ASSAM UNIVERSITY: SILCHAR

DEPARTMENT OF PHYSICS

Curriculum

For

FYUG Programme

Under NEP-2020

w.e.f. 2023-24

Semester wise list of Physics DSC (Discipline Specific Core) Papers

SEMESTER	PAPER	NAME	CREDITS
I	**PHYDSC101T**	Mathematical Physics - I	3
	PHYDSC102T	Mechanics and Relativity	3
II	**PHYDSC151T**	Electricity and Magnetism	3
	PHYDSC152P	Lab.: (Part A: Mechanics + Part B: Electricity)	3
III	**PHYDSC201T**	Waves and Optics	4
	PHYDSC202T	Thermal Physics	4
IV	**PHYDSC251T**	Mathematical Physics - II	4
	PHYDSC252T	Electronics (Analog + Digital)	4
	PHYDSC253P	Lab.: (Part A: Thermal Physics + Part B: Analog Electronics)	4
V	**PHYDSC301T**	Modern Physics	4
	PHYDSC302T	Introduction to classical mechanics and electromagnetic theory	4
	PHYDSC303P	Lab.: (Part A: Ray Optics + Part B: Physical Optics)	4
VI	**PHYDSC351T**	Nuclear and Particle Physics	4
	PHYDSC352T	Statistical Mech. and Plasma Physics	4
	PHYDSC353T	Solid State Physics	4
	PHYDSC354P	Lab.: (Part A: Solid State Physics + Part B: Digital Electronics)	4
VII	**PHYDSC401T**	Mathematical Physics -III	4
	PHYDSC402T	Classical Mechanics	4
	PHYDSC403T	Quantum Mechanics - I	4
	PHYDSC404P	Lab.: (Part A: Numerical Tech. & Programming including Quantum mechanics + Part B: Simulation & Software based learning of electronics i.e. virtual Labs)	4
VIII	**PHYDSC451T**	Quantum Mechanics - II	4
	PHYDSC452T	Electromagnetic Theory	4
	PHYDSC453(A)T	Astronomy Astrophysics and Cosmology	4
	PHYDSC453(B)T	Nano Science and Material science	4
	PHYDSC454T	Atomic and Molecular Physics	4

Semester wise list of Physics DSM (Discipline Specific Minor) Papers

SEMESTER	PAPER	NAME	CREDITS	NAME
I	**PHYDSM101T**	Mechanics, Relativity and Math Physics	3	DSM 1
II	**PHYDSM151T**	Mechanics, Relativity and Math Physics	3	DSM 2
III	**PHYDSM201T**	Electricity, Magnetism and Electronics	4	DSM 1
IV	**PHYDSM251P**	Lab. (Mechanics + Optics) and (Electricity + Electronics)	3	DSM 1
	PHYDSM252T	Electricity, Magnetism and Electronics	3	DSM 2
V	**PHYDSM301T**	Waves and Oscillations, Optics and Thermal physics	3	DSM 1
	PHYDSM302T	Waves and Oscillations, Optics and Thermal physics	3	DSM 2
VI	**PHYDSM351P**	Lab. (Mechanics + Optics) and (Electricity + Electronics)	4	DSM 2
VII	**PHYDSM401T**	Modern Physics and Solid State Physics	4	DSM 1
VIII	**PHYDSM451T**	Modern Physics and Solid State Physics	4	DSM 2

Semester wise list of Physics SEC (Skill Enhancement Course) Papers

SEMESTER	PAPER	NAME	CREDITS
I	**PHYSEC-101**	Workshop skill	3
II	**PHYSEC-151**	Electrical circuits and safety	3
III	**PHYSEC-201**	Renewable energy and energy harvesting	3

Semester wise list of Physics IDC (Interdisciplinary Course) Papers

SEMESTER	PAPER	NAME	CREDITS
I	**PHYIDC101T**	Physics in daily life	3
II	**PHYIDC151T**	Understanding the Climate	3
III	**PHYIDC201T**	Renewable energy and energy harvesting	3

SYLLABI OF PHYSICS DSC PAPERS

SEMESTER-I

PHYDSC101T

MATHEMATICAL PHYSICS-I

Contact Hours: 45

Full Marks = 100 [ESE (70) CCA (30)]

Course objective: *The emphasis of the course is on various tools required for solving problems of interest to physicists. The course will teach the students to model a physics problem mathematically and then solve those numerically using computational methods. The course aims to expose the students to some fundamental mathematical tools enabling them to solve a wide range of physics problems.*

Unit 1: Vector Algebra and Matrices

Scalar and vector products, Physical interpretation of vector product. Scalar and vector triple products & their properties with physical interpretation. Derivation of important identities. Preliminary ideas of Scalar and Vector fields.

Different types of matrices. Symmetric and antisymmetric matrices. Hermitian matrix and its properties. Inverse and transpose of matrices. Solution of simultaneous linear equations. Eigenvalue, Eigenvectors and diagonalization of a matrix. **(9 Lectures)**

Unit 2: Ordinary differential equations

Order and Degrees of a differential equation. First Order ODE: General form of first order ODE- $Mdx + Ndy = 0$, Separation of variables, Exact equation, in-exact equations and integrating factors, Linear equations. Second Order ODE: Homogeneous Equations with constant coefficients. Wronskian and general solution. Complementary function. Methods for finding particular integrals. **(9 Lectures)**

Unit 3: Vector Calculus

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

Vector Integration: Ordinary Integrals of Vectors. Line, surface and volume integrals of Vector fields. Gauss's divergence theorem and Stokes Theorem. **(10 Lectures)**

Unit 4: Orthogonal Curvilinear Coordinates

Definition and examples of Orthogonal Curvilinear Coordinates, transformation from orthogonal curvilinear coordinate systems to Cartesian coordinate system and vice versa. Expressions for infinitesimal line, surface and volume elements. Derivation of Gradient, Divergence, Curl and Laplacian in curvilinear Coordinate Systems (Spherical & Cylindrical). **(8 Lectures)**

Unit 5: Beta and Gamma Functions and Numerical Techniques

Beta and Gamma Functions: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson, Simpson Rule. Interpolation by Newton Gregory Forward & Backward difference formula. **(9 Lectures)**

Expected learning outcomes: *After completing this course, the students will be able to understand the concepts of vector algebras, vector calculus in addition to performing line, surface and volume integration and apply various theorems to compute these integrals. The students will also be able to understand concepts of curvilinear coordinates along with ideas of special functions and some numerical techniques.*

Reference Books:

i. Mathematical Physics by H.K. Dass, published by S. Chand.

ii. Mathematical Physics with Classical Mechanics by S. Prakash, published by Sultan Chand & Sons, Sixth edition.

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

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

v. Differential Calculus by B. C. Das and B. N. Mukherjee, published by U.N. Dhur

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

vii. Vector Analysis, by Murray R. Spiegel, published by McGraw Hill Education, part of the Schaum's Outlines Series.

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

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

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

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

xii. Mathematical Physics, Goswami, 1st edition, Cengage Learning.

PHYDSC102T

MECHANICS AND RELATIVITY

Contact Hours: 45

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The objective of this is to review few concepts of mechanics learnt earlier from a more advanced perspective and utilize those to build new concepts. It begins with fundamentals of dynamics and ends with the Special Theory of Relativity. It begins with fundamentals of dynamics and ends with the Special Theory of Relativity.*

Unit 1: Fundamentals of Dynamics

Force and Linear momentum, Principle of conservation of momentum, Momentum of variable-mass system: motion of rocket. Motion of a projectile in Uniform gravitational field, Dynamics of a system of particles. Centre of Mass. Impulse.

Work and Energy: Work - Energy Theorem. Conservative and non-conservative forces. Elastic potential energy. Force as gradient of potential energy. Law of conservation of mechanical Energy.

Collisions: Elastic and inelastic collisions in one and two dimensions. Collisions in Centre of Mass and Laboratory frames. **(10 Lectures)**

Unit 2: Rotational Dynamics

Angular momentum of a particle and system of particles. Torque, Principle of conservation of angular momentum. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies.

Elasticity: Hooke's law, Poisson's ratio and its limiting values, Relation connecting Elastic constants. Twisting torque on a Cylinder or Wire. **(8 Lectures)**

Unit 3: Gravitation and Central Force Motion

Law of gravitation, Gravitational potential and potential energy, Potential and field due to spherical shell and solid sphere.

Central force: Definition & Characteristics. Kepler's Laws with derivation. Deduction of Newton's law of gravitation from Keplers law. Satellite in circular orbit (orbital velocity, escape velocity & time period) and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). **(9 Lectures)**

Unit 4: Oscillations

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

Non-Inertial Systems: Inertial and Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems: Coriolis Theorem; Centrifugal force. Coriolis force and its applications. **(9 Lectures)**

Unit 5: Relativity

Galilean transformations; Galilean invariance; Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation and its experimental verification; Twin Paradox; Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. **(9 Lectures)**

Expected learning outcomes: *Upon completion of this course, the students will be able to learn the concepts of collisions, rotational dynamics, gravitation, oscillations, central forces and the Special Theory of Relativity including Lorentz transformations and its consequences.*

Reference Books:

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

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

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

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

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

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

vii. A treatise on General Properties of matter, Chatterjee & Sengupta, New Central Book Agency.

viii. Classical Mechanics and properties of Matter, A. B. Gupta, Books and Allied publisher.

SEMESTER-II

PHYDSC151T

ELECTRICITY AND MAGNETISM

Contact Hours: 45

Full Marks = 100 [ESE (70)   CCA(30)]

Course objective: *The objective of this course is to review the concepts of electromagnetism learnt earlier from a more advanced perspective and to build new concept on their basis. The course covers static and dynamic electric and magnetic fields due to continuous charge and current distributions respectively. The course also intends to built the concepts of thermoelectricity and its applications along with ideas of various electrical circuits.*

Unit 1: Electric Field and Electric Potential

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions for spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Relation between Electric field intensity and potential difference, Laplace's and Poisson equations. The Uniqueness Theorem (statement only). Potential and Electric Field of an electric dipole. Force and Torque on a dipole. **(9 Lectures)**

Unit 2: Electrostatic energy, capacitance and dielectric properties

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Surface charge and force on a conductor. Capacitance, Principle of a capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

Dielectric Properties of Matter: Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector **D**. Relations connecting **E, P** and **D**. Gauss' Law in dielectrics. **(10 Lectures)**

Unit 3: Magnetic Field

Magnetic force between current elements and definition of Magnetic Field B. Biot-Savart's Law and its simple applications: straight wire, circular loop and Helmhotz coil. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid.

Properties of B: curl and divergence. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. **(9 Lectures)**

Unit 4: Thermoelectricity

Introduction of thermoelectricity, variation of thermo-emf with temperature, neutral temperature and inversion temperature. Explanation of Seeback effect and Peltier effect, Peltier coefficient. Thomson effect and its prediction. Emf in a thermocouple, law of intermediate temperature and law of intermediate metals. Thermoelectric power and thermoelectric power diagram. Applications of thermodynamics on thermocouple. **(8 Lectures)**

Unit 5: Electrical Circuits:

AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (i) Resonance, (ii) Power Dissipation and (iii) Quality Factor and (iv) Band Width. Parallel LCR Circuit.

Network theorems: Thevenin's theorem, Norton's theorem, Maximum Power Transfer theorem.

Ballistic Galvanometer: Working and its Sensitivity. **(9 Lectures)**

Expected learning outcomes: *After completing this course, the students will be able to apply Gauss's law of electrostatics to distribution of charges, understand the effects of electric polarization and concepts of bound charges in dielectric materials, understand the applications of Biot-Savart's law to calculate magnetic field, understand concepts of thermoelectricity along with their applications and also to understand various network theorems for analysing various dc circuits.*

Reference Books:

i. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw.
ii. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education.
iii. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
iv. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education.
v. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
vi. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.
vii. Classical Electromagnetism in a Nutshell, Anupam Garg, 2012, Princeton University Press.

PHYDSC152P

LAB: MECHANICS AND ELECTRICITY

Contact Hours: 60

Full Marks = 100

Course objective: *In this course, the students will learn to use various instruments, estimate various physical parameters for every experiment performed and report the result of experiment related to mechanics and electricity magnetism. This course also aims at study and analysis of various electrical circuits using network theorems and various bridges.*

Two Experiments are to be performed – one from each part

Part-A: Mechanics

1. To determine the Moment of Inertia of a regular body by torsional pendulum.
2. To determine the Young's Modulus of a Wire by Searle's Method.
3. To determine the Modulus of Rigidity of a Wire by Statical method.
4. To determine g by Bar Pendulum.
5. To determine g by Kater's Pendulum.
6. To determine the co-efficient of viscosity of water by suitable method.
7. To study the motion of spring and calculate (a) spring constant (b) 'g'.
8. To determine the height of a building using a sextant.

Part-B: Electricity

1. To determine the specific resistance of the material of a given wire by meter bridge.
2. To determine an unknown low resistance using Carey Foster's bridge.
3. To determine an unknown low resistance using potentiometer.
4. To verify laws of series and parallel resistances by P.O. Box
5. To compare the magnetic moments of two given bar magnets by deflection magnetometer.
6. To convert a given galvanometer into an ammeter and to calibrate it using copper voltameter
7. To determine the resistance of a given galvanometer by half deflection method.
8. To determine the strengths of the magnetic field produced at the centre of the tangent galvanometer coil due to a current flowing in it and hence to determine the horizontal component of the earth's magnetic field.
9. To determine the value of 'J' by Joule's electrical calorimeter.

10. To verify Thevenin's/Norton's/maximum power transfer theorem.
11. To study response curve of a series LCR circuit and determine its (a) Resonant frequency (b) Impedance at resonance (c) Quality factor Q (d) Band width.

Expected learning outcomes: *At the end of the above course the students will have hands-on knowledge and overview of various experiments related to various key aspects of mechanics and electricity.*

Reference books:

i. Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House.
ii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
iii. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.
iv. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
v. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
vi. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
vii. Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
viii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

SEMESTER-III

PHYDSC201T

WAVES AND OPTICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The course aims at reviewing the concepts of waves and oscillations from a more advanced perspective and goes on to build new concepts. It begins with superposition of harmonic motion leading to physics of damped and forced oscillations. The course will also introduce students to the broad idea of wave optics including various interferometers.*

Unit 1:

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

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

Wave Motion: Plane Progressive (Travelling) Waves. Wave Equation. Differential Equation. Pressure of a Longitudinal Wave. Energy and Intensity of progressive wave. **(12 Lectures)**

Unit 2:

Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends (analytical treatment). Phase and group velocities and relations between them. Energy of vibrating string. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. **(12 Lectures)**

Unit 3:

Wave Optics: Definition and properties of wave front. Huygens Principle.

