BACHELOR OF SCIENCE (HONORS) PHYSICS

Detailed Syllabus

Programme Code: PHYB
Duration: 3 Years

EFFECTIVE FROM SESSION: 2019-2020

Faculty of Science
CHHATRAPATI SHIVAJI MAHARAJ UNIVERSITY, PANVEL, NAVI MUMBAI

About the Programme

The B. Sc. (Hons.) Physics programme is aimed at imparting knowledge on the fundamental principles of Physics. This programme is beneficial for the students in the area of higher studies, career opportunities in both private and public sectors.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOS):

The programme educational objectives of the B. Sc. (Hons.) Physics programme are:

PEO1 Basic Knowledge will apply for identification, formulation, creation, construction, design,development and optimization of various problems related to various fields of physics.

PEO2 Theskills and knowledge acquired during the course period will apply in the industry.

PEO3 To be prepared for the successful pursuit of graduate studies and shall have abilities to engage in lifelong learning in various fields.

PEO4 To demonstrate the ability of measurement of the impact of computing on society, and possess knowledge of ethical, social and professional implications and responsibilities of their work.

PEO5 The graduates will work and communicate effectively in inter-disciplinary environment, either independently or in a team, and demonstrate leadership qualities.

PEO6 The graduates will become successful professionals by demonstrating logical and analytical thinking abilities.

PROGRAMME OUTCOMES (PO):

After completion of the B. Sc. (Hons.) Physics programme students will be able to:

PO1 Acquire a fundamental/systematic or coherent understanding of the field of Physics, its different learning areas and applications.

PO2 Demonstrate the ability to use skills in Physics and its various areas of technology.

PO3 Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods.

PO4 Recognize the importance of mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

PO5 Identify their area of interest in academic and R&D.

SEMESTER I

Course Type	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	PHYB1010	Mechanics	4	0	0	30	70	100	4
DSC	PHYB1020	Mathematical Physics-I	4	0	0	30	70	100	4
GE	**	Generic Elective - I	4	0/1	4/0	30	70	100	4
AECC	ENGG1000	English Communication	2	0	0	15	35	50	2
DSC	PHYB1011	Mechanics Lab	0	0	4	15	35	50	2
DSC	PHYB1021	Mathematical Physics-I Lab	0	0	4	15	35	50	2
GE	**	Generic Elective - I Lab	0	1/0	0/4	15	35	50	2
		Total	**14**	**0**	**12**	**150**	**350**	**500**	**20**

Ability Enhancement Compulsory Courses (AECC)

Semester	Offering Department	Course Code	Course Name	(L-T-P)	Credits
I	English	ENGG1000	English Communication	2-0-0	2

PHYB1010	MECHANICS	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. To impart the knowledge of dynamical laws of motion.
2. To impart the knowledge of rotational dynamics, eleasiticity and fluid motion.
3. To make students learn the theory of gravitation and central forces.
4. To make students learn oscillatory motion and non-inertial systems.
5. To impart the knowledge of special theory of relativity.

Unit 1: **Fundamentals of Dynamics:** L:13

Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable- mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy. Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

Unit 2: **Rotational Dynamics, Elasticity and Fluid Motion: L: 17**

Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. Relation between Elastic constants. Twisting torque on a Cylinder or Wire. Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.

Unit 3: **Gravitation and Central Force Motion:** L:16

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

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

Unit 4: **Non-Inertial Systems:** L: 4

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

Unit 5: **Special Theory of Relativity:** L:10

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

Text /Reference Books:

1. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
2. Mechanics, Berkeley Physics, vol.1, C.Kittel, W.Knight, et.al. 2007, Tata McGraw-Hill.
3. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
4. Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
5. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
6. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.
7. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
8. Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
9. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
10. Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
11. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand concept of centre of mass and different kinds of frames of references.
2. Acquire knowledge of different types of forces of work and energy.
3. Understand the rotational and translational dimensions.
4. Understand the dynamics of oscillations and non inertial systems.
5. Impart the knowledge about theory of relativity and its importance.

