Code : PHY-V.CE-10

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Pre-requisite: PHY-II.C-3

Course Objectives: Topics covered include Power cycles, conversion of heat into useful work, phase transitions, classical and quantum distribution.

Learning Outcome: After completion of this course students will be able to understand applications of thermodynamics and statistical mechanics such as description of system involving many particles.

Theory

1. **Thermodynamic Potentials** **[4 h]**
   The Helmholtz function and Gibbs function,Thermodynamic Potentials, Maxwell Relations.
   [Ref#5 Section 7.1-7.3]

2. **Production of low temperature.[18 h]**
   Cooling by evaporation. Vapour compression machines. Refrigerators based on Vapour absorption. Cooling by sudden adiabatic expansion of compressed gases. Efficiency and performance of Refrigerating machines. Enthalpy and heat flow. Joule Kelvin effect. Expression for joule Kelvin coefficient and inversion temperature. Van der Waals' gas. Principles of regenerative and cascade cooling. Liquifaction of hydrogen and helium. Production of temperatures below 4 K. Properties of He I and He II. Cooling by Adiabatic Demagnetisation of paramagnetic substances.
   [Ref#1 Section 7.3,7.4,7.7,7.9,7.10-7.18 Ref#2 section 12.1-12.10]

3. **Probability** **[11 h]**

Random Events, Probability, Probability and Frequency, Some basic rules of Probability theory, Continuous random variables, Mean value of discrete and continuous variables, Variance: Dispersion, Probability Distribution, Binomial distribution: Mean value and fluctuation, Stirling's Approximation, Poisson Distribution: Mean value and Standard deviation, Gaussian Distribution: Standard deviation, Random Walk.
[Ref#1 Section 9.1-9.10 Ref# 2 pp 5-16]

4. **Statistical Thermodynamics** **[12 h]**
   Phase space, Macrostate and Microstate, Maxwell Boltzman Statistics. Molecular speeds: mean, most probable and rms speeds. Experimental verification of Maxwell Boltzman statistics. Statistical interpretation of Entropy, Quantum statistics: Bose Einstein and Fermi Dirac distribution law.
   [Ref#1 Section 11.4-11.6, 10.15, 10.21, 12.5-12.8 Ref# 4 15.1-15.6, 16.1, 16.5]

Experiments: (Minimum Six)

1. Specific heat of Graphite
2. Study the temperature dependence of resistivity.
3. OPAMP as a bridge amplifier and its application in temperature measurement
4. Determination of Boltzmann constant
5. Tutorial on Maxwell Equation and Free enrgy
6. Tutorial on Probability
7. Tutorial on Probability
8. Tutorial on Statistical Thermodynamics
9. Tutorial on Statistical Thermodynamics

References:

1. Brijlal, Subrahmanyam N., 2008, *Heat thermodynamics and Statistical Physics*, S Chand Company Ltd.
2. Laud B., 2003, *Introduction to Statistical Mechanics*, New Age International.
3. Saha M. and Shrivastava B., 1965, *Treatise on heat*, The Indian Press.
4. Beiser A., 1995, *Perspectives of modern physics,* 5th edition, McGraw hill.
5. Sears F. and Salinger G., 1998, *Thermodynamics*, *Kinetic Theory and Statistical Thermodynamics*, 3rd Edition, Narosa.

Additional References:

1. Garg S., Bansal R.and Ghosh C., 1993, *Thermal Physics*, Tata McGraw Hill.
2. Zemansky M. and Ditman R., 1997, Heat *and Thermodynamics*, McGraw Hill.
3. Reif F., 1965, *Fundamentals of Statistical and Thermal Physics*, Mc Graw Hill

Course Title : Electronics-II

Course Code : PHY-V.CE-11

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Pre-requisite: PHY-IV.CE-5

Course Objectives: This course aims at introducing students to analog and digital circuits.

Learning Outcome: After completion of this course, students will understand the analysis of AC circuits and will be able to apply these techniques in designing circuits.

Theory

1. **AC Models (BJT) [4 h]**
   Base-Biased amplifier, Emitter-Biased amplifier, Small signal operation, analyzing an amplifier.
   [Ref.# 1 Article 9.1 to 9.7]

2. **Transistor Multivibrators [4 h]**
   Transistor as a switch, switching times, Multivibrators – Astable, Monostable, Bistable and Schmitt Trigger.
   [Ref.# 3 Article 18.1 to 18.5]

3. **FET's and MOSFET's [9 h]**
   Basic structure of the JFET, Principles of operation, Characteristic curves and parameters, Common source amplifiers, Common gate amplifier,
   MOSFET: Depletion Mode and Enhancement mode, Dual-Gate MOSFET.
   FET Phase shift oscillator, FET as VVR and its applications in Attenuator, AGC and Voltmeter circuits.
   [Ref.# 1 Article 13.1 to 13.9, 14.1 to 14.5]

4. **OPAMP Applications [4 h]**

Active diode circuits, Comparator, Window comparator, Schmitt Trigger, Waveform generator –Square wave, Triangular and Ramp Generator and monostable.
[Ref. #1 Article 22.7, 22.8]

5. **Timers** **[4 h]**
The 555 Timer, Basic concept, 555 block diagram, Monostable, Astable, Bistable, Schmitt Trigger and Voltage controlled oscillator (VCO) using 555 timer.
[Ref.# 1 Article 23.7, 23.8]

6. **Monolithic Linear Regulators** **[3 h]**
Basic type of IC regulator, Load and line regulation,LM7800 series,Current Boosters,LM-317 or LM7812 as a voltage regulator.
[Ref#4 24.4,24.5]

7. **Digital Circuits** **[8 h]**
Binary number system, Binary to Decimal and Decimal to Binary conversion, Basic logic gates, AND, OR, NOT(realization using Diodes and Transistor), NAND, NOR as universal building blocks in logic circuits, EX-OR and Ex-NOR gates.
Boolean Algebra:De Morgan's Law's, Boolean Laws, NAND and NOR gates, Sum of Products methods and Product of Sum methods of representation of logical functions. Half adder and Full adder,
Data Processing Circuits: Multiplexer and Demultiplexer, Encoders and decoders.
[Ref. # 2 Article5.1 to 5.8.1, 6.1, and 6.2]

8. **Sequential Circuits** **[9 h]**
Basic RS FF, Clocked RS FF, JK FF, D-type and T-type FF, Master Slave Concept.
Shift Registers:Serial-in-Serial-Out, Serial-in-Parallel-out, Parallel-in-Serial-out, Parallel-in-Parallel-out Shift registers (upto 4 bits)
Counters:Applications of FF's in counters, binary ripple counter, Modulus of counter (3,5) BCD Decade Counter, Cascade BCD Decade counters.
[Ref.# 2 Article7.1 to7.9, 8.1, 8.2, 8.4]

Experiments (Minimum Six):

1. Astable Multivibrator
2. Monostable Multivibrator
3. Bistable Multivibrator
4. Schmitt Trigger
5. F.E.T Characteristics
6. Op-Amp As A Bridge Amplifier And Its Application In Temperature Measurement
7. IC Lm 317 Voltage Regulator
8. IC 555 Timer As Astable Multivibrator And Its Use As Voltage Controlled Oscillator
9. IC 555 Timer As Monostable Multivibrator
10. Digital Multiplexer
11. Verification Of De Morgan’s Theorems And Boolean Identities
12. Nand And Nor Gates As Universal Building Blocks
13. Binary Addition –Half Adder And Full Adder Using Gates

References :

1. Malvino A.,1996, *Electronic Principles*, 5th edition,Tata McGraw Hill.
2. Jain R. P. 2003, *Digital Electronics*, 3rd edition, Tata McGraw Hill.
3. Mottershed A. 1997, *Electronics Devices and Circuits an Introduction*, PHI
4. Malvino A. and Bates D.J., 2007, *Electronic Principles*, 7th edition, Tata McGraw Hill

Additional References:

1. Malvino A. and Leach D. 1986, *Digital Principles and Applications,*4th edition Tata McGraw Hill.
2. Millman J. and Halkias C., 1972, *Intergrated Electronics*, Tata McGraw Hill.
3. Millman J. and Halkais C., 1967, *Electronic Devices and Circuits,* Mc Graw Hill.
4. Mehta V.K., 2003, *Principles of Electronics,* 8th edition,S.Chand & Company.