Interference: Division of amplitude and wavefront. Methods for production of interference fringe by Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin films: Parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **(12 Lectures)**

Unit 4:

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

Diffraction: Types of diffraction, differences between Fresnel and Fraunhofer diffraction. Kirchhoff's Integral Theorem (statement only), Fresnel-Kirchhoff's Integral formula (Qualitative discussion only).

Fraunhofer diffraction: Single slit, double slit and transmission diffraction grating, resolving power of grating, Resolving Power of a telescope. **(12 Lectures)**

Unit 5:

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

Holography: Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. **(12 Lectures)**

Expected learning outcomes: *On successful completion of this course, the students will have the skill and knowledge to, understand simple harmonic motion, superposition of collinear harmonic oscillations, phenomena of interference, diffraction, various interferometers, zone plates and holography as manifestation of interference.*

Reference Books:

i. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
ii. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill.
iii. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
iv. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.
v. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
vi. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
vii. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.
viii. A text book on Light – B. Ghosh and K. G. Mazumdar (Shreedhar Publishers).
ix. Advanced Practical Physics Vol II – B. Ghosh (Shreedhar Publishers).

PHYDSC202T

THERMAL PHYSICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective*: This course aims at reviewing the basic concepts of thermodynamics, kinetic theory of gases, phenomena related to real gases with a brief introduction to Maxwell's thermodynamical equations. The primary goal is to understand the applications of fundamental laws of thermodynamics to various systems and processes.*

Unit 1: Introduction to Thermodynamics

Zeroth and First Law of Thermodynamics: Zeroth Law of Thermodynamics & Concept of Temperature, First Law of Thermodynamics and its differential form, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes.

Second Law of Thermodynamics: Heat Engines & its efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. **(12 Lectures)**

Unit 2:

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

Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. **(13 Lectures)**

Unit 3:

Maxwell's Thermodynamic Relations: Derivations of Maxwell's Relations. Application of Maxwell's Relations to:(1) Clausius Clapeyron equation, (2) Values of $C_P - C_V$ 3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Change of Temperature during Adiabatic Process etc.

Phase Transition: First and second order Phase Transitions with examples, Clausius Clapeyron Equation. **(10 Lectures)**

Unit 4: Kinetic Theory of Gases

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy. Specific heats of Gases.

Molecular Collisions: Basic idea of Mean Free Path. Collision Probability. Transport

Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Einstein's theory of translational Brownian Motion. **(12 Lectures)**

Unit 5:

Real Gases: Behaviour of Real Gases: Deviations from the Ideal Gas Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State, Vapour and Gas. Van der Waal's Equation of State for Real Gases. Values of Critical constants. Comparison with Experimental Curves. P-V Diagrams. Law of Corresponding States. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling. Regenerative cooling. **(13 Lectures)**

Expected learning outcomes: *At the end of this course, the students will get an essence of the basic concepts of thermodynamics - the first and the second law of thermodynamics, the concept of entropy and the associated theorems along with the thermodynamic potentials and their physical interpretations. They are also expected to learn Maxwell's thermodynamic relations, the fundamentals of the kinetic theory of gases, Maxwell-Boltzmann distribution law, mean free path of molecular collisions, transport phenomena including Brownian motion.*

Reference Books:

1. A Treatise on Heat, Meghnad Saha and B.N.Srivastava, 1958, Indian Press
2. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
3. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
4. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press.
5. Thermal Physics, A. Kumar and S.P. Taneja, 2014, S. Chand Publications.
6. Thermal physics, A. B. Gupta and H. P. Roy, Books and Allied Publisher.

SEMESTER-IV

PHYDSC251

MATHEMATICAL PHYSICS-II

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The emphasis of this course is on applications in solving problems of interest to physicists. The course will also expose students to fundamental computational physics skills enabling them to solve a wide range of physics problems. The skills developed during this course will prepare them not only for carrying out fundamental and applied research but also for a wide variety of careers.*

Unit 1: Fourier Series

Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Summing of Infinite Series. Even and odd functions and their Fourier expansions. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Term-by-Term differentiation and integration of Fourier Series. **(14 Lectures)**

Unit 2: Frobenius Method

Regular and Singular Points of Second Order Linear Differential Equations. Frobenius method and its applications to find the solution of Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre, Hermite and Laguerre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. **(12 Lectures)**

Unit 3: Special Functions & Partial Differential Equations

Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions [$J_0(x)$ and $J_1(x)$] and Orthogonality.

Solutions to partial differential equations using separation of variables: Laplace's Equation in problems of rectangular symmetry. **(10 Lectures)**

Unit 4: Laplace Transform (LT)

Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. **(12 Lectures)**

Unit 5: Inverse LT and Application of LT

Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform. **(12 Lectures)**

Expected learning outcomes: *At the end of this course, the students will be able to represent a periodic function by a sum of harmonics using Fourier series and their applications in physical problems. Students are also expected to, obtain power series solution of differential equation of second order with variable coefficient using Frobenius method, understand properties and applications of special functions like Legendre polynomials, Bessel functions and their differential equations, recurrence relations, learn about Laplace transform and inverse transform along with their applications.*

Reference Books:

i. Ordinary and Partial Differential Equations by M.D. Raisinghania, S Chand Publisher.
ii. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
iii. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
iv. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
v. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
vi. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
vii. Engineering Mathematics, S. Pal and S.C. Bhunia, 2015, Oxford University Press.
viii. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books.

PHYDSC252T

ELECTRONICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The emphasis of course is on building basic concepts of electronics covering both analog and digital parts. The course will also expose students to fundamental concepts of semiconductor devices and their wide range of applications. The topics covered in this course will also give flavours of digital electronics connecting both arithmetic and sequential circuits.*

Unit 1:

Semiconductor Diodes: Conductivity and Mobility, Concept of Drift velocity. Formation & V-I characteristics of p-n junction diode. Current Flow Mechanism in Forward and Reverse Biased Diode. Static & Dynamic resistance of p-n junction diode. Half-wave and Full-wave Rectifiers, Calculation of Ripple Factor and efficiency. C & π -filter. Zener and avalanche breakdown, Zener Diode and Voltage Regulation. LED & Solar cell (Principle and working).

(10 Lectures)

Unit 2:

Bipolar Junction transistors: Working of n-p-n and p-n-p transistors. Characteristics of CB and CE Configurations, Active, Cut-off and Saturation Regions. Current gains α and β. DC Load line and Q-point and its importance. Classification of Class A, B & C amplifiers.

Transistor biasing and stabilization: Transistor Biasing and Stabilization Circuits. Fixed bias and voltage divider Bias circuits along with derivation of stability factor.

Feedback in Amplifiers: Concepts of positive and negative feedback. Voltage gain of feedback amplifiers. Effect of feedback on impedance, Gain, Stability and BW. **(14 Lectures)**

Unit 3:

Amplifiers: Hybrid parameter & its Equivalent Circuit. Expressions of various gains and impedances for a CE amplifier using *h*-parameter. Idea of frequency response of two stage R-C coupled amplifier - gain & band width (No derivation).

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. Working of RC Phase shift oscillator and expression of frequency of oscillation (No derivation).

Operational Amplifiers: Characteristics of an ideal and practical OPAMP(IC-741), CMRR, Slew rate, concept of Virtual ground. Inverting and non-inverting amplifiers, Adder, Differentiator & Integrator. **(14 Lectures)**

Unit 4:

Boolean Algebra: Binary Numbers. Decimal to binary and binary to decimal conversion. BCD. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR Gate. De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Idea of Minterms and Maxterms. Canonical SOP & POS. Conversion of a Truth table into Equivalent Logic Circuit. Karnaugh Map. **(10 Lectures)**

Unit 5:

Arithmetic Circuits: Binary Addition and Subtraction using 1's complement. Half adder and Full Adder. 2-bit half subtractor and 2-bit Full subtractor.

Sequential Circuits: SR, JK & MS JK flip flop. Race-around condition in JK Flip-Flop.

Data processing circuits: Multiplexers and De-multiplexers. **(12 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to be conversant with semiconductors devices like junction diodes, transistors along with their applications. Students are also expected to have the clear idea of synthesis of Boolean functions, simplification and construction of digital circuits like flipflops, multiplexers, adders by employing Boolean algebra.*

Reference Books:

1. A Textbook on Electronics by S. Chattopadhay (Publisher: NCBA, 2016).
2. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
3. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India.
4. Electronic devices & circuits, Sanjeev Gupta & Santosh Gupta, Dhanpat Rai Pub.(P), Ltd.
5. Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.

PHYDSC253P

LAB: THERMAL PHYSICS AND ANALOG ELECTRONICS

Contact Hours: 60

Full Marks = 100

Course objective: *In this course, the students will learn to use various instruments, estimate various physical parameters for every experiment performed and report the results of experiments related to thermal physics and analog electronics.*

Two Experiments are to be performed – one from each part

Part-A: Thermal Physics

1. To determine Mechanical Equivalent of Heat, J, by Joule's / Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus or any suitable method.
3. To determine the coefficient of linear expansion by optical lever method or any other suitable method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method or any suitable method.
5. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of resistance with temperature by Carry-Foster bridge and hence determine the temperature coefficient of the material using hotplate.
7. To study the variation of Thermo-emf of a Thermocouple with difference of temperature of its two Junctions
8. To determine the specific heat of a liquid by the method of cooling.

Part-B: Analog Electronics

1. To study V-I characteristics of PN junction diode and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. To study the V-I and power curves of solar cells and find the maximum power point and efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
6. To study the frequency response of a single stage RC-coupled transistor amplifier.
7. To show the tunnelling effect in tunnel diode using I-V characteristics.
8. To design an inverting amplifier using Op-amp (741,351) for dc input voltage and find its closed loop gain.

9. To design non-inverting amplifier using Op-amp (741,351) for dc input voltage and find its closed loop gain.
10. To investigate the use of an op-amp (741,351) as an Integrator and Differentiator.
11. To investigate the use of an op-amp (741,351) as adder and subtractor.

Expected learning outcomes: *For demonstrating comprehensive knowledge and understanding, at the end of the above course the students will have hands-on knowledge and overview of various instruments and perform experiments related to various key aspects of thermal physics and analog electronics.*

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
4. A Laboratory Manual of Physics for undergraduate classes,D. P. Khandelwal,1985, Vani Pub.
5. Advanced Practical Physics Vol I – B. Ghosh (Shreedhar Publishers).
6. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
7. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
8. Electronic Principle, Albert Malvino, 2008, Tata Mc-Graw Hill.
9. Advanced Practical Physics Vol II – B. Ghosh (Shreedhar Publishers).
10. A Textbook on Electronics by S. Chattopadhay (Publisher: NCBA, 2016).

SEMESTER-V

PHYDSC301T

MODERN PHYSICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The emphasis of course is on building basic knowledge in the field of Modern physics which have utmost importance at both undergraduate and postgraduate level. Starting from limitations of Classical Physics, it develops the idea of wave particle duality, probability interpretation, Uncertainty Relation and then discusses the formulation of Schrodinger equation along with the idea of various quantum mechanical operators and their eigen states. The topics covered in this course will also give flavours of atomic physics along with LASERs and their applications.*

Unit 1: Inadequacy of classical mechanics

Inadequacy of classical mechanics with special reference to Black body radiation, Photo electric effect and Compton effect (No derivation), Planck’s quantum hypothesis. Planck’s radiational law: its derivation and special cases. de Broglie concept of matter wave and Wave-particle duality; Davisson-Germer's experiment as evidence of the wave property of particles; Concept of wave packet and its group and phase velocity, Complementary principle. **(12 Lectures)**

Unit 2: Uncertainty relation and Properties of wave function

Heisenberg’s Uncertainty Relation and application to simple problems, a) Non-existence of electron within nucleus b) Radius and ground state energy of Hydrogen atom.

Fundamental postulates of Quantum Mechanics, Physical interpretation of wave function, Boundary conditions for a wave function, Orthogonality and normalization of wave functions. Probability and probability current densitiy. Equation of continuity. **(12 Lectures)**

Unit 3: Schrödinger’s equation and Operators

Time dependent & time-independent Schrödinger equation for non-relativistic particles; Expectation value of dynamical variables, Quantum mechanical Operators and their algebra, Linear operator, Eigen value and eigen function, Hamiltonian operator, Kinetic energy operator, momentum operator, angular momentum operator, Commutation relations. Hermitian operators and their properties. **(12 Lectures)**

Unit 4: Atomic models

Rutherford’s gold foil experiment, Derivation of Rutherford’s differential scattering cross section formula, Rutherford’s model of atom and its limitations. Sommerfield’s atom model and explanation of fine structure of hydrogen atom. Limitations of Sommerfield atom model. Vector atom model and different quantum numbers associated with it. Gyromagnetic Ratio and Bohr Magneton. **(12 Lectures)**

Unit 5: Laser

Lasers, spontaneous and stimulated emission of radiation, optical pumping and population inversion. Metastable states. Three level and four level lasers. Einstein's coefficients, Requisites for producing laser light, Laser rate equations, Optical resonators, He-Ne laser, Solid state laser, Gas lasers, Semiconductor lasers, Laser applications. Basic idea of MASER. **(12 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to develop a comprehensive idea of the main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter, understand the theory of quantum measurements, wave packets and Uncertainty Principle, understand the central concepts of quantum mechanics: wave functions, various operators, the Schrodinger equation, probability density and the normalization techniques etc. Students are also expected to have the basic idea of some atomic models and applications of LASERs.*

Reference Books:

i. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
ii. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
iii. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
iv. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
v. Atomic Physics - J. B. Rajam, S. Chand & Co.
vi. Modern Physics by R. Murugesan, S. Chand & Co., Reprint, 2008.
vii. Atomic and Nuclear Physics- N. Subramaniam & Brijlal, S. Chand & Co.