PHYB1011	MECHANICS LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Measurements of length (or diameter) using vernier calipers, screw gauge and travellingmicroscope.
2. To study the random error inobservations.
3. To determine the elastic Constants of a wire by Searle'smethod.
4. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
5. To determine the Moment of Inertia of aFlywheel.
6. To determine the value of g using BarPendulum.
7. To determine the value of g using Kater'sPendulum.
8. To study the Motion of Spring and calculate (a) Spring constant, (b) **g** and (c) Modulus ofrigidity.
9. TodeterminetheModulusofRigidityofaWirebyMaxwell'sneedle.
10. Todetermine**g**andvelocityforafreelyfallingbodyusingDigitalTimingTechnique.
11. TodeterminetheYoung'sModulusofaWirebyOpticalLeverMethod.

PHYB1020	MATHEMATICAL PHYSICS-I	4L:0T:0P	4 Credits

Course objectives:

The objectives of this course are

1. To familiarize the students of basic calculus problems.
2. To make student learn of vector calculus.
3. To familiarize students with vector integration.
4. To impart the knowledge of curvilinear coordinates.
5. To impart the knowledge of probability theory and Dirac delta function.

Unit 1: **Calculus** L:21

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).

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

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

Unit 2: **Vector Calculus: L : 13**

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

Unit 3: **Vector Integration:** L:14

Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

Unit 4: **Orthogonal Curvilinear Coordinates:** L: 4

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

Unit 5: **Introduction to Probability and Dirac Delta function:** L: 8

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance Conditional Probability. Bayes' Theorem and the idea of hypothesis testing. Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

Text /Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013, 7th Edn., Elsevier.
2. An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
3. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
5. Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
6. Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
7. Mathematical Physics, Goswami, 1st edition, Cengage Learning
8. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K.F.Riley & M.P.Hobson, 2011, Cambridge Univ. Press.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand and apply the knowledge of calculus.
2. Perform vector calculus problems an vector diffentiation.
3. Exhibit sound knowledge of vector integration.
4. Understand the transformations with curvilinear coordinates.
5. Understand the ideas of probability theory.

PHYB1021	MATHEMATICAL PHYSICS-I LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Computer architecture and organization, memory and Input/output devices.
2. Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow-emphasize the importance of making equations in terms of dimensionless variables, Iterative methods.
3. Truncationandroundofferrors, Absolute and relative errors, Floating pointcomputations.
4. Introduction to Programming,constants,variablesand data types, operators and Expressions, I/O statements, scanf and printf, cinandcout, Manipulators for data formatting, Control statements (decision making and looping statements) *If-statement.If-else* Statement.
5. Nested *if* Structure. *Else-if*Statement.TernaryOperator. *Goto* Statement. Switch Statement. Unconditional and ConditionalLooping.*While*Loop.*Do-While*Loop.*FOR* Loop. Break and Continue Statements. Nested Loops)
6. Arrays(*1D&2D*)andstrings,userdefinedfunctions,Structures and Unions, Idea of classes and objects.
7. Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending/ descending order, Binary search.
8. Area of circle, area of square, volume of sphere, value of pi (π).
9. Solution of linear and quadratic equation.
10. Evaluation of trigonometric functions e.g. sin θ, cos θ, tan θ, etc.
11. Given Position with equidistant time data to calculate velocityandaccelerationandvice-versa.Findtheareaof B-H Hysteresisloop.
12. First order differential equation, Radioactive decay,Current in RC, LC circuits with DCsource.
13. Newton's law of cooling, Classical equations of motion, The differential equation describing the motion of a pendulum.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Write and compile computer programming to solve calculus problems
2. Exhibit sound knowledge of control statement, number system, floating point, double precision numbers.
3. Understand the basics of scientific computing.
4. Perform error analysis in scientific computing
5. Solve complex mathematical problems such as transcendental equations by numerical methods.
6. Solve numerical problems with analytical and stochastic methods such as Monte Carlo method.

SEMESTER II

Course Type	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	PHYB2010	Thermal Physics	4	0	0	30	70	100	4
DSC	PHYB2020	Mathematical Physics - II	4	0	0	30	70	100	4
GE	**	Generic Elective - II	4	0/1	4/0	30	70	100	4
AECC	EVSG2000	Environmental Studies	2	0	0	15	35	50	2
DSC	PHYB2011	Thermal Physics Lab	0	0	4	15	35	50	2
DSC	PHYB2021	Mathematical Physics – II Lab	0	0	4	15	35	50	2
GE	**	Generic Elective - II Lab	0	1/0	0/4	15	35	50	2
		Total	**14**	**0**	**12**	**150**	**350**	**500**	**20**

Ability Enhancement Compulsory Courses (AECC)

Semester	Offering Department	Course Code	Course Name	(L-T-P)	Credits
II	Basic Sciences	EVSG2000	Environmental Studies	2-0-0	2

PHYB2010	THERMAL PHYSICS	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. Impart the knowledge of the basic laws of thermodynamics
2. To make students learn the concept of entropy and free energies.
3. To impart the knowledge of thermodynamic relations and kinetic theroy of gases.
4. To impart the knowledge of heat through molecular collisions.
5. To convey the basic concepts related to behavior of real gasses.