Course Title: Mathematical Physics

Course Code: PHY-V.CE-12

Marks: 75 (Theory) + 25 (Practical)

Credits: 3 (Theory) + 1 (Practical)

Course Objectives: To acquaint students with mathematical skills which are required to study various concepts of Physics.

Learning Outcome: At the end of this course, students would be able to apply mathematical techniques such as: calculus of residues, solutions of Legendre, Bessel and Hermite equations, Fourier transforms of different functions in solving various Physics problems.

Pre-requisite: Introduction to Mathematical Physics (PHY-I.C-1)

Theory:

1. **Functions of a Complex Variables** **[8 h]**

Introduction, complex variables and representations: algebraic operations, Argand diagram: vector representation, complex conjugate, Euler's formula, De Moivre's theorem, the n^{th} root or power of a complex number, analytic functions of a complex variable: the derivative of f(z) and analyticity, harmonic functions, contour integrals, Cauchy's integral theorem, Cauchy's integral formula.

[Harper: 3.1, 3.2: 3.2.1 – 3.2.6, 3.3: 3.3.1 – 3.3.5]

2. **Calculus of Residues** **[8 h]**

Zeroes, isolated singular points, evaluation of residues: m^{th} order pole, simple pole, the Cauchy residue theorem, the Cauchy principal value, evaluation of some definite integrals.

[Harper: 4.1 – 4.3: 4.3.1 – 4.3.2, 4.4 – 4.6: 4.6.1-4.6.4]

3. **Partial Differential Equations and Special Functions of Mathematical Physics[14 h]**

Introduction,Some important partial differential equations in physics, an illustration of the method of direct integration, method of seperation of variables, the Hermite polynomials: basic equations of motion in mechanics, one-dimensional linear harmonic oscillator, solution of Hermite's differential equation, Legendre and associate Legendre polynomials: spherical harmonics, the azimuthal equation, Legendre polynomials, Bessel function: introduction: solution of Bessel's equation, analysis of various solutions of Bessel's equation, characteristics of Bessel functions.

[Harper: 6.1 – 6.5: 6.5.1 – 6.5.3, 6.5.8]

4. Fourier Series **[7 h]**

Introduction: The Fourier cosine and sine series, change of interval, Fourier integral, complex form of Fourier series, generalized Fourier series and Dirac-delta function, summation of the Fourier series.

[Harper: 7.1 – 7.3]

5. Fourier Transforms **[8 h]**

Introduction, theory of Fourier transforms: formal development of the complex Fourier transform, cosine and sine transforms, multiple-dimensional Fourier transforms, the transforms of derivatives, the convolution theorem, Parseval's relation, the wave packet in quantum mechanics: origin of the problem - quantization of energy, the development of a new quantum theory, a wave equation for particles - the wave packet.

[Harper: 8.1 – 8.3]

Experiments: (Minimum Six)

1. Generating and plotting Legendre Polynomials.
2. Generating and plotting Bessel function.
3. Generating and plotting Hermite Polynomials.
4. Using spherical polar co-ordinates obtain an expression for divergence and curl of a vector function, operate gradient and Laplacean operator on a scalar function.
5. Using cylindrical co-ordinates obtain an expression for divergence and curl of a vector function, operate gradient and Laplacean operator on a scalar function.
6. Fourier series: programme to sum: $\sum_{n=1}^{\infty}(0.2)^n$, and to evaluate Fourier co-efficients of a given periodic functions.
7. Compute the n^{th} roots of unity for n = 2, 3, and 4.

References:

1. Harper, C., 1993, *Introduction to Mathematical Physics*, 5^{th} Ed., Prentice Hall of India,.
2. Arfken G., 2005, *Mathematical Methods for Physicists*, Elsevier.
3. Spiegel, M.R., 2004, *Fourier Analysis*, Tata McGraw-Hill.

Additional References:

1. Riley K. F., Hobson M. P., Bence S. J., 1998, *Mathematical Methods for Physics and Engineering*, Cambridge University Press
2. Boas M. L., 2013, *Mathematical Methods in Physical Sciences*, John Wiley and Sons, 3rd Ed.
3. Lipschutz S., 1974, *Schaum Outline of Theory and Problems of Complex Variables*, Mc Graw Hill.

SEMESTER-VI

Course Title : Atomic and Molecular Physics

Course Code : PHY-VI.C-8

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Pre-requisite: Quantum Mechanics (PHY-IV.C-6)

Course Objectives: Atomic and molecular physics is the study of dynamics and interactions of the basic building blocks of matter. The objective of this course is to study the behaviour of the electrons that surround the atomic nucleus which will help students to understand the dynamics atoms and molecules.

Learning outcome: After successful completion of this course, student will be able to understand the atomic structure, and dynamics of atoms and molecules. They will also gain insight to the physics of atomic and molecular spectral lines.

Theory:

1. **Quantum Theory of the Hydrogen Atom**: **[6 h]**
   Schrodinger's equation for the H-atom. Separation of variables, Eigen values, Quantum numbers and Magnetic moment. Angular momentum, Electron Probability density.
   [Beiser 9.1-9.9]
2. **Many Electron Atoms: [7 h]**
   Electron Spin.. Pauli Exclusion Principle and classification of elements in periodic table. Symmetric and Antisymmetric wave functions. Electron configuration. Hund's rule. Total angular momentum. L-S coupling. J-J coupling.
   [Beiser 10.1, 10.3- 10.9]
3. **Atoms in a Magnetic Field: [7 h]**
   Effects of magnetic field on an atom. Larmor Precession. The Stern-Gerlach experiment. Spin Orbit Coupling. The Normal Zeeman effect, Lande 'g' factor. Zeeman pattern in a weak field (Anomalous Zeeman effect).
   [Eisberg 8.1-8.4, 10.6]

4. **Atomic Spectra:** **[4 h]**
   Origin of Spectral lines. Selection rules (derivation from transition probabilities). Alkali metal type spectra. Principal, Sharp, Diffused and Fundamental series, fine structure in alkali spectra.
   [Beiser 11.1-11.2, Mcgervey 9.1]

5. **X-ray Spectra:** **[4 h]**
   Characteristic spectrum. Moseley's law. Explanation of X-ray spectra on the basis of quantum mechanics. Energy levels and characteristic X-ray lines. X-ray absorption spectra. Fluorescence and Auger effect.
   [Richtmayer: 7.6, 7.7, 16.1-16.3, 16.5]

6. **Spectra of Diatomic Molecules:** **[10 h]**
   Rotational energy levels. Rotational spectra. Vibrational energy levels. Vibration - Rotation spectra. Fortrat Parabolas and explanation of band structure on its basis. Electronic spectra.
   [Beiser 14.1, 14.3, 14.5, 14.7, 14.8 and Rajam 11.2]

7. **Raman Effect:** **[7 h]**
   Quantum theory of Raman effect. Classical theory of Raman effect. Pure rotational Raman spectra. Vibrational Raman spectra. Rotational fine structure. Experimental set up for Raman effect.
   [Banwell 4.1-4.3]

Experiments: (Minimum Six)

1. Absorption spectra of $KMnO_4$
2. X-ray Emission (characteristic lines of copper target)- Calculation of wavelength and Energy.
3. Resolving Sodium D-lines using grating.
4. Resolving Mercury lines using prism.
5. Determination of wavelength of Sodium light using Lloyd's Mirror.
6. Determination of wavelength of Sodium light using a cylindrical obstacle.
7. Double Refraction

References:

1. Beiser, A. 1969, *Perspectives of Modern Physics*, McGraw-Hill Book Company, Singapore.
2. Eisberg, R. And Resnick, R. 2010, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles*, 2nd Edition, Wiley India Pvt Ltd.
3. Mcgervey, J. 1983, *Introduction to Modern Physics*, Academic Press, USA.
4. Richtmyer, F., Kennard, E., Cooper, J. 2001, *Introduction to Modern Physics*, 6th ed. Tata McGraw-Hill Book Company, New Delhi.
5. Rajam, J. 2000, *Atomic Physics*, S. Chand and Company limited, New Delhi.
6. Banwell, C. 1994, *Fundamentals for Molecular Spectroscopy*, 4th Edition, McGraw-Hill Higher Education.