PHYDSC302T

INTRODUCTION TO CLASSICAL MECHANICS AND ELECTROMAGNETIC THEORY

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The objective of this course is to build the concepts of classical mechanics with methods of formulations of Lagrangian and Hamiltonian and their applications. The emphasis of the course is also on understanding the basic concepts of electromagnetic induction and building the required prerequisites to understand electrodynamic wave propagation.*

Unit: 1: Classical Mechanics

Dynamics of a system of particles: Centre of mass of two particle system, Velocity, acceleration and linear momentum of centre of mass of two particle system, degrees of freedom, Constraints, and their classification

Characteristics of motion under central force, Reduction of two-body central force problem to the equivalent one body problem, Central force and motion in a plane, Equations of motion and differential equation of orbit. Kepler's laws of motion and their deductions. **(12 Lectures)**

Unit 2: Lagrangian formalism

Generalized coordinates and velocities, Principle of virtual work, D'Alembert's Principle. Langrange's equations from D'Alembert's principle. Hamilton's principle, and the Lagrange's equations. Deduction of Hamilton's principle from D'Alembert's principle. Application of the Euler-Lagrange equations to one-dimensional Simple Harmonic Oscillators, simple pendulum, compound pendulum and free-falling body in uniform gravity. **(12 Lectures)**

Unit: 3: Hamiltonian Formalism

Canonical momenta & Hamiltonian. Hamilton's equations of motion, Physical significance of Hamiltonian (H). Application of Hamilton's equation for free particle, Simple Harmonic Oscillators, simple pendulum, compound pendulum, particle in a central force field, charged particle in electromagnetic field, particle moving near the surface of earth, conservation of linear momentum, angular momentum and energy. **(12 Lectures)**

Unit: 4: Electromagnetic Induction

Electric and Magnetic flux, Electro-motive force, Faraday's law of induction (differential and integral form Lenz's law and conservation of energy. Self (L) and mutual inductance (M), self-inductances in series and in parallel. L of a long solenoid, coaxial cylinders and Toroids. Mutual inductance between two coaxial solenoids, coefficient of coupling & its derivation. Energy stored in magnetic Field. Transformer, different losses of transformer. **(12 Lectures)**

Unit 5: Maxwell`s equations and Electromagnetic wave propagation

Equation of continuity of current, Displacement Current. Maxwell's equations. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Wave Equations for Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Poynting Theorem and Poynting Vector.

(12 Lectures)

Expected learning outcomes: *At the end of this course the students are expected to know the Lagrangian and the Hamiltonian formulations of classical mechanics and their applications in appropriate physical problems. Students are also expected to have the basic idea with which they can comprehend the role of Maxwell's equations in unifying electricity and magnetism.*

Reference Books:

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

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

iii. Classical Electrodynamics, J.D. Jackson, 3rd Edn., 1998, Wiley.

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

v. Introduction to Electrodynamics, D.J. Griffiths, 2012, Pearson Education.

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

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

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

ix. Solved Problems in classical Mechanics, O.L. Delange and J. Pierrus, 2010, Oxford Press.
x. Classical Mechanics and properties of Matter, A. B. Gupta, Books and Allied publisher.
xi. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
xii. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
xiii. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning.
xiv. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning.

PHYDSC303P

LAB: RAY OPTICS AND PHYSICAL OPTICS

Contact Hours: 60

Full Marks = 100

Course objective: *In this course, the students will learn to use various instruments, estimate various physical parameters for every experiment performed and report the result of experiments related to Ray optics and Physical optics.*

Two Experiments are to be performed – one from each part

Part-A: Ray Optics

1. To determine the focal length of a given convex lens by pin method.
2. To determine the focal length of a given convex lens by displacement method.
3. To determine the focal length of convex mirror with the help of convex lens by optical bench.
4. To determine the refractive index of the given liquid with the help of plane mirror, convex lens and spherometer.
5. To determine the refractive index of a given liquid by travelling microscope.
6. To determine refractive index of the material of a prism using sodium light source.
7. To determine the angle of minimum deviation of the angle of the given prism with the help of spectrometer & hence to find the refractive index of the material of the prism.
8. To draw the calibration curve connecting refractive index & wavelength of some known lines using prism & spectrometer & hence to calculate the wavelength of an unknown line.
9. To draw the calibration curve connecting the deviation of a ray by a prism & wavelength of some known lines using spectrometer & hence to calculate the wavelength of unknown line.

Part-B: Physical Optics

1. To determine the dispersive power & Cauchy constants of the material of a prism using mercury source.
2. To determine wavelength of sodium light using Fresnel Bi-prism.
3. To determine wavelength of sodium light using Newton's Rings.
4. To determine wavelength of (i) Na source & (ii) spectral lines of Hg source using plane diffraction grating.
5. To determine dispersive power & resolving power of a plane diffraction grating.
6. To determine the width of a single slit by the spectrometer with diffraction method.
7. To determine the grating constant of plane diffraction grating & hence to find the wavelength of an unknown line.
8. To determine the wavelength of a laser source using diffraction of a single slit.
9. To determine specific rotation of sugar solution using polarimeter.

Expected learning outcomes: *For demonstrating comprehensive knowledge and understanding, at the end of the above course the students will have the hands-on experience of using various optical instruments like optical bench, spectrometer, travelling microscopes and polarimeter.*

Reference books:

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

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

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

iv. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill.

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

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

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

viii. A text book on Light – B. Ghosh and K. G. Mazumdar (Shreedhar Publishers).

ix. Advanced Practical Physics Vol II – B. Ghosh (Shreedhar Publishers).

SEMESTER-VI

PHYDSC351T

NUCLEAR AND PARTICLE PHYSICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The objective of this course is to build the concepts of ground state properties of a nucleus, the nuclear models and their roles in explaining the various properties of the nucleus, basic aspects of interaction of nuclear radiation with matter. The emphasis of the course is also on understanding the principles and basic constructions of particle accelerators and gain knowledge on the elementary features of Particle Physics.*

Unit 1: General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density, matter density, binding energy, packing fraction, main features of binding energy versus mass number curve, N/Z plot, angular momentum, parity, magnetic moment, dipole & quadrupole moments.

Alpha Decay: Basics of α-decay processes, theory of α-emission, Gamow's theory of alpha decay. Geiger Nuttall law, α-ray spectra. Range of alpha particle and its determination.

(12 Lectures)

Unit 2: Beta & Gamma decays: Beta-decay: energy kinematics for β-decay, β spectrum, positron emission, electron capture, neutrino hypothesis, Rein & Cowans experiment of detection of neutrino. Gamma decay: Gamma ray emissions and internal conversion.

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, Q value of alpha, beta and gamma decay, endothermic & exoergic reaction, Expression of scattering cross-section. **(12 Lectures)**

Unit 3:

Nuclear Models: Liquid drop model. Nuclear fission & Bohr-wheeler theory of nuclear fission. semi empirical mass formula and significance of its various terms, condition of nuclear stability. Nuclear shell model and basic assumption of shell model, evidences for nuclear shell model, nuclear magic numbers. Nuclear force & its properties, Meson theory of nuclear force (detail).

(12 Lectures)

Unit 4: Interaction of Nuclear Radiation with matter: Cerenkov radiation. Gamma ray interaction through matter: Detailed theory of photoelectric effect, Compton scattering and pair production. Mossbauer effect (qualitative idea only).

Detector for Nuclear Radiations: Ionization chamber, proportional counter, GM Counter and Cerenkov radiation detector.

Particle Accelerators: Cyclotron, Betatron. **(13 Lectures)**

Unit 5: Particle physics: Fundamental Particle interactions, relative strengths of these interactions and their basic features, types of particles and its families. Symmetries and Conservation Laws, Spin, baryon number, Lepton number, Isospin, Strangeness, hyper charge and charm. Concept of quark model, Standard model. Concepts of charge conjugation, parity, time reversal and CPT theorem. **(11 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to develop the skills to describe and explain the properties of nuclei and derive them from various models of nuclear structure. The students are also expected to understand, explain and derive the various theoretical formulation of nuclear disintegrations like α, β and γ decays, understand the construction and operation of detectors and particle accelerators and finally to develop the basic knowledge of elementary particles as fundamental constituent of matter, their properties, conservation laws during their interactions.*

Reference Books:

i. Introductory Nuclear Physics by Kenneth S. Krane. (Wiley-India Publication, 2008)

ii. Concepts of Nuclear Physics by Bernard L Cohen. (Tata McGraw Hill Publication, 1998).

iii. Introduction to the physics of nuclei & particles. R.A. Dunlap. (Thomson Asia,2004).

iv. Introduction to elementary particles, David J Griffiths, John Wiley & Sons.

v. Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi.

vi. Theoretical Nuclear Physics, J.M. Blatt &V.F.Weisskopf (Dover Pub.Inc., 1991).

vii. Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press.

viii. Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.

ix. Nuclear Physics by S. N. Ghosal, S. Chand Publication, 2010.

x. Modern Physics by R. Murugaeshan. S. Chand Publication, 2010.

xi. Principles of Modern Physics, A K Saxena, Narosa Publishing House.

xii. Atomic & Nuclear Physics by A. B. Gupta, Books & allied publisher.

xiii. Lecture notes in Physics: Particle Physics, Sabyasachi Roy (Tirthabhumi Publication, 2017).

PHYDSC-352T

STATISTICAL MECHANICS AND PLASMA PHYSICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course aims to introduce statistical mechanics and introductory plasma physics to the students. This course will enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behaviour of atoms and molecules through statistical mechanics.*

Unit 1:

Microstates and macrostates, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Concept of statistical ensemble - Micro-canonical, Canonical and Grand canonical ensemble. Basic idea of partition functions, Expressions of different thermodynamical quantities (e.g. Free energy, pressure, average energy, entropy, Specific heat) in terms of partition function. **(12 Lectures)**

Unit 2:

Properties of Thermal Radiation. Kirchhoff's law. Blackbody Radiation, Spectral Distribution of Black Body Radiation. Wein's law & Rayleigh Jeans law (No derivation), Ultraviolet catastrophe. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation and its derivation. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. Saha's Ionization Formula (qualitative idea only). **(12 Lectures)**

Unit 3:

Entropy of mixing and Gibb's paradox, Resolution of Gibb's paradox, Concept of identical particles, Limitation of classical statistics. Fermions and Bosons. Bose-Einstein distribution function and its behaviour with temperature, Basic idea of phenomenon of Bose-Einstein condensation (Qualitative description), Calculation of various thermodynamical quantities of photon gas (black body radiation). **(12 Lectures)**

Unit 4:

Fermi-Dirac distribution function and its behaviour with temperature, Basic idea of Fermi surface and fermi energy, Calculation of various thermodynamical quantities of free electron gas; Classical limits and distinguishing features of classical and quantum statistics. Basic idea of degenerate Fermi gas. Comparison of three distribution laws and their properties. **(13 Lectures)**

Unit 5:

Plasma: Its definition, composition and characteristics, microscopic and macroscopic descriptions of plasma. Difference between ordinary gas and plasma, Plasma Parameters, Concept of Debye shielding distance, Quassi-neutrality in plasma, Dielectric constant of plasma, Production of plasma through collisions, Plasma Diagnostics - Single probe method, magnetic confinement of plasma. Solar corona and Solar wind. **(11 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to understand the concepts of microstate, macrostate, ensemble, phase space, thermodynamic probability and partition function, understand the combinatory studies of particles with their nature and conditions which lead to the three different distribution laws, develop the ability to derive radiation laws of black body radiation. Students are also expected to learn Gibb's paradox & its resolution, understand the macroscopic properties of degenerate photon gas and degenerate fermi gas. Finally, the students are expected to know the basic ideas of plasma state of matter with ideas of composition, behaviour, magnetic confinement etc.*

Reference Books:

i. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.

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

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

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

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

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

vii. Introduction to Plasma Physics & Controlled fusion, Francis F. Chen, Springer.

viii. Elements of Plasma Physics, S. N. Goswami, NCBA, Publisher.

ix. Text book of Plasma Physics, Suresh Chandra, CBS Publishers & Distributors Pvt, Ltd.

PHYDSC353T

SOLID STATE PHYSICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course aims to introduce the basic phenomena in solid state physics. On successful completion of this course the students would be able to elucidate the main features of crystal lattices and phonons, understand the elementary lattice dynamics and its influence on the properties of materials, describe the main features of the physics of electrons in solids; explain the dielectric ferroelectric and magnetic properties of solids and understand the basic concept in superconductivity.*

Unit 1:

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Unit Cell, Lattice with a Basis, Types of Lattices, Bravais lattice, symmetry, point groups and space groups. Miller Indices. Reciprocal Lattice. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Theory of Laue Spots. **(11 Lectures)**

Unit 2:

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law.

Bonding in Solids: Types of bonding in solids, covalent, Ionic bindings, metallic bonding, Vander waal's bonding, hydrogen bond. **(13 Lectures)**

Unit 3:

Magnetic Properties of Matter: Magnetic moment due to spin and orbital motion of the electron in atom, Effect of magnetic field on the angular momentum of electron; Dia, Para, Ferro and Ferrimagnetic Materials. Classical Langevin Theory of dia and Paramagnetic Domains Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss. **(11 Lectures)**

Unit 4:

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion, Lorenz theory of dispersion for both Normal and Anomalous Dispersion. Cauchy and Sellmeier relations. Raman effect and its theory.

Ferroelectric Properties of Materials: Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect. **(13 Lectures)**

Unit 5:

Elementary Band Theory: Qualitative description of free electron theory, Band Gap, Conductor, Semiconductor (P and N type) and insulator. Conductivity and mobility of Semiconductor. Hall Effect and Hall coefficient. Effective mass of election.

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect. Idea of BCS theory (No derivation). **(12 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to learn the basics of crystal structure and physics of lattice dynamics, the physics of different types of magnetic materials and their properties, understand the physics of insulators, semiconductor and conductors with special emphasis on the elementary band theory, comprehend the basic theory of superconductors, Type I and II superconductors, their properties and concept of BCS theory.*

Reference Books:

i. Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley India Pvt. Ltd.

ii. Elements of Solid State Physics, J.P. Srivastava, 4th Edition, 2015, Prentice-Hall of India.

iii. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
iv. Solid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
v. Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
vi. Solid State Physics, Rita John, 2014, McGraw Hill.
vii. Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India.
viii. Solid State Physics, M.A. Wahab, 2011, Narosa Publications.
ix. Solid state Physics, S.O. Pillai, New age publisher.

PHYDSC354P

LAB: SOLID STATE PHYSICS AND DIGITAL ELECTRONICS

Contact Hours: 60

Full Marks = 100

Course objective: *In this course, the students will learn to use various instruments, estimate various physical parameters for every experiment performed and report the result of experiments related to solid state physics and digital electronics.*

Two Experiments are to be performed – one from each part

Part-A: Solid State Physics

1. To measurement the susceptibility of paramagnetic solution by (Quinck`s Tube Method)/suitable method.
2. To measure the Magnetic susceptibility of Solids.
3. To measure the Dielectric Constant of a dielectric Material by suitable method.
4. To study the P-E Hysteresis loop of a Ferroelectric Crystal.
5. To draw the B-H curve of Fe using Solenoid/transformer & determine energy loss from Hysteresis.
6. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap.
7. To determine the Hall coefficient of a semiconductor sample.
8. To determine magnetic field as a function of the resonance frequency for studying electron spin resonance
9. To Study the Zeeman effect: with external magnetic field; Hyperfine splitting.
10. To determine Planck's constant using LEDs of at least 4 different colours.
11. To determine Boltzmann's constant using V-I characteristics of PN junction diode.