Unit 1: **Introduction to Thermodynamics:** L:10

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First

Law: General Relation between CP and CV, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.

Unit 2: **Second Law of Thermodynamics:** L:8

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

Unit 3: **Entropy and Thermodynamic Potentials:** L:14

Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations.

Unit 4: **Maxwell's Thermodynamic Relations:** L:10

Derivations and applications of Maxwell's Relations, Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, (3) TdS Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process.

Unit 5**: Kinetic Theory of Gases:** L:20

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 (No proof required). Specific heats of Gases.Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport phenomenon in Ideal Gases. Brownian Motion and its Significance. Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. P-V Diagrams. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Effect.

Text /Reference Books:

1. Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N.Srivastava, 1958, Indian Press
3. Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, Tata McGraw-Hill
4. Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
5. Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
6. Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press
7. Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand different laws of thermodynamics.
2. Understand basic concepts of entropy and enthalpy.
3. Understand the concept of free energies and thermodynamics potential.
4. Understand the kinetic Theory of Gases.
5. Possess sound knowledge of theories for ideal and real gases.

PHYB2011	THERMAL PHYSICS LAB	0L:0T:4P	4 Credits

LIST OF EXPERIMENTS:

1. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
2. Newtons law of cooling.
3. Stefan's constant.
4. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
5. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
6. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
7. To calibrate a thermocouple to measure temperature in a specified Range using Null Method

PHYB2020	MATHEMATICAL PHYSICS-II	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. To impart the knowledge of Fourier series and its applications.
2. To make students learn Frobenius methods and special functions.
3. To impart the knowledge of special integrals and theory of errors.
4. To make students learn the basics of partial differential equation and its applications.

Detailed Syllabus:

Unit 1: **Fourier Series:** L:10

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

Unit 2: **Frobenius Method:**L:12

Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations.

Unit 3: **Special Functions:**L:12

Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions (Jo(x) and J1(x))and Orthogonality.

Unit 4: **Some Special Integrals and Errors Theory:** L:10

Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. Least-squares fit. Error on the slope and intercept of a fitted line.

Unit 5: **Partial Differential Equations:**L:14

Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Wave equation and its solution for vibrational modes of a stretched string, rectangular and circular membranes. Diffusion Equation.

Text /Reference Books:

1. Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
2. Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.

3. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
4. Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.
5. Partial Differential Equations for Scientists & Engineers, S.J. Farlow, 1993, Dover Pub.
6. Engineering Mathematics, S.Pal and S.C. Bhunia, 2015, Oxford University Press
7. Mathematical methods for Scientists & Engineers, D.A. McQuarrie, 2003, Viva Books

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand Fourier series and various periodic functions.
2. Understand Frobenius methods and its applications to solve differential equations.
3. Exhibit basic understanding of special functions and their properties (Legendre, Hermite, Bessel and Laguerre)
4. Solve problems using special integrals.
5. Understand and solve physics problems using

PHYB2021	MATHEMATICAL PHYSICS-II LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window,Editwindow,Variablesandarrays, initialising variables in Scilab.
2. Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting.
3. Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continuestatements, nested loops, logical arrays and vectorization.
4. User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays.
5. An introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methodsand developingtheskillsofwritingaprogram.
6. Ohms law to calculate R, Hooke’s law to calculate spring constant.
7. Solutionofmeshequationsofelectriccircuits(3meshes).
8. Solutionofcoupledspringmasssystems(3masses)