Additional References:

1. White, H. 1934, *Introduction to Atomic Spectra*, McGraw-Hill Inc., USA.

Course Title	**:**	**Mechanics – II**
Course Code	**:**	**PHY-VI.CE-13**
Marks	**:**	**75 (Theory) + 25 (Practical)**
Credits	**:**	**3 (Theory) + 1 (Practical)**

Course Objectives:To acquaint students with a higher level Mechanics which includes advanced concepts through topics like central force problems, mechanics in non inertial frames, motion of rigid bodies, collision theory and Langrangian formulation.

Learning Outcome:At the end of this course students will be able to comprehend and relate advanced concepts in Mechanics.

Pre-requisite **:** Mechanics – I

Theory

1. **Two-Body Central-Force Problems** **[9 h]**
   CM and Relative Coordinates; Reduced Mass, The Equations of Motion, The Equivalent One-Dimensional Problem, The Equation of Orbits, The Unbounded Kepler Orbits, Changes of Orbits
   [Ref. No. 1 pp. 293 – 315]

2. **Mechanics in Non-inertial Frames** **[9 h]**
   Acceleration without Rotation, The Tides, The Angular Velocity Vector, Time Derivatives in a Rotating Frame, Newton's Second Law in Rotating Frame, The Centrifugal Force, The Coriolis Force, Free Fall, Projectile motion and the Foucault Pendulum.
   [Ref. No. 1, pp. 327 – 358]

3. **Rotational Motion of Rigid Bodies** **[10 h]**
   Properties of the Center of Mass, Rotation about a Fixed Axis, Rotation about Any Axis, the Inertia Tensor, Principal Axis of Inertia, Finding the Principal Axis; the Eigenvalue

Equations, Precession of a Top due to a Weak Torque, Euler's Equations, Euler's Equations with Zero Torque, Euler Angles, Motion of Spinning Top
[Ref. No. 1 pp. 367 – 403]

4. **Collision Theory** **[7h]**
   The Scattering Angle and Impact Parameter, The Collision Cross Section, Generalizations of the Cross Section, Differential Scattering Cross Section and its Calculations Rutherford Scattering
   [Ref. No. 1 pp. 557 – 582]

5. **Lagrange's Equations** **[10h]**
   Constraints, Generalised coordinates, D'Alembert's Principle. Lagrange's Equations, A general expression for kinetic energy, Symmetries and laws of conservation. Cyclic or ignorable coordinates
   [Ref. No. 1 pp. 237 – 275 and Ref. No. 2 Section 8.1-8.7]

List of Experiments: (Minimum Six)

1. Study of Compound Pendulum as a Reversible Pendulum: Kater's Pendulum
2.Measurement of Moment of Inertia of Uniform Rigid Bodies: Bifilar Suspension
3.Principle of conservation of linear momentum using linear air track
4.Value of "g" by Rod pendulum
5.To Study the different oscillation modes of the coupled pendulum
6.To determine themoment of inertia of Gyroscope disc
7.Equation of Orbit (bounded orbit) simulation experiment
8.Equation of Orbit (unbounded orbit) simulation experiment

References:

1. Taylor J. R., 2005, *Classical Mechanics*, University Science Books.
2. Takwale R. G., and Puranik P. S., 1992, *Introduction to Classical Mechanics*, Tata Mc-Graw Hill

Additional Reference:

1. Symon K. R., 1971, *Mechanics*, Addison Wesley

Course Title : Nuclear and Elementary Particle Physics

Course Code : PHY-VI.CE-14

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course objectives: The objective of this course is to introduce students to the fundamental principles and concepts governing nuclear and particle physics.

Learning outcome: After successful completion of this course, student will be able to understand the fundamental principles governing the basic properties of nuclei, nuclear structure and particle physics. Students will also be able to solve elementary problems, relating theoretical predictions and measurement results, in nuclear and particle physics.

Theory:

1. **Constituents and properties of the Nucleus: [4h]**
   Measurement of Nuclear Radius. Nuclear spin. Magnetic dipole moment. Electric Quadrapole moment. Parity. Binding energies and a plot of B/A against A.
   [Patel: 4.1.3, 4.1.5, 1.2.4, 5.2]

2. **Nuclear forces: [3h]**
   Main characteristics of Nuclear Forces. Meson theory of Nuclear forces, Estimation of the mass of a meson using Heisenberg's Uncertainty Principle, Yukawa potential.
   [Patel: 8.6]

3. **The Q Equation**: **[4h]**
   Types of Nuclear Reaction, The Balance of mass and energy in Nuclear reaction, The Q Equation.
   [Patel: 3.2, 3.3, 3.4]

4. **Radioactive decay: [8h]**

Alpha decay: Velocity and energy of alpha particles, Geiger-Nuttal law, alpha spectra and fine structure, short range and long range alpha particles, disintegration energy, Gamow's theory of alpha decay. (Qualitative treatment)

Beta Decay: Types of Beta decay, Energies of (Beta -decay, The continuous beta particle spectrum & difficulties in understanding it, Pauli's neutrino hypothesis.

Gamma Decay : Origin of gamma decay, Internal Conversion, Nuclear isomerism.
[Patel : 2.3, 4.2.1-4.2.3, 4.3.1- 4.3.3, 4.4.1, 4.4.3, 4.4.4]

5. **Liquid drop model of a nucleus**: **[6h]**
   Analogy between liquid drop & a nucleus. Wiezsacker's semi empirical mass formula. Mass Parabolas: Prediction of stability against beta decay for members of a isobaric family, Stability against spontaneous fission, Bohr – Wheeler theory for nuclear fission.
   [Patel: 5.3, 5.4, 5.5]

6. **Nuclear Energy:** **[6h]**
   Neutron induced fission, Asymmetrical fission, Energy released in the fission of U-235. Fission chain reaction, Principle of a nuclear reactor, Neutron cycle in a thermal nuclear reactor (The four factor formula), Principle of a breeder reactor.
   [Patel: 6.1-6.5, 6.7-6.9]

7. **Nuclear Shell Model**: **[6 h]**
   Experimental evidences that lead to shell model, Main assumption of the single particle shell model, Jensen-Mayer Scheme (No derivation), Predictions of the shell model.
   [Patel: 7.1-7.3, 7.7, 7.8]

8. **Elementary Particle Physics:** **[8h]**
   Theory of the electron. Antiparticles. Types and properties of Mesons. Systematics of Elementary Particles. Strangeness Number. Isotopic Spin. Symmetries and Conservation Principles. Theory of Elementary Particles.
   [Beiser: 25.1-25.11]

Experiments:

1. Study of the characteristics of a GM tube and determination of its operating voltage, plateau length / slope etc
2. Study of nuclear counting statistics
3. Measurement of short half-life
4. Tutorial on Properties of the Nucleus
5. Tutorial on Q value
6. Tutorial on Radioactive decay

7. Tutorial on Liquid drop model
8. Tutorial on Nuclear fission

References:

1. Patel, S. 2011, *Nuclear Physics: An Introduction*, 2nd Edition. New Age Inernational Limited, New Delhi.
2. Beiser, A. 1969, *Perspectives of Modern Physics,* McGraw-Hill Book Company, Singapore.

Additional References:

1. Krane, K. 1987, *Introductory Nuclear Physics,* 3rdEdition. Wiley, New Jersey.
2. Kaplan, I. 1956, *Nuclear Physics,* 3rd Edition, Addison-Wesley, Boston.