Part-B: Digital Electronics

1. To verify the truth tables of AND, OR, NOT, NOR and NAND gates.
2. To study and verify NAND and NOR gates as a universal gate.
3. To design a combinational logic system for a specified Truth Table using breadboard.
4. To convert a Boolean expression (SOP/POS) into logic circuit and design it using logic gate ICs.
5. To design and verify the De Morgan's theorem.
6. To design and verify Half Adder and Full Adder.
7. To design and verify the truth tables of S-R flip-flop using NOR/NAND gates.
8. To design and verify the truth tables of D flip-flop using NOR/NAND gates.
9. To verify the truth tables of the multiplexer 74150 and demultiplexer 74154.

Expected learning outcomes: *For demonstrating comprehensive knowledge and understanding, at the end of the above course, the students will have the hands-on experience of using various instruments to carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, to trace hysteresis loop, hall coefficient, Planck's constant. The students are also expected to verify the fundamental and universal logic gates, construct both combinational circuits and sequential circuits by employing logic gates and demonstrate adders, multiplexers and flip flops.*

References:

1. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal.
3. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.
4. Advanced Practical Physics Vol II – B. Ghosh (Shreedhar Publishers).
5. Experiments in Digital Electronics, Dr. V. S. Bist, Neel Kamal Prakashan.
6. Practical Digital Electronics: Lab Manual, Nigel P. Cook.

SEMESTER-VII

PHYDSC401T

Mathematical Physics - III

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The emphasis of this course is on applications in on mathematical methods essential for solving the advanced problems in physics. It would be helpful in the development of the ability to apply the mathematical concepts and techniques to solve the problems in theoretical and experimental physics. The knowledge of this course on mathematical physics would be beneficial in further research and development as it serves as a tool in almost every branch of science and engineering Course.*

Unit 1: Linear Vector Space, Matrices and Tensors

Vectors in n-dimension, Linear independence, Basis and Dimension, Scalar product, Norm and Orthogonality, Schwarz inequality, Gram-Schmidt orthogonalization technique. Linear operators and their Matrix representation, Eigenvalues and Eigenvectors of a matrix, Cayley-Hamilton theorem, Orthogonal, Unitary and Hermitian matrices. Infinite dimensional space, Hilbert space.

Definition of Tensor, Covariant and Contravariant tensor, Fundamental operation with tensors, Metric tensor, Covariant differentiation and Christoffel symbols. **(12 Lectures)**

Unit 2: Differential Equations & Special functions

Second order linear differential equations, Series solution, Ordinary and Singular points. Partial differential equations: Classification. Boundary value problems. Concept of well posedness. Green's function technique for solution of Differential equations. Legendre, Hermite, Laguerre and Bessel Functions. **(12 Lectures)**

Unit 3: Complex Variables and Integral Transforms

Analytic functions, Cauchy-Riemann conditions, Cauchy integral theorem for simply and multiply connected regions, Cauchy integral formula, Taylor and Laurent series, Poles, Residue theorem, Evaluation of integrals.

Fourier transforms and its applications, convolution theorem, Parseval's relation, Laplace transforms, Laplace transform of derivatives, Inverse Laplace transform and Convolution theorem, use of Laplace's transform in solving differential equations. **(12 Lectures)**

Unit 4: Theory of Probability and Statistics and Numerical methods

Random Variables, Binomial, Poisson and Normal Distributions. Central Limit Theorem, Law of Large numbers. Hypothesis Testing. Finite difference, Interpolation and extrapolation (forward, backward and central), Roots of functions, Integration by trapezoidal and Simpson's rule, Solution of 1st order differential equation using Euler and 2nd order Runge-Kutta method. **(12 Lectures)**

Unit 5: Group Theory

Abstract groups: subgroups, classes, cosets, factor groups, normal subgroups, direct product of groups; Homomorphism & Isomorphism. Representations: reducible and irreducible, unitary representations, Schur's lemma and orthogonality theorems, characters of representation, direct product of representations. Introduction to continuous groups: Lie groups, rotation and unitary groups. Representation of SO(3), SU(2). **(12 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to learn the basics of linear vector spaces, group theory, tensors and their applications in various physical problems. Moreover, the students are expected to gain the knowledge of various mathematical tools like complex analysis, integral transform which will equip the students with skills to solving a given ODE, PDE.*

Reference Books:

i. Murry R Spiegel, Vector Analysis McGraw Hill.
ii. Murry R Spiegel, Complex variables McGraw Hill.
iii. A W Joshi, Elements of Group Theory for Physicists New Age International.
iv. A W Joshi, Matrices and tensors in physics New Age International.
v. I Snedden, Elements of partial differential equations McGraw Hill.
vi. G B Arfken, Mathematical Methods for Physicists Academic Press.
vii. Corte S.D. and de Boor, Elementary Numerical analysis, 3rd Ed, McGraw Hill, 1980.
viii. James B. Scarborough, Numerical Mathematical Analysis, Oxford.
ix. F.B. Hildebrand, Introduction to Numerical Analysis, McGraw Hill, 1956.
x. L.A. Pipes and L.R. Harwill, Applied Mathematics for Physicists and Engineers, McGraw Hill.

PHYDSC402T

CLASSICAL MECHANICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The objective of this course is to build the concepts of classical mechanics with problems involving central force motion, small oscillations, rigid body dynamics and methods of formulations of Lagrangian and Hamiltonian and their applications.*

Unit 1:

Mechanics of a system of particles: Centre of mass, conservation of linear and angular momentum, energy conservation. Two-body central force problem: reduction to one body problem, equations of motion, classification of orbits, differential equation of the orbit, Kepler's laws. **(12 Lectures)**

Unit 2:

Constraints, generalized coordinates, principle of virtual work, D'Alembert's principle, Lagrange's equations. Velocity dependent potential and dissipation function. First integrals of motion and cyclic coordinates. Hamilton's principle, Lagrange's equations from Hamilton's principle, Hamilton's principle for non-holonomic systems. Symmetry principles and conservation laws. **(12 Lectures)**

Unit 3:

Hamilton's equations of motion, Hamilton's equations from variational principle. Integrals of Hamilton's equations. Principle of least action. Canonical transformation, infinitesimal canonical transformation, Poisson brackets, fundamental properties of Poisson brackets, equations of motion in Poisson bracket form. Lagrange brackets. **(12 Lectures)**

Unit 4:

Hamilton-Jacobi theory, Hamilton's characteristic function, Harmonic oscillator in Hamilton-Jacobi method, separation of variables in Hamilton-Jacobi equation. Action and angle variables, Kepler problem in action-angle variables. **(13 Lectures)**

Unit 5:

Motion of rigid bodies: Angular momentum and kinetic energy, inertia tensor, principalaxes and moments of inertia. Euler's angles, Euler's equations of motion. Coriolis force. Force- free motion of a symmetrical top.

Small oscillations: equilibrium and potential energy, frequencies of free vibration and normal coordinates. Longitudinal vibration of linear triatomic molecule. **(11 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to learn the Lagrangian and the Hamiltonian formulations of classical mechanics and their applications in appropriate physical problems. Students are also expected to have the idea of Hamilton Jacobi theory, Kepler problem in action-angle variables, Euler's angles, Euler's equations of motion and small oscillations.*

Reference Books:

i. Goldstein, Classical Mechanics Narosa Publishing, Delhi,

ii. Landau & Lifshitz, Course of theoretical Physics, Vol-10, Oxford University, Press.

iii. Joag& Rana, Classical Mechanics, Mc Graw Hill.

iv. Berger, Classical Mechanics A modern Perspective, Mc Graw Hill International.

v. Awqhmare, Classical Mechanics, Prentice Hall.

vi. Sommerfield, Lectures on theoretical Physics. Vol-I, Academic Press, NY 1952.

vii. Hestness, New foundations for classical Mechanics, Kluwer Academic Publisher.

viii. R. Resnik, Introductions of Relativity, Wiley Eastern 1967.

ix. Corben & Stehle, Classical Mechanics, Wiley NY 1974.

PHYDSC403T

QUANTUM MECHANICS -I

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *In continuation with modern physics this course gives emphasis on stationary states, Ehrenfest theorem, Dirac's bra ket notations with their operations and applications of Schrodinger equation to various quantum mechanical problems. This course gives fair idea of symmetry transformations, time-independent Perturbation theory and its applications.*

Unit 1: Wave functions, Observables and Operator

Wave functions and Operators in co-ordinate and momentum representations, Stationary states, Ehrenfest theorem. Dynamical variables and linear operators. Ladder operator, Commutation relations of various operators. Compatible and incompatible Observable. Generalized uncertainty principle and its applications. Introduction of Hilbert space. Dirac's bra and ket notation and their operations. **(11 Lectures)**

Unit 2: Applications of Schrodinger's Equation

Applications of Schrödinger Equation: Free particle in one dimensional infinite potential well and calculation of its eigen values and eigen functions, Particle in three-dimensional box - concept of degeneracy, Calculation for transmission and reflection coefficient for particle encountering step potential, Particle inside finite rectangular potential barrier - Phenomenon of quantum tunneling; Linear harmonic oscillator: Energy eigen value and eigen function of linear harmonic oscillator, ground state wave function. **(13 Lectures)**

Unit 3: Matrix Representations of operators, Operator method to Harmonic Oscillator, Hydrogen atom

Representation of states and dynamical variables, completeness and closure property. Schrödinger, Heisenberg and interaction pictures. Matrix representation of an operator, change of basis, unitary transformation. Eigen values and eigen functions of simple harmonic oscillator by operator method.

Application of Schrodinger Equation to find energy eigen value and eigen function of hydrogen atom using spherical harmonics and Laguerre polynomials. **(14 Lectures)**

Unit 4: Conservation laws and Angular Momentum Algebra

Symmetry transformations: Space – time translations and rotations, Invariance under the transformations and conservation laws. Central force problem, orbital angular momentum, angular momentum algebra, spin, Addition of angular momenta, Clebsch Gordon coefficients.
(10 Lectures)

Unit 5: Time-Independent Perturbation Theory

Time-independent Perturbation theory (non-degenerate and degenerate) and applications to fine structure splitting, Zeeman effect (Normal and anomalous), Stark effect, and other simple cases. Variational method and applications to helium atom and simple cases. **(14 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to learn the mathematical formalism of Hilbert space, hermitian operators, eigen values, eigen states and unitary operators, which form the fundamental basis of quantum theory. Application to simple harmonic oscillators, hydrogen-like atoms and angular momentum operators will teach the students how to obtain eigen values and eigen states for such systems elegantly. Students are also expected to have fair knowledge on various symmetry transformations and time-independent Perturbation theory and its applications.*

Reference Books:

i. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
ii. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
iii. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
iv. Introductory Quantum Mechanics, Pearson Education (2006), R.L.Liboff.
v. Quantum Mechanics, Macmillan (2000), A.K. Ghatak and S. Lokanathan.
vi. Modern Quantum Mechanics, Addison-Wesley (1990), J.J. Sakurai.
vii. Quantum Mechanics, John Wiley & Sons (1999), E. Merzbacher.

PHYDSC404P

LAB: NUMERICAL TECHNIQUES AND VIRTUAL LAB

Contact Hours: 60

Full Marks = 100

Course objective: *In this course, the students will learn various aspects of computational techniques and train themselves with skills of writing codes for numerical scientific computation and simulations. Moreover, this course also will also develop the skills of the students in designing and analyzing electrical/electronic circuits through exposure of virtual lab which, will intern enable the students to achieve the knowledge of working with various electronic devices and circuits without physically visiting the laboratory.*

Two Experiments are to be performed – one from each part

Part-A: Numerical Techniques

Use C/C++/FORTRAN/ Scilab/ Python/Matlab/Mathematica/others to solve the following problems:

1. i. To add, multiply two matrices and find transpose of a given matrix.
   ii. To find inverse, eigen values and eigen vectors of a given matrix.
2. To solve algebraic equations by:
   i. Bisection method.
   ii. Newton-Raphson method.
   iii. Secant method.
3. To solve transcendental equations by suitable approximate numerical method.
4. To evaluate trigonometric functions $sin\theta$, $cos\theta$ and $\tan\theta$ using Newton Gregory Forward and Backward difference formula.
5. i. To find the value of R from a given current (I) with voltage (V) data using least square fitting, assuming that the Ohm's law is obeyed.
   ii. To measure spring constant using Hooke's law (neglecting negative sign) from a given displacement (x) with applied force (F) data using least square fitting.
6. i. Using Rodrigues' formula as a user-defined function, evaluate and plot the first six Legendre polynomials from $x = -1$ to $+1$.
   ii. Using Rodrigues' formula as a user-defined function, evaluate and plot the first six Hermite functions of the first kind from $x = -1$ to $+1$.
7. Solve differential equations
   i. $\dfrac{dy}{dx} = e^{-x}$ with $y = 0$ for $x = 0$ ii. $\dfrac{dy}{dx} + e^{-x} y = x^2$

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

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

$$\frac{d^2u(r)}{dr^2}=A(r)u(r),\ A(r)=\frac{2m}{\hbar^2}\left[V(r)-E\right],\quad \text{where } V(r)=-\frac{e^2}{r}$$

Where, ***m*** is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave-functions. Remember that the ground state energy of the hydrogen atom is $-13.6\ eV$. Take $e=3.795\left(eVA^0\right)^{1/2}$, $\hbar c=1973(eVA^0)$ and $m=0.511\times10^6\ eV/c^2$.

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

$$\frac{d^2u(r)}{dr^2}=A(r)u(r),\ A(r)=\frac{2m}{\hbar^2}\left[V(r)-E\right]$$

where ***m*** is the reduced mass of the system (which can be chosen to be the mass of an electron) for the screened coulomb potential $V(r)=-\frac{e^2}{r}e^{-r/a}$.

Also, find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take $e=3.795\left(eVA^0\right)^{1/2}$, $m=0.511\times10^6\ eV/c^2$ and $a=3A^0,\ 5A^0,\ 7A^0$. In these units $\hbar c=1973(eVA^0)$. The ground state energy is expected to be above $-12\ eV$ in all three cases.