SEMESTER III

Course Type	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	PHYB3010	Waves and Optics	4	0	0	30	70	100	4
DSC	PHYB3020	Mathematical Physics - III	4	0	0	30	70	100	4
DSC	PHYB3030	Digital Systems and Applications	4	0	0	30	70	100	4
GE	**	Generic Elective - II	4	0/1	4/0	30	70	100	4
DSC	PHYB3011	Waves and Optics Lab	0	0	4	15	35	50	2
DSC	PHYB3021	Mathematical Physics – III Lab	0	0	4	15	35	50	2
DSC	PHYB3031	Digital Systems and Applications Lab	0	0	4	15	35	50	2
GE	**	Generic Elective - II Lab	0	1/0	0/4	15	35	50	2
SEC	**	Skill Enhancement Course-I	0	0	2	15	35	50	2
		Total	**16**	**0**	**22**	**185**	**455**	**650**	**26**

PHYB3010	WAVES AND OPTICS	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. To impart the knowledge of collinear harmonic oscillator and wave motion.
2. To make students learn about superposition of harmonic waves
3. To make students learn the theories of interference and various interferometers.
4. To impart the knowledge of diffraction and diffractometers.
5. To impart the knowledge of holography.

Unit 1: **Superposition of Harmonic oscillations:** L:9

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

Unit 2: **Wave Motion:** L:8

Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves. 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.

Unit 3: **Superposition of Two Harmonic Waves:** L:10

Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

Unit 4: **Interference:** L:13

Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.

Unit 5: **Diffraction:** L:20

Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only) Fraunhofer diffraction: Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating. 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. Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

Text /Reference Books:

1. Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
2. Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
3. Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
4. Optics, Ajoy Ghatak, 2008, Tata McGraw Hill

5. The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons.
6. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
7. Fundamental of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand wave motion and theories of superposition of harmonic oscillations.
2. Understand superposition of harmonic waves and wave optics.
3. Understand theories of interference.
4. Possess sound knowledge of diffraction methods.
5. Understand principle of holography.

PHYB3011	WAVES AND OPTICS LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Familiarization with: Schuster`s focusing; determination of angle of prism.
2. To determine refractive index of the Material of a prism using sodium source.
3. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
4. To determine the wavelength of sodium source using Michelson's interferometer.
5. To determine wavelength of sodium light using Fresnel Biprism.
6. To determine wavelength of sodium light using Newton's Rings.
7. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
8. To determine dispersive power and resolving power of a plane diffractiongrating.
9. To study Lissajous Figures.
10. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –T law.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Take measurements using various optical benches, interferometers, diffractometers.
2. Determine angle, refrective index and dispersive power of a prism using various techniques.

3. Determine wavelength of a light source using various optical techniques.
4. Determine dispersive power and resolving power of diffraction gratings.
5. Study and understand lissajous figures.

PHYB3020	MATHEMATICAL PHYSICS-III	4L:0T:0P	4 Credits

1. Course learning objectives:

The objectives of this course are

1. To impart the knowledge of complex analysis
2. To make student learn complex integration
3. To impart the knowledge of integral transform and Fourier series.
4. To convey the basics of Laplace transformation

2. Detailed Syllabus:

Unit 1: **Complex Analysis: L: 16:**

Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts.

Unit 2: **Complex Integration:: L: 14:**

Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected region. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals.

Unit 3**Integrals Transforms:L: 15:**

Fourier Transforms, Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations.

Unit 4:**Laplace Transforms:L: 10**

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

Unit 5:**Special Functions:L: 5**

Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits, Coupled differential equations of 1st order. Solution of heat flow along infinite bar using Laplace transform.

Text /Reference Books:

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

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand and apply complex analysis
2. Understand methods of complex integration
3. Understand and solve problems of integral transforms
4. Understand and solve physics problems based on Laplace transformation

PHYB3021	MATHEMATICAL PHYSICS-III LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

Scilab/C^{++} based simulations experiments based on Mathematical Physics problems

1. Solve differentialequations:
   $dy/dx = e^{-x}$ with $y = 0$ for $x = 0$ $dy/dx + e^{-x}y = x^2$
   $d^2y/dt^2 + 2\, dy/dt = -y$ $d^2y/dt^2 + e^{-t}dy/dt = -y$
2. Frobenius method and Specialfunctions:
   $\int_{-1}^{+1} P_n(\mu)P_m(\mu)d\mu = \delta_{n,m}$
   Plot $P_n(x)$, $j_v(x)$
   Show recursion relation

3. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose anytwo).

4. Calculation of least square fitting manually without giving weightage to error. Confirmationofleastsquarefittingofdatathroughcomputerprogram.