Course Title : Introduction to Special Theory of Relativity

Course Code : PHY-VI.CE-15

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Pre-requisite: Electromagnetic Theory –I (PHY-III.C-5) and Electromagnetic Theory-II (PHY-V.C-7)

Course Objectives: The objective of this course is to introduce students to Special Theory of Relativity.

Learning Outcome: In this course, students will learn the true nature of Non-Relativistic and Relativistic mechanics.

Theory

1. Experimental Background: [10 h]

Galilean Transformation, Newtonian relativity, Electromagnetism and Newtonian relativity, Michelson Morley experiment, Lorentz-Fitzgerald contraction hypothesis, Ether Drag hypothesis, Attempts to modify electrodynamics,postulates of the theory of special Relativity. Einstein and origin of relativity theory.
[Ref#1 Article 1.1to 1.10]

2. Relativistic Kinematics [9h]

Relativity of simultaneity, Derivation of Lorentz transformation equations, some consequences of Lorentz transformation equations, Relativistic addition of velocities, relativistic transformation of velocities and Doppler effect in Relativity .
[Ref#1 Article 2.1to 2.8]

3. Relativistic Mechanics [8h]

Mechanics and Relativity, Redefining momentum, Relativistic momentum, Relativistic mass, Equivalence of mass and energy. The transformation properties of Momentum, Energy, Mass and Force.
[Ref#1 Article 3.1to 3.7]

4. Relativity and Electromagnetism [10 h]

Interdependance of electric and magnetic fields, Transformation for E and B, Field of a uniformaly moving point charge, Forces and fields near a current carrying wire, Forces between moving charges,The invariance of Maxwells equations, Limitations of special relativity.
[Ref#1 Article 4.1to 4.8]

5. The Geometric Representation of Space –Time and Twin Paradox [8h]

Space-Time Diagrams, Simultaneity, Contraction and Dilation, The time Order and Space Separation of events,The route dependance of proper time, space time diagram of the twin paradox, The experimental test.
[Ref#1 Article A1-A3 and B-1 to B-5]

Experiments: (Minimum Six)
1. Michelson Interferometer
2. Tutorial on Relativistic Kinematics
3. Tutorial on Relativistic Kinematics
4. Tutorial on Relativistic Mechanics
5. Tutorial on Relativistic Mechanics
6. Tutorial on Relativity and Electromagnetism
7. Tutorial on Relativity and Electromagnetism

References:

1. Resnick R., 1965, *Introduction to Special Relativity*, John Wiley.

Additional References:

1. Ghatak A., 2009, *Special Theory of Relativity,*Anshan Ltd

2. French A. P., 1968, *Special Relativity*, Chapman & Hall.

Course Title: Introduction to Materials Science

Course Code: PHY-VI.CE-16

Marks: 75 (Theory) + 25 (Practical)

Credits: 3 (Theory) + 1 (Practical)

Course Objectives: To acquaint students with fundamentals of materials science and study the properties and applications of materials.

Learning Outcome: At the end of this course, students would be able to investigate the relationship that exists between the structures and properties of materials.

Pre-requisite: Quantum Mechanics (PHY-IV.C-6), Solid State physics (PHY-V.CE-9).

Theory:

1. Structure of Crystalline Solids **[14 h]**

Introduction, metallic crystal structures: the face centered cubic crystal structure, the body centered cubic crystal structure, the hexagonal close-packed crystal structure, density computations, atomic arrangements, linear and planar densities, close-packed crystal structures, polymorphism and allotropy, ceramic crystal structures: radius ratio rules, AX-type crystal structures, A_MX_P-type crystal structures, $A_MB_NX_P$-type crystal structures, crystal structures from close packing of anions, ceramic density computations, silicate ceramics, carbon, polymer structures: polymer crystallinity, polymer crystals, x-ray diffraction: determination of crystal structures.

[Callister: 4.1 – 4.20]

2. Imperfections in Solids **[8h]**

Introduction, point defects: vacancies and self-interstitials, impurities in solids, specification of composition, imperfections in ceramics, miscellaneous imperfections: dislocations-linear defects, interfacial defects, bulk or volume defects, atomic vibrations, defects in polymers, microscopic examination: microscopic techniques, grain size determination.
[Callister: 5.1 – 5.13]

3. Diffusion [6h]
Introduction, diffusion mechanisms, steady-state diffusion, nonsteady-state diffusion, factors that influence diffusion, diffusion in ionic materials, diffusion in polymeric materials.
[Callister: 6.1 – 6.8]

4. Applications and Properties of Ceramics [9h]
Introduction, types and applications of ceramics: glasses, Glass-ceramics, clay products, refractories, abrasives, cements, advanced ceramics, mechanical properties: brittle fracture of ceramics, stress-strain behavior, mechanism of plastic deformations, miscellaneous mechanical considerations, glass properties, heat treatment of glasses, heat treatment of glass ceramics.
[Callister: 12.1 – 12.8, 12.10 – 12.16]

5. Structures of Polymers: [8h]
Introduction, hydrocarbon molecules, polymer molecules, the chemistry of polymer molecules, molecular weight, molecular shape, molecular structure, molecular configurations, thermoplastic and thermosetting polymers, copolymers.
[Callister: 13.1 –13.10]

Experiments: (Minimum Six)
1. Grain size estimation using XRD.
2. Determination of density of materials.
3. Analysis of surface morphology using SEM/TEM
4. Determination of compressibility of liquids using crystal oscillator.
5. To study the corrosion of metals with the help of galvanic cells.
6. Thermal diffusivity of brass.
7. Thermal conductivity of a poor conductor.
8. Specific heat of graphite.

References:

1. Callister W. D., 2015, *Materials Science and Engineering*,John Wiley and Sons, 2nd Ed.

2. West A. R.., 2014, *Solid State Chemistry and its Applications*, John Wiley and Sons.

Additional Reference:

1. Kittel C., 2015, *Introduction to Solid State Physics*, John Wiley and Sons, 8th Edition.

Course Title : Introduction to Astronomy and Astrophysics

Course Code : PHY-VI.CE-17

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives: The course aims to introduce the students to the Exciting World of Extra-galactic Universe.

Learning Outcome: On completion of this coursethe students will be able to understand

a) the various Extra-galactic objects.
b) the construction, working and mounting of modern telescopes.
c) Co-ordinate system of Celestial Objects.
d) types of stars and their life cycle.

Theory:

1. Fundamentals of Astronomy: [9 h]

Introduction: Components of the Universe; Stars, Planets, Asteroids, Meteors, Comets, Galaxies. Solar System: Age, Origin Basic measurements: Planetary orbits, distances, physical size, mass, density, temperature, rotation period determination, Kepler's laws, black body radiation and curves, Doppler effect.

[Ref#1: chapter1: 1.1-1.5, chapter 3: 3.1- 3.4]

2. Astronomical Instruments: [10 h]

Optical telescopes, mounts, light gathering power, magnification, resolution. Spectroscopes, CCD camera, photometer, filters Radio telescopes, interferometry UV, IR, X-ray and Gamma ray telescopes. Modern telescopes: HST, Chandra.

[Ref#1: chapter19: 19.1-19.5, chapter20: 20.1-20.5]

3. Star and Star Systems [10 h]

Stars life cycle, Neutron stars, black holes, white dwarf, Chandrasekhar limit. Spectral classification of stars, O,B,A,F,G,K,M. Sytem of stars: Binaries / Cepheids / RR Lyrae, HR diagram, sun and solar system.

[Ref#1: chapter5: 5.1-5.7, chapter12:12.3, 12.4]

4. Galaxies, Dark Matter and Dark Energy [7 h]

Galaxies, classification of galaxies, Hubble's tuning fork diagram, Open and Globular clusters, ISM.

[Ref#1: chapter16: 16.4, chapter 17:17.1-17.4]

5. Observational Astronomy [9 h]

Co-ordinate system, Celestial hemisphere, Concept of time, Magnitudes: apparent and absolute, constellations. Star dial, Observation of Sun, Eclipses, Moon, planets, meteor showers, transits, occultation's.