Part-B: Virtual Lab.

Use Multi-sim/ LT Spice/ Tinkercad/ TINA/Proteus/ Dcalab/ 123D circuits/ Circuitlab/ Other softwares or websites to perform the following experiments:

1. To study the characteristics of a p-n diode and find its knee voltage.
2. To study the characteristics of a zener diode find the breakdown voltage.
3. To study the characteristics of a npn transistor in CE mode to find the various *h*-parameters.
4. To design and study OPAMP as adder and subtractor.
5. To design and study OPAMP as differentiator and integrator.
6. To design and study OPAMP as inverting and non-inverting amplifier.
7. To verify the truth tables of AND, OR, NOT, NOR and NAND gates.
8. To study the truth tables of NAND and NOR gates as a universal gate.
9. To study the truth table of various combinational logic circuits.
10. To simplify a given Boolean expression (SOP/POS) and realize the corresponding truth table.

11. To design and verify the De Morgan's theorem.
12. To design and verify Half Adder and Full Adder.
13. To verify the truth table of RS, JK and D flip-flops using NAND and NOR gates.

Expected learning outcomes: *For demonstrating comprehensive knowledge and understanding, at the end of the above course, the students are expected to have thorough familiarity with computing softwares and developing skills of writing codes for various numerical computations. The Online Virtual Lab Experiments are expected to give an insight in simulation techniques and provide a basis for modelling of electronic circuits.*

References:

i. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn. , 2012, PHI Learning Pvt. Ltd.
ii. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
iii. Computer Programming in FORTRAN 90 and 95, 19th Edn., 2019, PHI Learning Pvt. Ltd.
iv. Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rd Edn., 2007, Cambridge University Press.
v. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.
vi. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.
vii. An Introduction to computational Physics, T.Pang, 2nd Edn. , 2006,Cambridge Univ. Press
viii. Scientific Computing in Python, A K Gupta, 2018, TECHNO WORLD.
ix. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.
x. Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand & Company.
xi. Virtual Labs at Amrita Vishwa Vidyapeetham, https://vlab.amrita.edu/?sub=1&brch=74
xii. https://de-iitr.vlabs.ac.in/List%20of%20experiments.html

SEMESTER-VIII

PHYDSC451T

QUANTUM MECHANICS - II

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course gives emphasis on time dependent perturbation theory, WKB approximation, Variational technique, Scattering Theory, relativistic formulation of Quantum Mechanics and scalar field theories including interpretation of the quantized fields.*

Unit 1: Time dependent perturbation theory

The pictures of quantum mechanics - Schrödinger, Heisenberg and interaction pictures. Time dependent perturbation theory - Fermi Golden rule, Transition probabilities for constant and harmonic perturbation. Adiabatic and sudden approximations. Interaction of atoms with radiation: Absorption and emission of Radiation, Einstein's A, B coefficients, selection rules, transition rates within dipole approximation, Spontaneous Emission. **(12 Lectures)**

Unit 2: WKB approximation and others

WKB approximation, connection with classical limits, connection formula, validity of WKB approximation, Alpha emission (Barrier penetration and tunnelling.). Variational technique – examples of hydrogen atom, helium atom and harmonic oscillator. **(10 Lectures)**

Unit 3: Scattering Theory

Scattering Theory: Amplitude and cross-section, CM and Laboratory frame, Scattering by spherically symmetric potentials, partial waves and phase shifts, Scattering by an attractive square well potential, Breit-Wigner formula. Born approximation and its validity, Coulomb scattering. **(12 Lectures)**

Unit 4: Relativistic Quantum Mechanics

Attempt for relativistic formulation of Quantum Mechanics, Klein-Gordon equation and its significance, Klein Gordon equation in presence of electromagnetic field and its non-relativistic reduction, Dirac equation for a free particle, properties of Dirac. Solution of the free particle, orthogonality and completeness relation for Dirac spinors, fine structure of hydrogen atom, interpretation of negative energy solution. **(14 Lectures)**

Unit 5: Scalar field Theory

Concept of systems with infinite degrees of freedom, Classical fields, Equations of motion, Hamiltonian. Symmetries and invariance principles – Noether's Theorem.

Canonical quantization of scalar field: Creation, annihilation operators, Commutation relations. Interpretation of the quantized field – number operator, connection with harmonic oscillator.

(12 Lectures)

Expected learning outcomes: *At the end of this course the students are expected to learn applications of time-dependent perturbation theory, WKB approximation, Scattering by spherically symmetric potentials, partial waves, Born approximation and its validity, relativistic formulation of Quantum Mechanics, Dirac spinors, fine structure of hydrogen atom, interpretation of negative energy solution, Concept of systems with infinite degrees of freedom, Classical fields and Canonical quantization of scalar field.*

Reference Books:

i. Introduction to Quantum Mechanics, David J. Griffiths, Cambridge India.

ii. R. L. Liboff, Introductory Quantum Mechanics, Pearson Education (2006).

iii. Quantum Mechanics, Vol. 1 and 2: Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe.

iv. L.I. Schiff, Quantum Mechanics, McGraw Hill (1998).

v. A.K. Ghatak and S. Lokanathan: Quantum Mechanics, Macmillan (2000).

vi. J.J. Sakurai, Modern Quantum Mechanics, Addison-Wesley (1990).

vii. E. Merzbacher, Quantum Mechanics, John Wiley & Sons (1999).

viii. Satya Prakash, Advanced Quantum Mechanics, Kedar Nath (1990).

ix. V.K. Thankappan, Quantum Mechanics, New Age Intl. Pub (1996).

x. S. Gasiorowiz, Quantum Mechanics, Wiley (1995).

xi. P M Mathews and S Venkateswan, Quantum Mechanics, Tata McGraw Hill (1976).

xii. N Zettili, Quantum Mechanics, John Wiley (2001).

xiii. John L Powell and B Crasemann, Quantum Mechanics, Narosa (1991).

PHYDSC452T

ELECTROMAGNETIC THEORY

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course gives emphasis on Electromagnetic field tensor, Motion of a charged particle in electromagnetic field, Saha's equation of ionization, Plasma oscillations, Plasma Parameters, Radiation from an accelerated point charge, Retarded potentials, Dipole radiation, Quadrupole and magnetic dipole radiation and electromagnetic scattering formulations.*

Unit 1: Covariant formalism of electromagnetism

Minkowski space-time, Four vector, Lorentz Transformation matrix, Lorentz transformation of electric and magnetic fields, Lorentz invariant quantities involving $\vec{E}$ and $\vec{B}$ $\left(\text{i.e. } E^2 - B^2 \text{ and } \vec{E}.\vec{B}\right)$, Electromagnetic field tensor, current density 4-vector, 4-vector potential, Maxwell's equations in terms of field tensor. **(12 Lectures)**

Unit 2: Motion of a charge particle in electromagnetic field

Motion of charged particle in a) uniform electric field b) uniform magnetic field and c) combined uniform electric and magnetic field. Grad B drift, curvature drift. Particle in a non-uniform magnetic field, Particle in a non-uniform electric field and uniform magnetic field, Particle in time varying electric and magnetic fields. **(12 Lectures)**

Unit 3: Fluid description of plasma

Saha's equation of ionization (No derivation), Fluid description of plasma: Equation of motion for fluid, Equation of continuity, Plasma approximation, Plasma oscillations, Electron plasma wave, Ion wave, Magneto Sonic and Alfven waves, Collision parameters and diffusion parameters in the diffusion process of plasma, ambipolar diffusion and its coefficient.

(12 Lectures)

Unit 4: Radiation from an accelerated charge

Retarded potentials, Lienard-Wiechert potentials, field of a system of charges at large distances. Electric Dipole radiation, Quadrupole and magnetic dipole radiation. Derivation of Larmor formula of radiation for accelerated charged particles. **(12 Lectures)**

Unit 5: Scattering

Scattering: coulomb collision due to a harmonically bound charge, Thomson scattering, Rayleigh scattering, Mie Scattering and phase function formulation – consideration of a large particle - Other scattering formulations (expressions only): T-matrix, Discrete Dipole Approximation. **(12 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to learn Lorentz transformation in 4-dimensional Space, Covariant formalism of electromagnetism, Motion of a charged particle in electromagnetic field, Saha's equation of ionization, Plasma oscillations, Plasma Parameters, Radiation from an accelerated point charge, Retarded potentials, dipole radiations and electromagnetic scattering formulations.*

Reference Books:

i. J.D. Jackson, Classical Electrodynamics, Wiley Eastern, 1989.
ii. Griffiths, Introduction of Electrodynamics, Prentice Hall.
iii. L.D. Landau & E. M Lifshitz, The classical theory of fields, Butterworth Heinemann Ltd.Oxford.
iv. Miah M.A.W, Fundamentals of Electromagnetic, Tata Mc Graw Hill.
v. Cook D.M, Theory of Electromagnetic Fluids, Prentice Hall.
vi. Lorrain & Corson, Electromagnetic field and waves, Freeman & Company Sanfrancisco.

PHYDSC453 (A)T

ASTRONOMY, ASTROPHYSICS AND COSMOLOGY

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course gives emphasis on providing the platform for understanding the origin and evolution of the Universe. The topics covered in this course gives a comprehensive introduction on the measurement of basic astronomical parameters such as astronomical scales, luminosity, astronomical quantities and astronomical techniques. The course also reviews the formation of planetary system and its evolution with time including stellar and interstellar components of our Milky Way galaxy.*

Unit 1: Basic concepts of positional astronomy

Celestial Sphere, Geometry on a Sphere (Spherical Triangle), Astronomical Coordinate Systems, Geographical Coordinate Systems, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star.

(12 Lectures)

Unit 2: Astronomical techniques

Basic Optical Definitions for Astronomy (Magnification Light Gathering Power, Resolving Power and Diffraction Limit, Atmospheric Windows), Optical Telescopes (Types of Reflecting Telescopes, Telescope Mountings, Space Telescopes, Detectors and Their Use with Telescopes (Types of Detectors, detection Limits with Telescopes). **(12 Lectures)**

Unit 3: Sun

The sun: Solar Parameters, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity.

The solar family: Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings.

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

(12 Lectures)

Unit 4: The Milky Way

Galaxy Morphology, Hubble's Classification of Galaxies, Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Qualitative ideas only), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus. **(12 Lectures)**

Unit 5: Large scale structure & expanding universe

Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Galaxy clusters, Virial theorem and introduction to dark Matter, Big-bang theory (Qualitative ideas). **(12 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to learn basic concepts of positional astronomy, astronomical techniques, telescope optics and instrument detectors. Students are also expected to gather knowledge on the formation of planetary system and its evolution with time, the physical properties of Sun and the components of the solar system with special reference to our Milky Way galaxy. On successful completion of this course, the students will also have the knowledge to understand the physical laws that enable us to know the origin and evolution of galaxies, presence of dark matter and large-scale structures of the Universe.*

Reference Books:

i. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.

ii. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.

iii. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.

iv. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.

v. The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.

vi. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer.

vii. Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice -Hall of India Privatelimited, New Delhi, 2001.

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

PHYDSC453 (B)T

NANO SCIENCE & MATERIAL SCIENCE

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course introduces the essence of nano materials, their synthesis, and characterization. On successful completion of this course students should also be able to understand the various optical properties of nanomaterials along with few important applications of nano materials used in this technological era.*

Unit 1: Nanoscale systems

Introduction to Nanoscience: Emergence of Nanoscience with special reference to Feynman and Drexler, Length scales in physics, Role of particle size , Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), surface effect, Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences.

(12 Lectures)

Unit 2: Synthesis of nanostructure materials

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

Basic Idea about Buckyballs, Carbon nano tubes, Graphene, Zeolites Porous Materials, Metal Nanocrystals, Semiconductor nanomaterials. **(13 Lectures)**

Unit 3: Characterization

X-Ray Diffraction. UV Visible spectroscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. Electron transport: Carrier transport in nanostructures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.

(11 Lectures)

Unit 4: Optical properties:

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

Unit 5: Applications:

Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices, Surface Acoustic Wave (SAW), Sensor applications, Single electron transfer devices (no derivation). CNT based transistors.

Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS).

(12 Lectures)

Expected learning outcomes: *At the end of this course the students are expected to learn basic concepts of nano scale systems, Role of particle size, Nanostructures, Quantum confinement, Synthesis and characterization of nano materials along with applications of nanoparticles, quantum dots, nanowires and thin films and Nanomaterial Devices. On successful completion of this course, the students are expected to know the methods of creating many new materials and devices with a range of applications, such as nanoelectronics, biomaterials energy production and consumer products.*

Reference Books:

i. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).

ii. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).

iii. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).

iv. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

v. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook (Elsevier, 2007).

vi. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.

vii. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004).

viii. Guozhong Cao, Wang, Ying, Nanostructures And Nanomaterials: Synthesis, Properties, And Applications (2nd Edition) (World Scientific Series in Nanoscience and Nanotechnology), January 2011

ix. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, November 2014, Springer.

PHYDSC454T

ATOMIC AND MOLECULAR PHYSICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *This course introduces students to the basic physics of atoms, molecules, their spectra and the interaction of light with matter including the study of influence of electric and magnetic fields on atoms with the help of understanding Stark effect and Zeeman effect.*

Unit 1:

Review of atomic models and concepts, Hydrogen spectrum from the Bohr and Bohr-Sommerfeld theories, Variation of the Rydberg constant, Unquantized states and continuous spectra, Larmor's precession, Space quantization, Electron spin, Stern-Gerlach experiment. Magnetic moment of atom (one and two electrons system), Quantization of magnetic moment.