5. Evaluation of trigonometric functions e.g. *sin θ,* Given Bessel's function at N points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computerintegration.

6. Compute the n^{th} roots of unity for n = 2, 3, and4.

7. Find the two square roots of$-5+12j$.

8. Integral transform: FFT ofe^{-s^2}

9. SolveKirchoff'sCurrentlawforanynodeofanarbitrarycircuitusingLaplace's transform.

10. SolveKirchoff'sVoltagelawforanyloopofanarbitrarycircuitusingLaplace's transform.

11. PerformcircuitanalysisofageneralLCRcircuitusingLaplace'stransform.

PHYB3030	DIGITAL SYSTEMS AND APPLICATIONS	4L:0T:0P	4 Credits

1. Course learning objectives:

The objectives of this course are

1. To impart the basic knowledge of cathode ray oscilloscope and integrated circuits.
2. To convey the knowledge of digital cirucuit and boolen algebra.
3. To imapart the knowledge of data processing circitu and timer ICs.
4. To make students learn operational principles of resistors, counters and memory devices.
5. To impart basic understanfding of Intel 8085 microprocessor.

2. Detailed Syllabus:

Unit 1: **Introduction to CRO: L : 8**

Block Diagram of CRO. Electron Gun, Deflection System and Time Base. Deflection Sensitivity. Applications of CRO: (1) Study of Waveform, (2) Measurement of Voltage, Current, Frequency, and Phase Difference. **Integrated Circuits (Qualitative treatment only):** Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital ICs.

Unit 2: **Digital Circuits: L : 10**

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

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

Unit 3: **Data processing circuits: L : 18**

Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. Arithmetic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor. Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. Timers: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator.

Unit 4: **Registers and Counters: L : 8**

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits). Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter. Computer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

Unit 5: **Intel 8085 Microprocessor Architecture: L : 12**

Main features of 8085. Block diagram. Components. Pin-out diagram. Buses. Registers. ALU. Memory. Stack memory. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. Introduction to Assembly Language: 1 byte, 2 byte & 3 byte instructions.

Text /Reference Books:

1. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 7th Ed., 2011, Tata McGraw
2. Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHI Learning Pvt. Ltd.
3. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
4. Digital Electronics G K Kharate ,2010, Oxford University Press
5. Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer, 2001, PHI Learning
6. Logic circuit design, Shimon P. Vingron, 2012, Springer.
7. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
8. Digital Electronics, S.K. Mandal, 2010, 1st edition, McGraw Hill
9. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the operation and application of CRO.
2. Possess basic knowledge on the design and fabrication of ICs (MSI, LSI and VLSI).
3. Explain fundamental concepts of the decimal number system.
4. Understand principles of Boolean algebra and digital logic circuit.
5. Exhibit sound knowledge of data processing circuits, arithmetic sequential and timer circuits.
6. Understand operational principles of shift registers, counters and memory devices.
7. Understand basic architecture of Intel 8085 microprocessor.

PHYB3031	**DIGITAL SYSTEMS AND APPLICATIONS LAB**	**0L:0T:4P**	**2 Credits**

SUGGESTIVE LIST OF EXPERIMENTS:

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
12. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
13. To design an astable multivibrator of given specifications using 555 Timer.
14. To design a monostable multivibrator of given specifications using 555 Timer.
15. Write the following programs using 8085 Microprocessor
    - a) Addition and subtraction of numbers using direct addressing mode
    - b) Addition and subtraction of numbers using indirect addressing mode
    - c) Multiplication by repeated addition.
    - d) Division by repeated subtraction.
    - e) Handling of 16-bitNumbers.
    - f) Use of CALL and RETURN Instruction.
    - g) Block data handling.