[Ref#1: chapter2; 2.1-2., Ref#2; chapter1: 1.1-1.4]

Experiments: (Minimum six)

1. Resolving power of telescope.
2. Study of scattering of light (Diameter of Lycopodium powder).
3. Study of Diffraction using plane grating.
4. To find radius of curvature of a convex lens using optical lever.
5. Measurement of the solar constant.
6. To obtain proper motion of Barnard's star using Aladin.
7. Draw constellation map of a) Orion b) Auriga c) Taurus d) Ursa Major (Big Dipper) marking of pole star.
8. To determine the elements in sun using Fraunhofer spectra.
9. To estimate Astronomical Unit using Venus transit data by parallax method.
10. Data analysis technique using virtual observatory.
11. Determine the period of revolution of sun using virtual laboratory.

Reference

1. Abhyankar K.D., 2001, *Astrophysics - Stars and Galaxies*, Tata McGraw Hill Pub.
2. Shu F., 1981, *Physical Universe-An Introduction to Astronomy*,University Science Books, U.S.
3. Roy A.E. and Clarke D., 1989, *Astronomy structure of the Universe*, Adam Hilger Pub.
4. Glasstone S., 1965, *Source book on theSpace Sciences*, Van Nostrand Reinhold Inc.,U.S
5. Bhatia V. B., 2001, *Textbook of Astronomy and Astrophysics with Elements of Cosmology*, Narosa Pub.
6. Narlikar J.V.,1976, *Structure of the Universe*, Oxford Paperbacks.
7. Badyanath and Basu., 2010, *An Introduction to Astrophysics*, 2nd Edition, Prentice Hall India Learning Private Limited

SYLLABUS OF COURSES FOR STUDENTS OPTING PHYSICS AS THEIR MINOR SUBJECT

SEMESTER-I

Course Title : Mechanics, Sound and Properties of Matter

Course Code : PHY-I.CM-1

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives: This course provides an introduction to topics in mechanics, sound and properties of matter. An objective of this course is to build up an understanding of fundamental physical principles which are required for most of other physical sciences.

Learning outcome: After successful completion of this course,

- Students will gain an introductory knowledge of Newtonian mechanics, its conservation laws and its applications to basic physical problems.
- They will have knowledge of waves, sound and ultrasonic waves and its application.
- Students will be able to comprehend the phenomenon of elasticity, surface tension, viscosity and their application.

1. **Elements of Newtonian Mechanics** **[5 h]**
   Newton's Laws of motion, equation of motion. Elementary problems in mechanics: Atwood machine and motion along a rough inclined plane and free fall.

   [Symon 1.4, 1.7]

2. **Motion of a particle in one dimension** **[10 h]**

Momentum and energy conservation theorems. Discussion of the general problem of one dimensional motion. Applied force depending on time. Motion under damping force depending on velocity. Conservative force depending on position. Brief review of simple harmonic motion and potential energy curve. Body falling under gravity in a resistive medium proportional to velocity.

[Symon 2.1 - 2.7]

3. **Gravitation Field and potentials:** **[6 h]**
   Newton's Law of Gravitation. Gravitation field and Gravitation potential energy, Gravitational potential and field due to a thin spherical shell.

   [Brij Lal 5.5-5.8]

4. **Sound** **[10 h]**
   Transverse vibrations in strings.Velocity of longitudinal waves in gases. Newton's formula for velocity of sound. Velocity in a homogeneous medium. Laplace's correction. Kundt's tube-determination of velocity of sound in a gas and in solids. Intensity level and Bel and Decibel. Doppler Effect. Source and listener in relative motion (Normal incidence only). Production and detection of Ultrasonic waves and its applications.

[Khanna 4.2, 5.3-5.5, 11.1, 11.3, 12.1-12.4, 19.6 and Subra. 11.23 11.25,11.27]

5. **Elasticity** **[8 h]**
   Modulii of elasticity, Poisson's ratio and relationship between them. Bending of beams-bending moment, flexural rigidity. Cantilever (rectangular bar). Depression of a beam supported at the ends and loaded at the center. A vibrating cantilever. Torsion in a string-couple per unit twist, Torsional Pendulum.

[Mathur 8.8, 8.9, 8.12 -8.18, 8.22, 8.26, 8.29, 8.30]

6. **Surface Tension** **[3 h]**
   Brief review of molecular theory of surface tension. Relation between surface tension and surface energy. Angle of contact. Capillarity-rise of liquid in a capillary tube.

   [Mathur 14.1-14.4, 14.6, 14.14, 14.15 and 14.17]

7. **Viscosity** [**3 h]**
   Streamline flow, Turbulent flow, Critical velocity, Coefficient of viscosity, Poiseuille's formula for flow of liquid through a capillary tube.

   [Mathur 12.1, 12.2, 12.7, 12.11]

List of Experiments: (Minimum Six: Three from each section)

I. **Mechanics and Sound**

1. Dimensions of different solid body
2. Moment of Inertia of a flywheel
3. Spring Mass System: Determining the Spring Constant
4. Velocity of sound by Helmholtz Resonator

II. Properties of Matter

1. Young's Modulus by Vibration
2. Young's Modulus by Bending
3. Surface Tension by rise of a liquid in a capillary tube.
4. Coefficient of Viscosity by Poiseuille's Method.

References:

1. K. R. Symon, *Mechanics (*Addison Wesley, 1971)
2. Brij Lal and N. Subrahmanyam, *Mechanics and Electrodynamics*, (S. Chand and Company LTD , 2005)
3. D. R. Khanna and R. S. Bedi ,*A Textbook of Sound* (Atma Ram and Sons, 1992)
4. N. Subrahmanyam and Brijlal,*Waves and Oscillation* (Vikas Publishing House 1994)
5. D. S. Mathur, *Elements of Properties of Matter* (S.Chand & Co. 2005)

Additional References:

1. John Taylor, Classical Mechanics (University Science Books, 2004)
2. Atam Arya, *Introduction to Newtonian Mechanics,* (Addison-Wesley, 1997)
3. Kittle and Knight, Mechanics (Berkeley Physics Course, Vol. 1), (McGraw Hill Education, 2011)
4. R. G. Takawale and P. S. Puranik, *Introduction to Classical Mechanics*, (Tata McGraw-Hill, 1997)
5. R. Murugeshan and Er. Kiruthiga Sivaprasath, *Properties of Matter and Acoustics* (S. Chand & Co., 2011)

SEMESTER-II

Course Title : Electricity, Magnetism and Electronics

Course Code : PHY-II.CM-2

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives: The objective of this course is to introduce fundamentals of electricity, magnetism and basic electronics to the students, which are essential allied learning components for most of the subjects of Physical Sciences.

Learning Outcome: On successful completion of this course, the students will be able to:

- Comprehend basic concepts like: laws of electrostatics and magnetostatics, self and mutual inductions
- Understand the working of d.c. and a.c. circuits in terms of the role of passive components like capacitor and inductor present in the circuits.
- Understand the working and application of various electronic circuits like rectifier, voltage regulator, CE Amplifier, Op-Amps and Logic gates.
- Correlate the theoretical basis of various concepts of electricity, magnetism and electronics while performing experiments.