(12 Lectures)

Unit 2:

Excitation & Ionization potentials, Frank and Hertz experiment. Characteristics X-ray spectra, Moseley's law, Difference between continuous & characteristics X-ray spectra. Moseley's law. Effect of nuclear motion on atomic spectra. Reduced mass, modified Rydberg constant and wave number, Evidences in favour of Bohr's theory. Correspondence principle. Zeeman Effect and its Experimental arrangement. Anomalous Zeeman effect. Classical & quantum treatment of normal Zeeman Effect. **(12 Lectures)**

Unit 3:

Paschen-Back effect, Stark effect. Spin orbit coupling - LS and JJ coupling schemes. Spectral notations for atomic states. Lande Interval rule. Normal and inverted multiplets. Spectra of alkali atoms: Characteristic features, term value, Selection and intensity rules. Pauli's exclusion principle and its explanation. Justification of Periodic arrangement of atoms by Pauli's exclusion conclusion. Hund's rule. **(12 Lectures)**

Unit 4:

Born-Oppenheimer approximation, Origin of molecular spectra, Fluorescence and phosphorescence, Rotational Spectra (Rigid and non-rigid rotator approximations). Vibration Rotational levels in a vibrating and rotating diatomic molecule. Rotational spectra of Polyatomic molecules, Isotopic effect on rotational spectra, Vibrational spectra (Harmonic and anharmonic approximations), Rotational-Vibrational spectra. **(12 Lectures)**

Unit 5:

UV Spectroscopy: Electronic spectra in emission and absorption, Vibrational and rotational structures of electronic bands, Frank-Condon Principle and its applications. Isotopic effect on electronic spectra, Molecular electronic states.
Raman Effect and Raman spectroscopy. Classical theory of Raman effect, Vibrational Raman spectrum, selection rules, Stokes & anti-Stokes lines, intensity of anti-stokes line. **(12 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to learn concepts various atomic models with their limitations, space quantization, Effect of nuclear motion on atomic spectra, the atomic spectra of one and two valance electron atoms, L-S and J-J couplings, Origin of molecular spectra and Raman effect.*

Reference Books:

i. Atomic Physics, J. B. Rajam, S. Chand Publication.
ii. Atomic & Molecular Spectroscopy, Rita Kakkar, Cambridge Univ. Press.
iii. Atomic & molecular Physics, R. K. Tripathi, Crescent Publishing.
iv. Atomic & Molecular Spectra Laser, Raj Kumar, Kedar Nath Ram Nath Publisher.
v. Atomic and Molecular Spectra and Lasers, A. K. Saxena, CBS Publisher.
vi. Atomic spectra and atomic structure, Herzberg, Dover Publication.

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SYLLABI OF PHYSICS DSM PAPERS

SEMESTER-I

PHYDSM101

TMATHEMATICAL PHYSICS, MECHANICS AND RELATIVITY

Contact Hours: 45

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The emphasis of the course is on various tools required for solving problems of interest to physicists. The course will teach the students to model a physics problem mathematically. This course also aims to review few concepts of mechanics learnt earlier from a more advanced perspective and utilize those to build new concepts.*

Unit 1:

Vectors: Dot and Cross product of vectors and their properties. Scalar and vector triple products. Introduction to Gradient, divergent and curl and their significance. Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

Ordinary Differential Equations: 1^{st} order homogeneous differential equations. 2^{nd} order homogeneous differential equations with constant coefficients. **(9 Lectures)**

Unit 2:

Momentum and Energy: Conservation of momentum, Conservation of energy. Work energy theorem, Centre of Mass and centre of gravity.

Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum. Moment of inertia and radius of gyration. Calculation of moment of inertia of rectangular bar, cylinder and shell. **(8 Lectures)**

Unit 3:

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws. Satellite in circular orbit, orbital velocity, Geosynchronous orbits, Geostationary satellites and applications. Weightlessness. Basic idea of global positioning system (GPS). **(9 Lectures)**

Unit 4:

Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder, Torsional pendulum. Cantilever, bending of beams. **(9 Lectures)**

Unit 5:

Fluids: Surface Tension, Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature -. Viscosity: Rate flow of liquid in a capillary tube - Poiseuille's formula and Variations of viscosity of a liquid with temperature.

Special Theory of Relativity: Frames of reference, Galilean transformation, Postulates of Special Theory of Relativity. Lorentz Transformation, Length contraction and Time dilation. **(10 Lectures)**

Expected learning outcomes: *After completing this course, the students will be able to understand the concepts of vector algebras and differential equations. Moreover, upon completion of this course, the students will be able to learn the concepts rotational dynamics, gravitation, elasticity, fluids and the Special Theory of Relativity including Lorentz transformations and its consequences.*

Reference Books:

i. University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. Addison Wesley.

ii. Mechanics Berkeley Physics course, v.1: Charles Kittel, et. Al. 2007, Tata McGraw-Hill.

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

iv. Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press.

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

SEMESTER-II

PHYDSM151T

MATHEMATICAL PHYSICS, MECHANICS AND RELATIVITY

Contact Hours: 45

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The emphasis of the course is on various tools required for solving problems of interest to physicists. The course will teach the students to model a physics problem mathematically. This course also aims to review few concepts of mechanics learnt earlier from a more advanced perspective and utilize those to build new concepts.*

Unit 1:

Vectors: Dot and Cross product of vectors and their properties. Scalar and vector triple products. Introduction to Gradient, divergent and curl and their significance. Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

Ordinary Differential Equations: 1^{st} order homogeneous differential equations. 2^{nd} order homogeneous differential equations with constant coefficients. **(9 Lectures)**

Unit 2:

Momentum and Energy: Conservation of momentum, Conservation of energy. Work energy theorem, Centre of Mass and centre of gravity.

Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum. Moment of inertia and radius of gyration. Calculation of moment of inertia of rectangular bar, cylinder and shell. **(8 Lectures)**

Unit 3:

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws. Satellite in circular orbit, orbital velocity, Geosynchronous orbits, Geostationary satellites and applications. Weightlessness. Basic idea of global positioning system (GPS). **(9 Lectures)**

Unit 4:

Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder, Torsional pendulum. Cantilever, bending of beams. **(9 Lectures)**

Unit 5:

Fluids: Surface Tension, Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature -. Viscosity: Rate flow of liquid in a capillary tube - Poiseuille's formula and Variations of viscosity of a liquid with temperature.

Special Theory of Relativity: Frames of reference, Galilean transformation, Postulates of Special Theory of Relativity. Lorentz Transformation (derivation), Length contraction & time dilation. **(10 Lectures)**

Expected learning outcomes: *After completing this course, the students will be able to understand the concepts of vector algebras and differential equations. Moreover, upon completion of this course, the students will be able to learn the concepts rotational dynamics, gravitation, elasticity, fluids and the Special Theory of Relativity including Lorentz transformations and its consequences.*

Reference Books:

i. University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. AddisonWesley.

ii. Mechanics Berkeley Physics course, v.1: Charles Kittel, et. Al. 2007, Tata McGraw-Hill.

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

iv. Engineering Mechanics, Basudeb Bhattacharya, 2nd edn., 2015, Oxford University Press.

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

SEMESTER-III

PHYDSM201T

ELECTRICITY, MAGNETISM AND ELECTRONICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The objective of this course is to review the concepts of electrostatics and electromagnetism learnt earlier from a more advanced perspective and to build new concept on their basis. The course also intends to cover the basics of analog and digital electronics and their applications.*

Unit 1: Electrostatics

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet. Electric potential as line integral of electric field, potential due to a point charge, electric dipole. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field.

(12 Lectures)

Unit 2: Electromagnetism

Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law and its application for Solenoid and toroidal coils.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Idea of dia, para and ferro-magnetic materials. **(12 Lectures)**

Unit 3: Electromagnetic Induction and Maxwell’s equations

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic Field. Transformer, different losses of transformer,

Maxwell`s equations, Equation of continuity of current, Displacement current, Electromagnetic wave propagation: Poynting vector. **(12 Lectures)**

Unit 4: Analogue electronics

Semiconductor Diodes: P and N type semiconductors. Conductivity and Mobility, Concept of Drift velocity. Characteristics of PN Junction diode. Static and Dynamic Resistance. Application of PN junction as Rectifier; Half-wave and Full-wave Rectifiers (Circuit diagram & working), Zener Diode and Voltage Regulation.

Transistors: NPN and PNP transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β, Relations between α and β. **(13 Lectures)**

Unit 5: Digital electronics

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. Half adder and full adder. Binary addition and subtraction using 1's complement. **(13 Lectures)**

Expected learning outcomes: *After completing this course, the students will be able to apply Gauss's law of electrostatics to distribution of charges, understand the applications of Biot-Savart's law to calculate magnetic field, understand the classification of magnetic materials and understand the process of electromagnetic induction. The students are also expected to learn the introductory ideas of analog and digital electronics.*

Reference Books:

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

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

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

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

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

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

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

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

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

x. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.

SEMESTER-IV

PHYDSM251P

LAB: (MECHANICS + OPTICS) AND (ELECTRICITY + ELECTRONICS)

Contact Hours: 60

Full Marks = 100 [ESE (70)   CCA(30)]

Course objective: *In this course, the students will learn to use various instruments, estimate various physical parameters for every experiment performed and report the result of experiment related to mechanics, optics, electricity and electronics.*

Two Experiments are to be performed – one from each part

Part-A: Mechanics + Optics

1. To determine the Moment of Inertia of a regular body by torsional pendulum.
2. To determine the Young's Modulus of a Wire by Searle's Method.
3. To determine the Modulus of Rigidity of a Wire by Statistical method.
4. To determine g by Bar Pendulum.
5. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of g.
6. To determine the focal length of convex mirror with the help of convex lens by optical bench.
7. Determination of the refractive index of the material of a convex lens by measuring its focal length and radii of curvatures.
8. To determine the focal length of a given convex lens by displacement method.
9. To determine the refractive index of a given liquid by travelling microscope.
10. To determine the angle of minimum deviation of the angle of the given prism with the help of spectrometer & hence to find the refractive index of the material of the prism.
11. To determine wavelength of sodium light using Newton's Rings.

Part-B: Electricity + Electronics

1. To determine the specific resistance by metre bridge.
2. To determine the strength of the magnetic field produced at the centre of the tangent galvanometer coil due to a current flowing in it and hence to determine horizontal component of earth's magnetic field.
3. To determine the self-inductance of a coil and its internal resistance in an L-R circuit.

4. To study the series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor.
5. To determine the resistance of a galvanometer by half deflection method.
6. To determine a resistance per unit length of metre bridge wire by Carey Foster's method.
7. To verify series and parallel laws of resistance by Post office Box.
8. To compare the emf of two cells by potentiometer.
9. To study V-I characteristics of PN junction diode.
10. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
11. To verify the truth tables of AND, OR, NOT, NOR and NAND gates.
12. To study and verify NAND and NOR gates as a universal gate.
13. To design and verify the De Morgan's theorem.

Expected learning outcomes: *At the end of the above course the students will have hands-on knowledge and overview of various experiments related to various key aspects of mechanics, optics, electricity and electronics.*

Reference books:

i. Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House.
ii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
iii. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.
iv. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
v. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
vi. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
vii. Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
viii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

PHYDSM252T

ELECTRICITY, MAGNETISM AND ELECTRONICS

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The objective of this course is to review the concepts of electrostatics and electromagnetism learnt earlier from a more advanced perspective and to build new concept on their basis. The course also intends to cover the basics of analog and digital electronics and their applications.*

Unit 1: Electrostatics

Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet. Electric potential as line integral of electric field, potential due to a point charge, electric dipole. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field.
(12 Lectures)

Unit 2: Electromagnetism

Biot-Savart's law and its applications - straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law and its application for Solenoid and toroidal coils.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Idea of dia, para and ferro-magnetic materials. **(12 Lectures)**

Unit 3: Electromagnetic Induction and Maxwell's equations

Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic Field. Transformer, different losses of transformer,

Maxwell`s equations, Equation of continuity of current, Displacement current, Electromagnetic wave propagation: Poynting vector. **(12 Lectures)**

Unit 4: Analogue electronics

Semiconductor Diodes: P and N type semiconductors. Conductivity and Mobility, Concept of Drift velocity. Characteristics of PN Junction diode. Static and Dynamic Resistance. Application of PN junction as Rectifier; Half-wave and Full-wave Rectifiers (Circuit diagram & working), Zener Diode and Voltage Regulation.

Transistors: NPN and PNP transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β, Relations between α and β. **(13 Lectures)**

Unit 5: Digital electronics

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates. Half adder and full adder. Binary addition and subtraction using 1's complement. **(13 Lectures)**

Expected learning outcomes: *After completing this course, the students will be able to apply Gauss's law of electrostatics to distribution of charges, understand the applications of Biot-Savart's law to calculate magnetic field, understand the classification of magnetic materials and understand the process of electromagnetic induction. The students are also expected to learn the introductory ideas of analog and digital electronics.*

Reference Books:

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

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

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

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

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

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

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

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

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

x. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.

SEMESTER-V

PHYDSM301T

WAVES & OSCILLATIONS, OPTICS AND THERMAL PHYSICS

Contact Hours: 45

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The course aims at reviewing the concepts of waves and oscillations from a more progressive perspective and goes on to build new concepts. This course also aims at reviewing the basic concepts of thermodynamics, kinetic theory of gases, radiation and basic concepts of physical optics.*

Unit 1:

Oscillation: Superposition of Two Collinear Harmonic Oscillations: Linearity and Superposition Principle, (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods, Lissajous Figures with equal and unequal frequency and their uses.

Wave Motion: Transverse waves on a string, Travelling and standing waves on a string, Normal modes of a string, Group velocity, Phase velocity. **(10 Lectures)**

Unit 2:

Interference: Division of amplitude and division of wavefront, Young's Double Slit experiment, Lloyd's Mirror and Fresnel's biprism. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: measurement of wavelength and refractive index.
(8 Lectures)

Unit 3:

Diffraction: Fraunhoffer diffraction: Single slit; Double slit, Multiple slits & Diffraction grating. Fresnel Diffraction: Half-period zones, Zone plate, Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

Polarization: Nicol Prism, Production and analysis of Plane Polarised light by Nicol Prism, Zone Plate, Half wave and quarter wave plate. **(9 Lectures)**

Unit 4:

Thermodynamic Description of system: Various thermo dynamical processes, Applications of First law; General relation between C_p and C_v, Work done during Isothermal and Adiabatic processes, Reversible & Irreversible processes, Second law & Entropy, Entropy changes in reversible & irreversible processes, Carnot's theorem (Statement only)

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal energy functions, Maxwell's relations & applications. **(10 Lectures)**

Unit 5:

Kinetic theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean Free path, Transport Phenomena: Viscosity, Thermal Conductivity and Diffusion.

Theory of Radiation: Black body radiation, spectral distribution, concept of energy density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan-Boltzmann law. Wien's displacement law from Planck's law. **(8 Lectures)**

Expected learning outcomes: *On successful completion of this course, the students will have the skill and knowledge to, understand simple harmonic motion, phenomena of interference, diffraction, polarization, various thermodynamical processes, thermodynamical potentials, kinetic theory of gases and the process of blackbody radiation.*

Reference Books:

i. Fundamental of Optics, F. A. Jenkins and H. E. White,1976¸McGraw-Hill

ii. Principles of Optics, B.K. Mathur, 1995, Gopal Printing

iii. Fundamentals of Optics, H.R. Gulati and D. R. Khanna, 1991, R. Chand Publication

iv. University Physics, F. W. Sears, M. W. Zemansky and H D Young13/e, 1986, Addison-Wesley

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

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

vii. University Physics, Ronald Lane Reese, 2003, Thomson Books/Cole

viii. Thermal Physics, A. Kumar and S. P. Taneja, 2014, R. Chand Publications.