SEMESTER IV

Course Type	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	PHYB4010	Elements of Modern Physics	4	0	0	30	70	100	4
DSC	PHYB4020	Electricity and Magnetism	4	0	0	30	70	100	4
DSC	PHYB4030	Analog Systems and Applications	4	0	0	30	70	100	4
GE	**	Generic Elective - III	4	0/1	4/0	30	70	100	4
DSC	PHYB4011	Elements of Modern Physics Lab	0	0	4	15	35	50	2
DSC	PHYB4021	Electricity and Magnetism Lab	0	0	4	15	35	50	2
DSC	PHYB4031	Analog Systems and Applications Lab	0	0	4	15	35	50	2
GE	**	Generic Elective – III Lab	0	1/0	0/4	15	35	50	2
SEC	**	Skill Enhancement Course-II	0	0	2	15	35	50	2
		Total	**16**	**0**	**22**	**185**	**455**	**650**	**26**

PHYB4010	ELEMENTS OF MODERN PHYSICS	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. To impart the knowledge of quantum theory of radiation
2. To impart the knowledge of basic quantum mechanics
3. To make student learn elements of nuclear physics
4. To impart the knowledge on lasers and their applications

Detailed Syllabus:

Unit 1: **Quantum theory of Radiation:** L:14

Planck's quantum law, Planck's constant and light as a collection of photons; Blackbody, Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions.Position measurement-gamma ray microscope thought experiment; Wave-particle duality, Unit 2: **Quantum Mechanics:** L:19

Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets, impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction. Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension. One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunneling in one dimension-across a step potential & rectangular potential barrier.

Unit 3: **Nuclear Physics:** L:12

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers.Radioactivity**:** stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

Unit 4: **Fission and fusion:** L:8

Mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions).

Unit 5: **Lasers:** L:8

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

Text /Reference Books:

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
3. Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
4. Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
5. Modern Physics, G.Kaur and G.R. Pickrell, 2014, McGraw Hill

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

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

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

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

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

11. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand quantum theory of radiation
2. Possess knowledge of introductory quantum mechanics
3. Understand the fundamentals of nuclear physics.
4. Understand the working principle and applications of lasers.

PHYB4011	ELEMENTS OF MODERN PHYSICS LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. To determine the wavelength of laser source using diffraction of single slit.
2. To determine the wavelength of laser source using diffraction of double slits.
3. To determine (1) wavelength and (2) angular spread of He-Ne laser using plane diffraction grating
4. Measurement of Planck's constant using black body radiation and photo-detector.
5. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
6. To determine work function of material of filament of directly heated vacuum diode.
7. To determine the Planck's constant using LEDs of at least 4 different colours.
8. To determine the wavelength of H-alpha emission line of Hydrogen atom.
9. To determine the ionization potential of mercury.
10. To determine the absorption lines in the rotational spectrum of Iodine vapour.

11. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
12. To setup the Millikan oil drop apparatus and determine the charge of an electron.
13. To show the tunneling effect in tunnel diode using I-V characteristics.

PHYB4020	ELECTRICITY AND MAGNETISM	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. To impart the knowledge of electric field and potential
2. To make student learn about electrostatics and magnetostatics.
3. To impart the knowledge of dielectric and magnetic properties of matter.
4. To impart the knowledge of electromagnetic induction.
5. To make student learn about network theorems.

Unit 1: **Electric Field and Electric Potential :** L:12

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with Spherical, cylindrical and planar symmetry. Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.

Unit 2: **Electrostatic Energy:** L: 9

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

Unit 3: **Dielectric Properties of Matter:** L: 9

Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between E, P and D. Gauss' Law in dielectrics.

Unit 4: **Magnetic Properties of Matter:** L: 13

Magnetic force between current elements and definition of Magnetic Field**B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field. Magnetization vector (M).

Magnetic Intensity (H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.

Unit 5: **Electromagnetic Induction:** L:9

Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current. Electrical Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.

Unit 6: **Network theorems:** L: 8

Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits. Ballistic Galvanometer: Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.

Text /Reference Books:

1. Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
2. Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
3. Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
4. Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M. Sands, 2008, Pearson Education
5. Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
6. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol. I, 1991, Oxford Univ. Press.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the basic ideas of elelctric field and electric potential
2. Exhibit sound knowledge of electrostatics and dielectric properties of matters.
3. Exhibit sound knowledge of magnetostaics and magnetic properties of matters.
4. Understand the theories of electromagnetic induction.
5. Understand network theorem such as Thevenin and Norton theorem.

PHYB4021	ELECTRICITY AND MAGNETISM LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. To determine an unknown Low Resistance using Carey Foster's Bridge.
3. To verify the Thevenin theorem.
4. To verify the Norton theorem.
5. To verify the Superposition theorem.
6. To verify the Maximum power transfer theorem.
7. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
8. To study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor Q.
9. To study the characteristics of a series RC Circuit.
10. To compare capacitances using De'Sauty's bridge.
11. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
12. To determine self inductance of a coil by Anderson's bridge.
13. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
14. Determine a high resistance by leakage method using Ballistic Galvanometer.