Theory:

I. Electricity and Magnetism

1: Laws of Electrostatics [5 h]

Coulomb's law: Statement, Vector form of Coulomb's law for like and unlike charges, Variation force with distance (F v/s r graph)
Concept of electric field and Electric Field Lines
Concept of electric flux: Gauss's theorem in electrostatics (conceptual explanation)
Coulomb's Law from Gauss' Law
Concept of Electric Potential: Electric Potential Energy, Equipotential Surfaces
Calculating the Potential from the Field, Calculating the Field from the Potential

[Ref. No.1: 22.4, 23.2, 23.3, 24.1-24.5, 25.1-25.4, 25.9] [Ref. No.2: 2.4(1)]

2 : Laws of Magnetostatics **[4 h]**
Concept of magnetic field, Definition and properties of magnetic field
Biot – Savart's law and its applications: (i) Long straight conductor and (ii) Current carrying circular loop (for a point on the axis only)
Ampere's circuital law and its application: Field of solenoid.
Magnetic Field lines and Magnetic flux, Gauss's law for magnetism

[Ref. No.1: 29.1, 29.2, 30.1, 30.3, 32.2][Ref. No.3:27.2, 27.3]

3: Self and Mutual Inductance **[5 h]**
Self induction; Calculation of self inductance of (i) a long solenoid, (ii) long parallel wires and (iii) a coaxial cable
Mutual inductance, Coefficient of coupling; Mutual inductance of two coils in series
Energy stored in the magnetic field

[Ref. No.4: 5.1, 5.2, 5.8] [Ref. No.1:31.8, 31.10, 31.12]

4 : Transient Circuits and Alternating Current Circuits **[9 h]**
Transient currents
Growth and Decay of current in an inductive (L-R) circuit, Physical meaning of time constant
Charging and Discharging of a capacitor through resistor in C-R circuit, Physical meaning of time constant
Inductive and Capacitive reactance, Variation of inductive reactance, capacitance reactance with frequency.
Introduction to vector or phasor diagrams method and its application to A.C. circuits (Series L-R and Series C-R); Physical significance of Quality factor
A.C. bridges: Maxwell's Inductive bridge and de Sauty's Capacitance bridge

[Ref. No.4:5.3, 5.4] [Ref. No.2:22.3, 22.4, 22.6, 22.7, 22.8, 22.9, 22.10]
[Ref. No.4: 6.20, 6.21, 6.22]

II. Electronics

5: Rectifiers and Regulators **[6 h]**
Volt-ampere characteristics of Junction diode
Working of Half Wave and Full Wave Rectifiers without and with capacitive filters, Percentage regulation, Ripple factor and Rectification efficiency (only qualitative explanation with respect to HWR and FWR).
Zener diode characteristics and its use as a simple voltage regulator.
Thermistor characteristics and its use in A.C. voltage regulation.

[Ref. No. 1: 4.1-4.7 and Ref. No. 2: 6.1-6.4, 6.13-6.17]

6: Transistors **[8 h]**

Basic configurations of transistors, Transistor's leads identification, Biasing of Transistor and working of Transistor as a switch

Transistor characteristic in CE and CB mode, Current gains and their interrelation, Leakage currents in transistor

Basic Amplifier Characteristics: Current gain, Voltage gain, Power gain, Input resistance, Output resistance

Classes of amplifier operations, DC load Line, Frequency response and Amplifier bandwidth of CE Amplifier

[Ref. No.3: 8.1, 8.4, 8.7-8.12, 8.17, 8.18, 8.26] [Ref. No. 2: 7.1-7.7, 7.10, 8.7, 8.8]
[Ref.No.4 : 7.6]

7: Operation Amplifiers and Logic Gates **[8 h]**

The Differential Amplifier;Op-Amp Characteristics: Input and Output impedance, Input bias current, Input offset current, Input and Output offset voltages.

Op-Amp as Inverting and Non-Inverting amplifier.

[Ref. No.4:17.2, 18.4][Ref. No.5: 8.1-8.3] [Ref. No.6: 3.2]

Binary number system, Binary to Decimal and Decimal to Binary conversion.

Boolean Algebra, Basic logic gates: OR, AND, NOT, NOR, NAND, and EX-OR gates.

De Morgan's Theorems, NAND and NOR gates as universal building blocks in logic circuits.

[Ref. No.3: 26.3-26.6, 26.20, 26.12-26.17, 26.22]

Experiments: (Minimum Six: Three from each section)

I. Electricity and Magnetism

(1) Step Response of RC circuit Charging and discharging of a capacitor
(2) Response of LR and CR circuits to A.C. using phasor diagrams
(3) de Sauty's capacitance bridge
(4) Self inductance of a coil using Maxwell's inductive bridge
(5) Mutual inductance of two coils in series

II. Electronics

(1) Half wave and Full wave rectifier using Junction Diode, Load regulation characteristics.
(2) Zener Diode Regulation
(3) C.E. Amplifier: Gain v/s Load, Input and Output Impedance
(4) Op-Amp: Input and Output Impedance
(5) Inverting and Non-inverting Op-Amp
(6) Verification of De Morgan Law's and Boolean Identities (Construction using Gates)
(7) NAND and NOR gates as universal building blocks.

References:

I. Electricity and Magnetism

1. Halliday David, Resnik Robert and Walker Jearl, Fundamentals of Physics, John Wiley & Sons, Inc., 6th Edition (2003)
2. Vasudeva D. N., Fundamentals of Magnetism and Electricity, S. Chand & Company Ltd., 12th Revised Edition (1999)
3. Young Hugh D., Freedman Roger A. and Ford A. Lewis, Sears and Zemansky's University Physics with Modern Physics, Addison-Wesley Publishers, 13th Edition(PDF) (2012)
4. Fewkes J. H. and Yarwood John, Electricity, Magnetism and Atomic Physics, Volume I, Oxford University Press Ltd., 10th Impression (1991)
5. Purcell Edward M., Electricity and Magnetism-Berkeley Physics Course,Volume 2, Mcgraw-Hill Book Company(PDF)

II. Electronics

6. Bhargava N. N., Kulshreshtha D. C. and Gupta S. C., Basic Electronics and Linear Circuits, Tata McGraw Hill Education Private Ltd., 54th Reprint (2010)
7. Mottershed Allen, An Introduction to Electronics Devices and Circuits, Prentice-Hall of India Private Ltd., Eastern Economy Edition (2008)
8. Metha V. K. and Mehta Rohit, Principles of Electronics ,S. Chand & Company, Multicolour Revised Edition (2008)
9. Malvino A. P., Electronic Principles, Tata McGraw Hill Education Private Ltd., 5th Edition (1996)
10. Bapat Y. N., electronic Circuits and Systems, Tata McGraw-Hill Publishing company Limited New Delhi, First Reprint (1993).
11. Choudhury D. Roy, Jain Shail, Linear Integrated circuits, New Age International (P) Ltd., Twelfth Reprint, (1998).

SEMESTER-III

Course Title : Elementary Modern Physics

Course Code : PHY-III.CM-3

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objective:
The course will focus on the two major theories, which were developed in the beginning of the 20th century, the special theory of relativity and the quantum mechanics. Lectures will help the students in clarifying the concepts of modern physics through various conceptual questions and problems.

Learning Outcome:
Upon completion of this course students will develop a better understanding of fundamental concepts and theories of modern physics required for advanced courses in physics and other physical sciences. Students will also be able to analyze and solve basic problems in modern physics.

Theory:

1. **Special Theory of Relativity: [8 h]**
   Postulates of special theory of relativity. The Michelson-Morley experiment. The Galilean transformation. The Lorentz transformation. The Lorentz-Fitzgerald contraction. Time dilation.Simultaneity.
   [Beiser 1.2-1.8]

2. **Relativistic Mechanics: [4 h]**
   Velocity addition.The relativity of mass. Mass and energy
   [Beiser 2.1-2.5]

3. **Particle Properties of waves: [4 h]**
   Concepts of Black Body Radiation.The Photoelectric effect. Compton effect, Experimental verification of the Photoelectric effect.
   [Singh 1.1-1.3, Beiser 3.1-3.2, 3.5]

4. **Wave Properties of Particles: [8 h]**
   De Broglie's hypothesis.Wave function.Wave and group velocities.Davisson-Germer Experiment.Experiments with bullets, waves and electrons. The interference of electron waves. Watching the electrons. The uncertainty principle and its application.
   [Beiser 4.1-4.8, Feynman 1.1-1.8]

5. **Schrodinger's Wave Equation**: **[8 h]**
   Derivation of the wave equation on a stretched string. Schrodinger's Equation: Time-dependent form. Probability current.Expectation values and operators. Schrodinger's equation: Steady state form. Eigenvalues and Eigenfunctions.
   [Beiser 7.1-7.9]

6. Application of Quantum Mechanics **[13 h]**

6.1 Free particle.

6.2 Particle in a one-dimensional infinite square well potential.

6.3 One dimensional step potential of finiteheight (Energy less than step height and energy greater than step height)

6.4 One dimensional potential barrier. Qualitative discussion of alpha decay.

[Eisberg: 6.2-6.6, 6.8]

Experiments: (Minimum Six)

1. Measurement of diameter of Lycopodium powder
2. Fraunhoffer diffraction over double slit
3. Frank Hertz Experiment
4. Photoelectric effect.
5. Determination of Boltzmann's constant using transistor.
6. Determination of e/m of electrons using Thomson's method.
7. Michelson Interferometer.