PHYDSM302T

WAVES & OSCILLATIONS, OPTICS AND THERMAL PHYSICS

Contact Hours: 45

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *The course aims at reviewing the concepts of waves and oscillations from a more progressive perspective and goes on to build new concepts. This course also aims at reviewing the basic concepts of thermodynamics, kinetic theory of gases, radiation and basic concepts of physical optics.*

Unit 1:

Oscillation: Superposition of Two Collinear Harmonic Oscillations: Linearity and Superposition Principle, (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods, Lissajous Figures with equal and unequal frequency and their uses.

Wave Motion: Transverse waves on a string, Travelling and standing waves on a string, Normal modes of a string, Group velocity, Phase velocity. **(10 Lectures)**

Unit 2:

Interference: Division of amplitude and division of wavefront, Young's Double Slit experiment, Lloyd's Mirror and Fresnel's biprism. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: measurement of wavelength and refractive index. **(8 Lectures)**

Unit 3:

Diffraction: Fraunhoffer diffraction: Single slit; Double slit, Multiple slits & Diffraction grating. Fresnel Diffraction: Half-period zones, Zone plate, Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

Polarization: Nicol Prism, Production and analysis of Plane Polarised light by Nicol Prism, Zone Plate, Half wave and quarter wave plate. **(9 Lectures)**

Unit 4:

Thermodynamic Description of system: Various thermodynamical processes, Applications of First law; General relation between C_p and C_v, Work done during Isothermal and Adiabatic processes, Reversible & Irreversible processes, Second law & Entropy, Entropy changes in reversible & irreversible processes, Carnot's theorem (Statement only)

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal energy functions, Maxwell's relations & applications. **(10 Lectures)**

Unit 5:

Kinetic theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean Free path, Transport Phenomena: Viscosity, Thermal Conductivity and Diffusion.

Theory of Radiation: Black body radiation, spectral distribution, concept of energy density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan-Boltzmann law. Wien's displacement law from Planck's law. **(8 Lectures)**

Expected learning outcomes: *On successful completion of this course, the students will have the skill and knowledge to, understand simple harmonic motion, phenomena of interference, diffraction, polarization, various thermodynamical processes, thermodynamical potentials, kinetic theory of gases and the process of blackbody radiation.*

Reference Books:

i. Fundamental of Optics, F. A. Jenkins and H. E. White,1976¸McGraw-Hill

ii. Principles of Optics, B.K. Mathur, 1995, Gopal Printing

iii. Fundamentals of Optics, H.R. Gulati and D. R. Khanna, 1991, R. Chand Publication
iv. University Physics, F. W. Sears, M. W. Zemansky and H D Young13/e, 1986, Addison-Wesley
v. Thermal Physics, S Garg, R.Bansal and C. Ghosh,1993,Tata McGraw-Hill
vi. A Treatise on Heat, Meghnad Saha and B.N.Srivastava, 1969, Indian Press
vii. University Physics, Ronald Lane Reese, 2003, Thomson Books/Cole
viii. Thermal Physics, A. Kumar and S. P. Taneja, 2014, R. Chand Publications.

SEMESTER-VI

PHYDSM351P

LAB: (MECHANICS +OPTICS) AND (ELECTRICITY + ELECTRONICS)

Contact Hours: 60

Full Marks = 100 [ESE (70) CCA(30)]

Course objective: *In this course, the students will learn to use various instruments, estimate various physical parameters for every experiment performed and report the result of experiment related to mechanics, optics, electricity and electronics.*

Two Experiments are to be performed – one from each part

Part-A: Mechanics + Optics

1. To determine the Moment of Inertia of a regular body by torsional pendulum.
2. To determine the Young's Modulus of a Wire by Searle's Method.
3. To determine the Modulus of Rigidity of a Wire by Statistical method.
4. To determine g by Bar Pendulum.
5. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of g.
6. To determine the focal length of convex mirror with the help of convex lens by optical bench.
7. Determination of the refractive index of the material of a convex lens by measuring its focal length and radii of curvatures.
8. To determine the focal length of a given convex lens by displacement method.
9. To determine the refractive index of a given liquid by travelling microscope.
10. To determine the angle of minimum deviation of the angle of the given prism with the help of spectrometer & hence to find the refractive index of the material of the prism.
11. To determine wavelength of sodium light using Newton's Rings.

Part-B: Electricity + Electronics

1. To determine the specific resistance by metre bridge.
2. To determine the strength of the magnetic field produced at the centre of the tangent galvanometer coil due to a current flowing in it and hence to determine horizontal component of earth's magnetic field.
3. To determine the self-inductance of a coil and its internal resistance in an L-R circuit.

4. To study the series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor.
5. To determine the resistance of a galvanometer by half deflection method.
6. To determine a resistance per unit length of metre bridge wire by Carey Foster's method.
7. To verify series and parallel laws of resistance by Post office Box.
8. To compare the emf of two cells by potentiometer.
9. To study V-I characteristics of PN junction diode.
10. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
11. To verify the truth tables of AND, OR, NOT, NOR and NAND gates.
12. To study and verify NAND and NOR gates as a universal gate.
13. To design and verify the De Morgan's theorem.

Expected learning outcomes: *At the end of the above course the students will have hands-on knowledge and overview of various experiments related to various key aspects of mechanics, optics, electricity and electronics.*

Reference books:

i. Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House.
ii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
iii. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.
iv. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
v. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
vi. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
vii. Engineering Practical Physics, S.Panigrahi & B.Mallick, 2015, Cengage Learning India Pvt. Ltd.
viii. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

SEMESTER-VII

PHYDSM401T

MODERN PHYSICS AND SOLID STATE PHYSICS

Contact Hours: 60

Full Marks = 100 [ESE (70)   CCA(30)]

Course objective: *The emphasis of course is on building basic knowledge in the field of Modern physics which have utmost importance at both undergraduate and postgraduate level. Starting from failure of Classical mechanics, it develops the idea of wave particle duality followed by Heisenberg Uncertainty Relation with its applications. This course also aims to introduce the basic concepts of Solid State Physics along with Radioactivity.*

Unit 1: Matter wave & Uncertainty Principle

Failure of classical Mechanics and origin of quantum mechanics, Photoelectric effect, Compton Effect, Wave-particle duality, De-Broglie concept of matter waves, De-Broglie relation, properties of matter waves. wave velocity and group velocity. Heisenberg's uncertainty principle its proof and its application in the non-existence of electrons in the nucleus, ground state energy of electron in Hydrogen atom, radius of Bohr orbit, complementary principle. **(10 Lectures)**

Unit 2: Structure of atom

Aston Mass Spectrograph. Bohr's theory of hydrogen atom, expression of radii of electrons, expression of energies and hydrogen atom spectrum. Effect of nuclear motion on atomic spectra, reduced mass, modified Rydberg constant and wave number, Evidences in favour of Bohr's theory, correspondence principle, fine structure of special lines and Sommerfield's relativistic atom model (qualitative idea). Excitation and Ionisation potentials, Frank and Hertz experiment, characteristic X-ray spectra, Moseley's law, Bragg's law. **(15 Lectures)**

Unit 3: Radioactivity

Law of successive disintegration, secular and transient equilibrium, Alpha ray spectrum, Geiger-Nuttal law. Beta ray spectrum and Pauli's neutrino hypothesis. Nuclei and their properties - charge, mass, size, density, angular momentum, nuclear magnetic moment, binding energy curve, packing fraction and nuclear stability. Nuclear fission and sustained chain reaction. Linear accelerator and cyclotron. Cosmic rays and composition, altitude effect, cosmic ray showers.

(15 Lectures)

Unit 4: Crystal Structure

Amorphous and crystalline materials, Lattice translation vectors, unit cell, primitive cell, basis, Miller indices and representation of crystal planes, interplanar spacing, symmetry consideration, symmetry group, space group, different types of crysta1 structures, classification of crystals based on nature of structures, Bravias lattice, reciprocal lattice, Theory of Laue Spots. Bragg's law, diffraction of X-ray, measurement of Lattice parameter for cubic lattices. **(10 Lectures)**

Unit 5: Lattice Vibrations

Linear monatomic chains, Acoustical and optical phonons, Qualitative description of the phonon spectrum, Brillouin Zones, Einstein and Debye theories of specific heat of solid T^3 Law. Qualitative description of free electron theory and its inadequacies with reference to Hall effect and specific heat of electrons in metals. **(10 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to develop a comprehensive idea of the introductory quantum mechanics and ability to discuss and interpret the facts that reveal the dual nature of matter and the Uncertainty Principle with its applications. Students are also expected to have the basic idea of crystal structure and physics of lattice dynamics in addition to Radioactivity covering various properties of nuclei and their decay processes.*

Reference Books:

i. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.

ii. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill

iii. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.

iv. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, CengageLearning.

v. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan.

vi. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.

vii. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, TataMcGraw-Hill Publishing Co. Ltd.

viii. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.

ix. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.

x. Introduction to Solid State Physics, Kittel C. 5th Ed, John Wiley.

xi. Solid State Physics by Dekker A.J., Prentice Hall.

SEMESTER-VIII

PHYDSM451T

MODERN PHYSICS AND SOLID STATE PHYSICS

Contact Hours: 60

Full Marks = 100 [ESE (70)   CCA(30)]

Course objective: *The emphasis of course is on building basic knowledge in the field of Modern physics which have utmost importance at both undergraduate and postgraduate level. Starting from failure of Classical mechanics, it develops the idea of wave particle duality followed by Heisenberg Uncertainty Relation with its applications. This course also aims to introduce the basic concepts of Solid State Physics along with Radioactivity.*

Unit 1: Matter wave & Uncertainty Principle

Failure of classical Mechanics and origin of quantum mechanics, Photoelectric effect, Compton Effect, Wave-particle duality, De-Broglie concept of matter waves, De-Broglie relation, properties of matter waves. wave velocity and group velocity. Heisenberg's uncertainty principle its proof and its application in the non-existence of electrons in the nucleus, ground state energy of electron in Hydrogen atom, radius of Bohr orbit, complementary principle. **(10 Lectures)**

Unit 2: Structure of atom

Aston Mass Spectrograph. Bohr's theory of hydrogen atom, expression of radii of electrons, expression of energies and hydrogen atom spectrum. Effect of nuclear motion on atomic spectra, reduced mass, modified Rydberg constant and wave number, Evidences in favour of Bohr's theory, correspondence principle, fine structure of special lines and Sommerfield's relativistic atom model (qualitative idea). Excitation and Ionisation potentials, Frank and Hertz experiment, characteristic X-ray spectra, Moseley's law, Bragg's law. **(15 Lectures)**

Unit 3: Radioactivity

Law of successive disintegration, secular and transient equilibrium, Alpha ray spectrum, Geiger-Nuttal law. Beta ray spectrum and Pauli's neutrino hypothesis. Nuclei and their properties - charge, mass, size, density, angular momentum, nuclear magnetic moment, binding energy curve, packing fraction and nuclear stability. Nuclear fission and sustained chain reaction. Linear accelerator and cyclotron. Cosmic rays and composition, altitude effect, cosmic ray showers.

(15 Lectures)

Unit 4: Crystal Structure

Amorphous and crystalline materials, Lattice translation vectors, unit cell, primitive cell, basis, Miller indices and representation of crystal planes, interplanar spacing, symmetry consideration, symmetry group, space group, different types of crysta1 structures, classification of crystals based on nature of structures, Bravias lattice, reciprocal lattice, Theory of Laue Spots. Bragg's law, diffraction of X-ray, measurement of Lattice parameter for cubic lattices. **(10 Lectures)**

Unit 5: Lattice Vibrations

Linear monatomic chains, Acoustical and optical phonons, Qualitative description of the phonon spectrum, Brillouin Zones, Einstein and Debye theories of specific heat of solid T^3 Law. Qualitative description of free electron theory and its inadequacies with reference to Hall effect and specific heat of electrons in metals. **(10 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to develop a comprehensive idea of the introductory quantum mechanics and ability to discuss and interpret the facts that reveal the dual nature of matter and the Uncertainty Principle with its applications. Students are also expected to have the basic idea of crystal structure and physics of lattice dynamics in addition to Radioactivity covering various properties of nuclei and their decay processes.*

Reference Books:

i. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.

ii. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill

iii. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.

iv. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, CengageLearning.

v. Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan.

vi. Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.

vii. Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, TataMcGraw-Hill Publishing Co. Ltd.

viii. Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.

ix. Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.

x. Introduction to Solid State Physics, Kittel C. 5th Ed, John Wiley.

xi. Solid State Physics by Dekker A.J., Prentice Hall.

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<u>SYLLABI OF PHYSICS SEC PAPERS</u>

SEMESTER-I

PHYSEC101

PART-A: WORKSHOP SKILL

Contact Hours: 30

Marks = 100 [ESE (50) IT (20) LAB (30)]

Course objective: *The aim of this course is to enable the students to familiar and experience with various mechanical and electrical tools through hands-on mode.*

Unit 1: Introduction

Units of measurements. Conversion to SI and CGS. Familiarization with meter scale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains. **(6 Lectures)**

Unit 2: Mechanical Skill

Concept of workshop practice. Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Common materials used for manufacturing like steel, copper, iron, metal sheets, composites, alloy and wood. **(6 Lectures)**

Unit 3: Machining Process

Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. **(6 Lectures)**

Unit 4: Electrical and Electronic Skill

Multimeter, Use of Multimeter as ammeter, voltmeter and ohmmeter. Specifications of good multimeters. Cathode Ray Oscilloscope, Block diagram of basic CRO. Construction of CRT, Electron gun, electrostatic focusing and acceleration, uses of CRO. Regulated power supply, Relays, Fuses and switches, Electronic switch using transistor. **(7 Lectures)**

Unit 5: Introduction to prime movers

Principle of Lever Mechanism, 1st ,2nd and 3rd kind of lever with examples, Lifting of heavy weight using lever, gear system, Fixing of gears with motor axel, wheel, Braking systems, pulleys. Working principle of power generation systems. **(5 Lectures)**

LAB: PART-B: 30 hours. (Practical /Project/Field work):

The following is the list of practicals:

1. Cutting of a metal sheet using blade to give a symmetrical shape.
2. Drilling of holes of different diameter in metal sheet and wooden block.
3. Soldering of electrical circuits having discrete components (R, L, C and diode) and ICs on PCB.
4. Demonstration of pulley experiment.
5. Construction of regulated power supply.
6. Measurement of (a) voltage (b) rise and fall times (c) time period of a periodic waveform using CRO.