PHYB4030	ANALOG SYSTEMS AND APPLICATIONS	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. To make students learn about semiconductor p-n junction diode.
2. To convey the applications of diodes and transistors.
3. To impart the knowledge of circuit design of amplifier.
4. To impart the knowledge of various amplifiers and oscillators.
5. To convey basic knowledge of OPAMPS and its applications

Detailed Syllabus:

Unit 1:**Semiconductor Diodes:**L:14

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

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

Unit 2:**Bipolar Junction transistors:**L:8

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

Unit 3:**Amplifiers:**L:10

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

Unit 4:**Coupled Amplifiers:**L:12

Two stage RC-coupled amplifier and its frequency response. Feedback in Amplifiers: Effects of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.

Unit 5:**OP-AMPS:**L:14

Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. Frequency Response. CMRR. Slew Rate and concept of Virtual ground. Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Log amplifier, (7) Zero crossing detector (8) Wein bridge oscillator. Conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation).

Text /Reference Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
3. Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning
4. Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill

5. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall
6. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.
7. Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer
8. Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, Wiley India
9. Microelectronic Circuits, M.H. Rashid, 2nd Edition, Cengage Learning
10. Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand principles and applications of p-n junction diodes.
2. Design rectifier and switching circuit using diodes and transistors.
3. Understand the mechanism of amplifiers
4. Exhibit sound knowledge on various coupled amplifiers and oscillators.
5. Understand and analyze various analog operations using OPAMPS.

PHYB4031	ANALOG SYSTEMS AND APPLICATIONS LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

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 characteristics of a Bipolar Junction Transistor in CE configuration.
4. To study the various biasing configurations of BJT for normal class A operation.
5. To study the frequency response of voltage gain of a RC-coupled transistor amplifier.
6. To design a Wien bridge oscillator for given frequency using an op-amp.
7. To design a phase shift oscillator of given specifications using BJT.
8. To study the Colpitt`s oscillator.
9. To design a digital to analog converter (DAC) of given specifications.
10. To study the analog to digital convertor (ADC) IC.
11. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain
12. To design inverting amplifier using Op-amp (741,351) and study its frequency response

13. To design non-inverting amplifier using Op-amp (741,351) & study its frequency response
14. To study the zero-crossing detector and comparator
15. To add two dc voltages using Op-amp in inverting and non-inverting mode
16. To design a precision Differential amplifier of given I/O specification using Op-amp.
17. To investigate the use of an op-amp as an Integrator.
18. To investigate the use of an op-amp as a Differentiator.
19. To design a circuit to simulate the solution of a 1st/2nd order differential equation.
20. Study of V-I & power curves of solar cells, and find maximum power point & efficiency.
21. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.

SEMESTER V

Course Type	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	PHYB5010	Quantum Mechanics and Applications	4	0	0	30	70	100	4
DSC	PHYB5020	Solid State Physics	4	0	0	30	70	100	4
DSE	**	Discipline Specific Elective-I	4	0	0	30	70	100	4
DSE	**	Discipline Specific Elective-II	4	0/1	4/0	30	70	100	4
DSC	PHYB5011	Quantum Mechanics and Applications Lab	0	0	4	15	35	50	2
DSC	PHYB5021	Solid State Physics Lab	0	0	4	15	35	50	2
DSE	**	Discipline Specific Elective-I Lab	0	0	4	15	35	50	2
DSE	**	Discipline Specific Elective-II Lab	0	1/0	0/4	15	35	50	2
		Total	**16**	**0**	**20**	**180**	**420**	**600**	**24**

PHYB5010	QUANTUM MECHANICS AND APPLICATIONS	4L:0T:0P	4 Credits

Course learning objectives:

The objectives of this course are

1. To impart the knowledge of the fundamentals of quantum mechanics
2. To make students learn Schrodinger equations and their solutions.

3. To impart the knowledge of eigen value equation based on Schrodinger equation and its general solutions.
4. To impart the knowledge the solution of Schrodinger equation for hydrogen like atoms.
5. To convey the understanding of the atoms in electric and magnetic fields.