References:

1. Beiser, A 1969, *Perspectives of Modern Physics,* McGraw-Hill Book Company, Singapore.
2. Eisberg, R. And Resnick, R. 2010, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles,* 2nd Edition, Wiley India Pvt Ltd.
3. Feynman, RP 2012, *Feynman Lectures on Physics: Quantum Mechanics (Volume - 3)*, Pearson Education, India.
4. Singh, K. And Singh, S. 2013, *Elements of Quantum Mechanics,* S. Chand, New Delhi.

Additional References:

1. Griffiths, D 2015, *Introduction to Quantum Mechanics*, Pearson Education, India.
2. Singh, K. 2013, *Elements of Quantum Mechanics*, S. Chand and Company, New Delhi.
3. Resnick, R. 2010, *Introduction to Special Relativity*, Wiley India Pvt Ltd, India.
4. Verma, HC 2012, *Quantum Physics*, TBS, Calicut.
5. Wichmann E 2010, *Quantum Physics: Berkeley Physics Course Vol 4*, Mcgraw Hill Education, India.

SEMESTER-IV

Course Title : Heat and Optics

Course Code : PHY-IV.CM-4

Marks :75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives: The objective of this course is to understand basics of Heat and Optics.

Learning Outcome: On completion of this course, the students will get necessary foundation in Heat and Optics that will prepare them for the advanced study in Thermodynamics and Optics.

Theory:
Section-I : Heat

Unit 1: Equations of State **[5 h]**
Equation of state, Andrew's experiment, Amagat's experiment, Van der Waal's equation of State, Critical constants, Reduced equation of state, Boyle temperature.
[Saha& Srivastava: 10.1 -10.6, Brij.&Subr.: 2.6, 2.14]

Unit 2: Laws of Thermodynamics **[12 h]**
Thermodynamic system, Thermodynamic variables, Thermodynamic equilibrium, and Thermodynamic processes, Zeroth law of thermodynamics, Concept of work and internal energy, First law of thermodynamics, Isothermal and adiabatic changes, Work done in isothermal and adiabatic changes, Relation between pressure, volume and temperature in adiabatic process, Reversible and irreversible processes, Carnot Heat engine, Carnot cycle for perfect gas, efficiency, Second law of thermodynamics (Kelvin – Planck Statement, Clausius Statement).
[Brij.&Subr.: 4.1, 4.4 – 4.7, 4.10.4, 4.11 - 4.13, 4.20 – 4.24, 4.28]

Unit 3: Principle of Thermometry **[5 h]**
Review of concept of heat and temperature, Thermometry, Types of thermometers, Centrigrade, Fahrenheit, Rankine Scales and relations between them, Platinum resistance thermometer, Thermocouple (thermoelectric) thermometers.
[Saha& Srivastava: 13.1 – 13.5, 13.15, 13.23]

Section-II: Optics

Unit-1 **[6 h]**
Lenses: thin and thick lenses, Lens equation, Lens maker's formula, Cardinal points of an optical system, Combination of coaxially placed two thin lenses (equivalent lenses) (including derivation for focal length and cardinal points).
[Ref.1: 4.8, 4.9, 4.10, 4.11, 4.12, 4.15, 5.2, 5.2.1, 5.2.2, 5.2.3, 5.3, 4.17, 5.10, 6.1, 6.2]

Lens Aberrations: Introduction, Types of Aberrations: Monochromatic and Chromatic aberration, Methods to minimize Spherical and Chromatic Aberrations (only concept, without derivation)
[Ref.1: 9.1, 9.2, 9.5, 9.5.1, 9.10 , 9.11, 9.12, 9.13]

Optical Instruments:
Objective and Eyepiece, Huygen's eyepiece, Ramsden's eyepiece and Constant deviation Spectrometer.
[Ref.1: 10.8, 10.10, 10.10.1, 10.11, 10.11.1, 10.12, 10.17]

Unit-2 **[6 h]**
Interference:
Introduction: Superposition of waves, Interference, Coherence, Conditions for Interference, Techniques of obtaining Interference, Phase Change on reflection: Stoke's law.
[Ref.1: 14.3, 14.4, 14.4.2, 14.4.4, 14.6, 14.7, 14.8 and Ref.2: 6.3]

Interference in Thin Films: Thin Film, Plane Parallel Film, Interference due to Transmitted light, Haidinger Fringes, Wedge-shaped Film, Newton's Rings.
[Ref.1: 15.1, 15.2, 15.2.1 to 15.2.5, 15.3, 15.4, 15.5, 15.5.1 to 15.5.4, 15.6, 15.6.1 to 15.6.9]

Unit-3 **[6 h]**
Diffraction:
Difference between Interference and Diffraction, Types of diffraction: Fresenel Class and Fraunhoffer Class.
[Ref.1: 17.6, 17.7 and Ref.2: 7.5, 7.6]

Diffraction of Light (Fresnel Class):
Division of cylindrical wave-front into Fresnel's half period strips(concept), Diffraction at Straight edge.
[Ref.2: 7.9, 7.10]

Diffraction of Light (Fraunhoffer Class):
Diffraction at a single slit (Central maximum, Secondary maxima and Secondary minima), Diffraction at double slit(Concept, no derivation), Distinction between single slit and double slit diffraction patterns, Missing orders in a double slit diffraction pattern, Resolving Power, Rayleigh's criterion, Resolving power of telescope.
[Ref.1: 18.2, 18.2.1, pg.431 to 433, 18.4, 18.4.1, 18.4.2, 18.4.3, 19.1, 19.2, 19.6, 19.7]

Unit-4 **[5 h]**
Polarization:
Polarized Light, Natural Light, Production of Linearly Polarised Light, Anisotropic Crystal, Calcite Crystal, Huygens Theory of Double Refraction in Uniaxial crystal, Nicol prism- its fabrication, working and use, Optical activity, Specific rotation, Simple Polarimeter.
[Ref.1: 20.3, 20.4, 20.5, 20.5.1, 20.5.2, 20.7, 20.8, 20.8.1 to 20.8.3, 20.9, 20.9.1, 20.9.2, 20.6.1, 20.24, 20.25, 20.26]

Experiments:(Minimum six)

I. Heat: (Minimum Three)

1. Calibration of Si diode as a Thermometer
2. Constant Volume Air Thermometer
3. Thermal conductivity by Lee's method
4. Temperature coefficient of resistance of Copper

II. Optics: (Minimum Three)

1. Newton's Rings
2. Brewster's Law
3. Cardinal points
4. Spectrometer: Dispersive Power of prism

References:

I. Heat:

1. Saha M.N., Shrivastava B.N., *Treatise on Heat*, The Indian Press 5th Ed. (1965).
2. Brijlal, Subramanyam N., Hemne P.S., *Heat Thermodynamics and Statistical Physics*, S. Chand (2007).

II. Optics:

3. Subhramanyam N., Lal Brij, Avadhanulu M. N., A Text book of Optics, S. Chand & Company Ltd., New Delhi, Firstmulticolour Edition (2006).
4. Singh S. P. and Agarwal J. P., Optics, PragatiPrakashan, 8th Edition (2001).

Additional References:

1. Roberts J. K., Miller A.R., *Thermodynamics*, E.L.B.S. (1960).
2. Zemansky M.W., Ditman R.H., *Heat and Thermodynamics*, McGraw Hill, 8th Ed. (5th reprint), 2013
3. GhatakAjoy, Optics, Tata McGraw-Hill Publicashing Company Ltd. (1977)
4. Jenkins F. A. and White H. E., Fundamentals of Optics, Tata McGraw-Hill Publishing Company Ltd., (1981)

SEMESTER-V

Course Title : Statistical Physicsand Solid State Physics

Course Code : PHY-V.MI-5

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Contact Hours : 45 (Theory) + 30 (Practical)

Course Objective: To give the students a firm understanding of the basics of Statistical Physics and Solid State Physics. The course broadly deals with the statistical distribution of particles, structural aspects and electrical properties of crystalline solids, and concept of energy bands in solids.