Expected learning outcomes: *At the end of this course the students are expected to develop theoretical knowledge on various workshop skills such as mechanical skills, machining process, electrical skills and electronic skills along with their hand on experience.*

Reference Books:

i. A text book in Electrical Technology - B L Theraja – S. Chand and Company.

ii. Performance and design of AC machines – M.G. Say, ELBS Edn.

iii. Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.

iv. Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732].

v. New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480].

vi. https://ncert.nic.in/vocational/pdf/kvcj3103.pdf

SEMESTER-II

PHYSEC151

PART-A: ELECTRICAL CIRCUITS AND SAFETY

Marks = 100 [ESE (50) IT (20) LAB (30)]

Contact Hours: 30

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

Unit 1:

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel and series-parallel combinations of resistances and voltages. KCL & KVL. AC Electricity and DC Electricity. Electrical load and its types with examples. Introductory idea of amplitude, instantaneous value, cycle, Time period, frequency, phase angle, Phase difference. **(6 Lectures)**

Unit 2:

Electrical Wiring Components: Wiring materials and its types with examples. Different types of conductors and cables. Basics of wiring-Star and delta connection. Various wiring Accessories like Switches (1 way, 2 way and Intermediate), Holder, ceiling rose, Socket plug, Main switch. Advantages & disadvantages of casing-capping wiring. Advantages and disadvantage of conduit wiring and concealed wiring. **(6 Lectures)**

Unit 3:

Electrical Drawing and Symbols: Main electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Power factor. Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Reading of circuit schematics.

Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance and impedance. Operation of transformers. **(7 Lectures)**

Unit 4:

Electric Motors: Single-phase and three-phase AC motors. Basic design. Speed & power of ac motor.

Solid State Devices: Resistors, inductors and capacitors. Response of inductors and capacitors with DC or AC sources. Diode, half & full wave rectifiers, filter circuits. LED. **(5 Lectures)**

Unit 5:

Electrical Hazards and safety: Hazards of electricity and its various types, effects of electricity on the human body, Types of Overcurrent (Overload and fault), Protective devices such as Fuses, Circuit breakers, MCB, RCCB & DP isolator along with their functions. Concept of grounding, short circuit and its prevention. **(6 Lectures)**

LAB: PART-B: 30 hours. (Practical/Project/ Field work):

The following is the list of practicals:

1. To use digital multimeter for measuring voltages, currents, resistances.
2. To measure the phase difference and frequency using CRO.
3. To study the LCR bridge and determine the value of given components.
4. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
5. To observe the limitations of a multimeter for measuring high frequency voltage and currents.

Expected learning outcomes: *At the end of this course the students are expected to get acquainted with the theoretical knowledge on various electrical circuits and their safety measures along hands-on learning.*

Reference Books:

i. A text book in Electrical Technology - B L Theraja - S Chand & Co.

ii. A text book of Electrical Technology - A K Theraja.

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

iv. https://www.ittchoudwar.org/upload/1st_sem_Basic_Electrical.pdf

v. https://www.labtrain.noaa.gov/osha600/refer/menu12a.pdf

SEMESTER-III

PHYSEC201

PART-A: RENEWABLE ENERGY AND ENERGY HARVESTING

Marks = 100 [ESE (50) IT (20) LAB (30)]

Contact Hours: 30

Course objective: *The aim of this course is to impart theoretical knowledge on various energy sources and their harvesting techniques along with the exposure of hands-on learning.*

Unit 1: Energy Sources

Concept of work and energy. Definition and units of energy, power. Classification of energy sources: Primary and Secondary energy, Commercial and Non-commercial energy, Renewable and Non-renewable energy, Importance of renewable energy resources. Overview of Indian & world energy scenario with latest statistics- consumption & necessity. Need of eco-friendly & green energy. **(6 Lectures)**

Unit 2: Fossil fuels and Alternate Sources of energy: Energy consumption in various sectors. Fossil fuels and their classifications. Advantages and disadvantages of fossil fuels. Nuclear fuel and its types. Nuclear reactor: Construction and working. Advantages and disadvantages of nuclear energy. Need of renewable energy, non-conventional energy sources and sustainability. Biomass and biogas generation and applications. Hydroelectric power. **(7 Lectures)**

Unit 3: Solar energy: Solar energy and its origin (pp-cycle). Importance of solar energy, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell. Need and characteristics of photovoltaic (PV) systems. **(5 Lectures)**

Unit 4:

Wind Energy harvesting: Fundamentals of Wind energy, Wind speed and power relation, Wind Turbines and different electrical machines in wind turbines.

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy. **(5 Lectures)**

Unit 5:

Geothermal Energy: Geothermal Resources, Geothermal Technologies.

Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity, Piezoelectric parameters, Piezoelectric energy harvesting applications. **(7 Lectures)**

LAB: PART-B: 30 hours. (Practical/Project/ Field work):

The following is the list of practicals:

1. To study the voltage and current of solar cells in series.
2. To study the voltage and current of solar cells in parallel.
3. To calculate the efficiency of a solar cell.
4. To study the application of solar cells for providing electrical energy to the domestic appliances.
5. To study the conversion of vibration to voltage using piezoelectric materials.
6. To study the conversion of thermal energy into voltage using thermoelectric modules.

Expected learning outcomes: *At the end of this course the students are expected to get acquainted with the theoretical knowledge on various energy sources such as Fossil fuels, Solar energy, Wind energy, Ocean Energy, Geothermal Energy, Piezoelectric energy along with energy harvesting techniques through the exposure of hands-on learning.*

Reference Books:

i. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi.

ii. Solar energy - M P Agarwal - S Chand and Co. Ltd.

iii. Solar energy - Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.

iv. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.

v. Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009.

vi. J. Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

vii. http://en.wikipedia.org/wiki/Renewable_energy.

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SYLLABI OF PHYSICS IDC PAPERS

SEMESTER-I

PHYIDC101T

PHYSICS IN DAILY LIFE

Contact Hours: 45

Full Marks = 100 [ESE (70) CCA (30)]

Course objective: *This course is intended for students of disciplines other than Physics. Through this course, students can understand their surroundings by understanding the basic rules of* Nature *and able to connect some daily life observations to Physics and Biophysics principles.*

Unit 1: Quantities, Energy and Power

Physical quantities, Standards and Units, International system of Units, Standards of time, length and mass, Precision and significant figures, errors. Energy and Power: Explosions and energy; Kinetic energy and conservation of momentum in explosions; Different types of Energy: Renewable and non-renewable, Heat energy and its units; Energy table and discussions; Discussion of cost of energy; Measuring energy; Power; Different power sources. **(10 Lectures)**

Unit 2: Gravity and Force

The force of Gravity; Friction; its advantages and disadvantages, Bending of cyclist and banking of roads; Weightlessness; Geosynchronous satellites; Spy satellites; weather satellites, Rockets; Airplanes, helicopters; Hot air and helium balloons. Ice skater spin and planet orbiting around sun (application of conservation of angular momentum). Swing of cricket ball (application of Bernoulli's theorem). **(8 Lectures)**

Unit 3: Commonly used appliances and devices

Basic understating and application of common appliances in daily life: Pressure cooker, Water purifiers: UV & RO, Electric motors, fans, Sound system, microphones, micro-ovens, refrigerators, air conditioners, Music Player, Electronic displays (LCD and LED), digital / smart watches, mobile phones, computers. **(8 Lectures)**

Unit 4: Vision, sound and radiation

Radioactivity; Elements and isotopes; Radiation and rays; The radiation poisoning; Medical applications of radiation.

Vision: Visible light spectra; concept of colour, vision defects. Hearing: Sound waves and hearing, sound intensity; the decibel scale, Noise Pollution. Acoustics of building and auditorium. **(10 Lectures)**

Unit 5:

Bio-imaging: Ultrasound, MRI imaging, CT scan and X-ray.

Radiation effect on biological systems: High doses received in a short time, Low-level doses limits, direct ionization of DNA, radiation damage to DNA, Biological effects (Genetic, Somatic, Cancer and sterility). **(9 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to connect their surroundings by understanding the basic rules of Nature and able to connect some daily life observations to Physics principles. Moreover, this course expects students to have some ideas on various commonly used appliances and various Bio-imaging techniques which in inevitable for present day therapeutics.*

Reference Books:

i. Physics for future presidents by Richard A. Muller.

ii. Nuclei and Radioactivity by G.R. Choppin (W. A. Bejamin, N.Y. York).

iii. Space, Time and Gravitation by A.S. Eddington (Cambridge University Press).

iv. S. S. Martellucci and A. N. Chester, Laser Photobiology and Photomedicine, Plenum Press, New York, 1985.

v. The Casual Sky Observer's Guide by Rony De Laet Springer 2012.

vi. Fundamentals of Physics with Applications (Schaum's Outline Series) by Arthur Beiser.

vii. Essentials of Biophysics: P. Narayanan, New age international publisher, 2009.

viii. A Text Book of Biophysics, R.N. Roy, New Central Book Agency (P) Ltd. 2005 Edition.

SEMESTER-II

PHYIDC151T

UNDERSTANDING THE CLIMATE

Contact Hours: 45

Full Marks = 100 [ESE (70) CCA (30)]

Course objective: *This course introduces students to Earth-Atmosphere and Meteorology including environmental pollution and climate change etc. This course is useful for the students who want to work in Meteorological department or intend to gather more knowledge in the field of environmental science.*

Unit 1: Introduction to Earth Atmosphere and Meteorology

Elementary concept of atmosphere and its composition. Introduction to atmospheric dynamics, Basic conservation laws. Thermal and pressure variation in earth atmosphere, Thermal structure of the troposphere, stratosphere, mesosphere and ionosphere, spectral distribution of the solar radiation. Meteorological process and different system, Overview of meteorological observations. **(10 Lectures)**

Unit 2: Climate Science

Weather and climate. Biodiversity and climate change, Impact of deforestation, fossil fuel burning, industrialization. Surface weather stations and satellite observation. Cloud seeding, lightning and discharge. Formation of trade winds, local winds, monsoons, fogs, clouds, Cyclones, anti-cyclones, thunderstorms, droplet growth and condensation. humidity and humidity parameters. **(8 Lectures)**

Unit 3: Changing Climate

Definition of climate long term changes, Natural causes of climate change. Detection of climate Change. Carbon-di-oxide, trace gases and climate change. Greenhouse effect and global warming, Manifestations of global warming in the form of sea level rise, melting of glaciers, variation in monsoon patterns. Weather extremes: increase in frequency and intensity of cyclones, hurricanes, tornadoes, heat waves EL Nino/LA Nino. **(10 Lectures)**

Unit 4: Instrumentation and Observational Techniques

Convectional measurements of pressure, temperature, humidity, wind speed and direction, sunshine duration, radiation clouds, upper air pressure, temperature, humidity and wind measurements. Application of radars to study the atmospheric phenomenon, SONAR. Atmospheric aerosols, classification and properties, concentration and size distribution.

(8 Lectures)

Unit 5: Environmental pollution and Mitigation of Climate change

Atmospheric pollution, type of pollutants, various sources of emissions, Trace gages, Production and loss processes of stratosphere ozone, Tropospheric ozone. International legal and policy framework for climate change, the Kyoto protocol, Main issues. Climate change adaption and developmental planning, Climate change mitigation, Geo-engineering as a tool to mitigate global warming. Concept of Panchamrit. **(9 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to learn basic concepts of earth atmospheric composition, meteorological processes, weather and climate, climate change and ways of mitigating the issues of climate change along with various types of environmental pollutions.*

Reference Books

i. Basics of Atmospheric Science – A Chndrashekar, PHI Leaving Private Ltd. New Delhi, 2010.

ii. Fundamental of Atmospheric Modelling – Mark Z Jacbson, Cambridege University Press, 2000.

iii. Atmosphere: An Introduction to meteorology – Frederik K Lutgens and Edward J Tarbuck, Pearson, 2013

SEMESTER-III

PHYIDC201T

RENEWABLE ENERGY AND ENERGY HARVESTING

Contact Hours: 45

Full Marks = 100 [ESE (70) CCA (30)]

Course objective: *The aim of this course is to impart theoretical knowledge on various energy sources and cause of environmental degradation due to energy production and utilization along with few energy harvesting techniques.*

Unit 1:

Energy sources: Concept of work and energy, definition and units of energy, power, sources of energy in general, its significance & necessity, Classification of energy sources: Primary and Secondary energy, Commercial and Non-commercial energy, Renewable and Non-renewable energy, Importance of renewable energy resources. **(10 Lectures)**

Unit 2:

Conventional energy sources: Energy consumption in various sectors, Fossil fuels (coal, oil, natural gas). Nuclear energy- production & extraction, usage rate and limitations. Impact on environment and their issues & challenges, Overview of Indian & world energy scenario with latest statistics- consumption & necessity. Need of eco-friendly & green energy. **(10 Lectures)**

Unit 3:

Renewable energy sources: Need of renewable energy, non-conventional energy sources. An overview of developments in offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, principle of generation of Hydroelectric power.

(9 Lectures)

Unit 4:

Solar energy: Solar Energy-Key features and its importance, Merits & demerits of solar energy, Applications of solar energy. Solar water heater, solar cooker, solar green houses, solar cell - brief discussion of each. Importance and characteristics of photovoltaic (PV) systems and Suntracking systems. **(9 Lectures)**

Unit 5:

Environmental Effects: Environmental degradation due to energy production and utilization, air and water pollution, depletion of ozone layer, global warming, biological damage due to environmental degradation. Environmental effects of thermal power station, nuclear power generation, hydroelectric power, Geothermal power, Ocean energy harvesting, Wind energy harvesting, Solar energy harvesting. **(7 Lectures)**

Expected learning outcomes: *At the end of this course the students are expected to acquire basic knowledge on various energy sources such as Fossil fuels, Solar energy, Wind energy, Ocean Energy, and cause of environmental degradation due to energy production and utilization along with few energy harvesting techniques.*

Reference Books:

i. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi

ii. Solar energy - M P Agarwal - S Chand and Co. Ltd.

iii. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.

iv. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.

v. Dr. P Jayakumar, Solar Energy: Resource Assessment Handbook, 2009

vi. J. Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

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