Learning Outcome: After completion of this course, students will develop a comprehensive broad knowledge in Maxwell-Boltzmann Statistics, Fermi-Dirac Statistics, Bose-Einstein Statistics, Bondings in Solids, Crystal Physics, Electrical properties of solids and Origin of energy band structure in solids.

Theory:

I. Statistical Physics: [15 h]

Introduction-basic concepts-phase space, microstate, macrostate, thermodynamic Probability, Maxwell-Boltzmann statistics- basic postulates, distribution function, Maxwell Boltzmann energy distribution function for an ideal gas, Applications of Maxwell-Boltzmann Distribution law: Total Internal energy and specific heat at constant volume of an ideal gas, Bose Einstein statistics- postulates, Bose-Einstein distribution law, Fermi-Dirac statistics, Fermi-Dirac distribution law

[Lal, 10.1-10.4, 9.7, 9.8, 11.1-11.4, 12.1,12.2,12.4, 12.5,12.8]

II. Solid State Physics

1. Bonding in Solids: [3 h]

Introduction,Bonding in Solids, Ionic bonding, Covalent bonding, Metallic bonding, Hydrogen bonding, Van der Waals (Molecular) bonding.

[Palanisamy: 1.1, 1.2, 1.4, 1.6 - 1.9]

2. Crystal Structure: [9 h]

Introduction, Space Lattice, Unit cell, Lattice Parameter of unit cell, Bravais lattices, Crystal Symmetry, Stacking sequences in metallic crystal structure, SC, BCC, FCC and HCP structures, Directions in crystals, Planes in crystals- Miller indices.

[Palanisamy: 2.1, 2.2 - 2.2.3, 2.3 - 2.3.3, 3.1, 3.2, 3.3 -3.3.2]

3. Electron Theory of Metals: [18 h]

Introduction, Classical free electron theory, Quantum theory of free electrons, Fermi distribution function, Density of energy states, Sources of electrical resistance, Electrons in a periodic potentials, Energy bands in Solids.

[Palanisamy: 6.1, 6.2 - 6.2.2, 6.3, 6.3.1, 6.4, 6.5, 6.6, 6.7-6.7.5, 6.8]

Experiments: (Minimum Six)

1. Energy band gap of a semiconductor
2. Energy band gap of LEDs
3. To determine value of Planck's constant using LEDs of at least 4 different colours.
4. Fermi energy of Copper
5. Measurement of Hysteresis loss using CRO
6. Determination of Boltzmann Constant
7. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (room temperature to 150 oC) and to determine its band gap

References:

1. Palanisamy P. K., 2004, *Solid State Physics,* Scitech Publications (India) Pvt. Ltd.
2. Pillai S. O., 1999, *Solid State Physics*, 3rd Edition, New Age International (P) Ltd, Publisher.
3. Kittel C.,2004, *Introduction to Solid State Physics*, 8th Edition,John Wiley and Sons.
4. Dekker A. J., 1998, *Solid State Physics*, Macmillan India Ltd. Publisher.
5. Lal B., Subrahmanyam N. And Hemne P. S., 2012, *Heat Thermodynamics and Statis*tical *Physics*, S. Chand & Company Ltd.
6. Beiser, A 1969, *Perspectives of Modern Physics,* McGraw-Hill Book Company, Singapore.

SEMESTER-VI

Course Title : Atomic and Nuclear Physics

Course Code : PHY-VI.MI-6

Marks : 75 (Theory) + 25 (Practical)

Credits : 3 (Theory) + 1 (Practical)

Course Objectives: The objective of this course is to introduce students to the fundamental aspects of atomic and nuclear physics.

Learning outcome: After successful completion of this course, student will be able to understand the fundamental principles governing the basic properties of atoms, atomic spectra, nucleus and radioactive decay.

Theory:

1. **Quantum Theory of the Hydrogen Atom**: **[6 h]**
   Schrodinger's equation for the H-atom. Separation of variables, Eigen values, Quantum numbers and Magnetic moment. Angular momentum, Electron Probability density.
   [Beiser 9.1-9.9]
2. **Many Electron Atoms: [7 h]**
   Electron Spin.. Pauli Exclusion Principle and classification of elements in periodic table. Symmetric and Antisymmetric wave functions. Electron configuration. Hund's rule. Total angular momentum. L-S coupling. J-J coupling.
   [Beiser 10.1, 10.3- 10.9]
3. **Atoms in a Magnetic Field: [7 h]**
   Effects of magnetic field on an atom. Larmor Precession. The Stern-Gerlach experiment. Spin Orbit Coupling. The Normal Zeeman effect, Lande 'g' factor, Zeeman pattern in a weak field (Anomalous Zeeman effect).
   [Eisberg 8.1-8.4, 10.6]
4. **Atomic Spectra: [4 h]**
   Origin of Spectral lines. Selection rules (derivation from transition probabilities), Alkali metal type spectra, Principal, Sharp, Diffused and Fundamental series, fine structure in alkali spectra **[Beiser 11.1-11.2, Mcgervey 9.1]**

5. **Properties of the Nucleus: [3 h]**
   Nuclear sizes. Nuclear spin. Binding energy, B.E versus A plot. Saturation of nuclear forces.
   [Beiser: 21.2, 21.4-21.6]

6. **Nuclear Forces and Models: [5 h]**
   Main characteristics of Nuclear Forces. Meson theory of Nuclear forces. Yukawa potential. Brief discussion of the Liquid drop Model and Shell Model.
   [Beiser: 22.4-22.6]

7. **Radioactivity and Radioactive Decay:** **[9 h]**
   The law of Radioactivity Decay. Mean lifetime. Half life and Decay constant. Successive radioactive transformation (A-B-C) type, Ideal transient and secular equilibrium. Radioactive series. Carbon dating. Artificial radioactivity. Brief qualitative discussion on apha decay, beta decay and gamma decay.
   [Patel: 2.3, 2.6-2.9, 2.11, 2.13; Beiser: 23.3, 23.6-23.10]

8. **Nuclear Fission and Nuclear Fusion:** **[4 h]**
   Nuclear fission. The chain reaction. Transuranic elements. Thermonuclear energy
   [Beiser: 24.7-24.10]

Experiments: (Minimum Six)

I. Atomic Physics

1. X-ray Emission (characteristic lines of copper target)- Calculation of wavelength and Energy.
2. Prism Spectrometer: Optical levelling, Angle of Prism
3. Single Slit Diffraction
4. Diffraction Gratings

II. Nuclear Physics

1. Geiger Muller Counter
2. Tutorial on Properties of the nucleus
3. Tutorial on Nuclear Forces and Models
4. Tutorial on Radioactivity

References:

1. Beiser, A. 1969, *Perspectives of Modern Physics,* McGraw-Hill Book Company, Singapore.
2. Eisberg, R. And Resnick, R. 2010, *Quantum Physics of Atoms, Molecules, Solids, Nuclei and particles,* 2nd Edition, Wiley India Pvt Ltd.
3. Mcgervey, J. 1983, *Introduction to Modern Physics,* Academic Press, USA.
4. Patel, S. 2011, *Nuclear Physics: An Introduction,* 2nd Edition. New Age Inernational Limited, New Delhi.

Additional References:

1. Richtmyer, F., Kennard, E., Cooper, J. 2001, *Introduction to Modern Physics*, 6th ed. Tata McGraw-Hill Book Company, New Delhi.
2. Krane, K. 1987, *Introductory Nuclear Physics,* 3rdEdition. Wiley, New Jersey.
3. Kaplan, I. 1956, *Nuclear Physics,* 3rd Edition, Addison-Wesley, Boston.