Detailed Syllabus

Unit 1:**The Schrodinger equation:** L: 16

Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.Time independent Schrodinger equation:Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

Unit 2:**General discussion of bound states in an arbitrary potential::** L: 12

continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.

Unit 3:**Quantum theory of hydrogen-like atoms:** L: 10

time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells.

Unit 4:**Atoms in Electric & Magnetic Fields** L: 12

Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton. Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect. Paschen Back and Stark Effect (Qualitative Discussion only).

Unit 4:**Many electron atoms** L: 10

Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total angular momentum. Vector Model. Spin-orbit coupling in atoms- L-S and J-J couplings. Hund's Rule. Term symbols. Spectra of Hydrogen and Alkali Atoms (Na etc.).

Text /Reference Books:

1. A Text book of Quantum Mechanics, P.M.Mathews and K.Venkatesan, 2nd Ed., 2010, McGraw Hill
2. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
3. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
4. Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
5. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
6. Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
7. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press
8. Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
9. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
10. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand about the origin of quantum mechanics.
2. Understand about the time independent and time dependent Schrodinger equation and their general solutions.
3. Solve Schrödinger equation for hydrogen like atoms and simple harmonic oscillators.
4. Understand the effects for atoms in electric and magnetic fields.
5. Understand the quantum mechanics of many electron atoms.

PHYB5011	QUANTUM MECHANICS AND APPLICATIONS LAB	0L:0T:2P	2 Credits

LIST OF EXPERIMENTS:

Use C/C^{++}/Scilab for solving the following problems based on Quantum Mechanics like

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

Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is -13.6 eV. Take e = 3.795 (eVÅ)$^{1/2}$, ħc

= 1973 (eVÅ) and m = $0.511x10^6 eV/c^2$.

2. Solve the s-wave radial Schrodinger equation for anatom:
Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, m = $0.511x10^6$ eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

3. Solvethes-*wave*radialSchrodingerequationforaparticleofmassm:
For the anharmonic oscillator potentialfor the ground state energy (in MeV) of particle to an accuracy of three significant digits.Also,plotthecorrespondingwavefunction.Choose m=940MeV/c^2,k=1MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3}In these units, cħ = 197.3 MeV. Solve the *s-wave* radial Schrodinger equation for the vibrations of hydrogen molecule:

4. Find the lowest vibrational energy (in MeV) of the molecule to anaccuracy of three significant digits. Also plot the corresponding wave function. Take: m = $940x10^6$eV/C^2, D = 0.755501 eV, α = 1.44, r_o = 0.131349 Å

Laboratory based experiments:

1. Study of Electron spin resonance- determine magnetic field as a function of the resonancefrequency.
2. StudyofZeemaneffect:withexternalmagneticfield;Hyperfinesplitting
3. Toshowthetunnelingeffectintunneldiodeusing I-Vcharacteristics.
4. Quantum efficiency ofCCDs

PHYB5020	SOLID STATE PHYSICS	4L:0T:0P	4 Credits

1. Course learning objectives:

The objectives of this course are

1. To impart the knowledge of crystal structure.
2. To make students learn elementary lattice dynamics.
3. To impart the knowledge of magnetic and dielectric properties of matereials.
4. To impart the knowledge of elementary band theory.
5. To provide a good understanding of superconductivity and its applications.

2. Detailed Syllabus

Unit 1: **Crystal Structure** :L12

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

Unit 2: **Elementary Lattice Dynamics** :L10

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.

Unit 3: **Magnetic Properties of Matter**:L10

Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

Unit 4: **Dielectric and FerroelectricProperties of Matter**:L12

Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons, TO modes.Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Electrostrictive effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop.

Unit 4: **Band Theory and Superconductivity**:L16

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

Text /Reference Books:

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

3. Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand crystal structure and symmetries.
2. Understand elementary lattice dynamics, lattice vibrations and phonons.
3. Understand magnetic and dielectric properties of material.
4. Understand the applications of elementary band theory.
5. Understand superconductivity, Meissner effect and its applications.

PHYB5021	SOLID STATE PHYSICS LAB	0L:0T:2P	2 Credits

LIST OF EXPERIMENTS:

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

SEMESTER VI

Course Code	Course Code	Course Name	L	T	P	IA	UE	Total Marks	Credits
DSC	PHYB6010	Electromagnetic Theory	4	0	0	30	70	100	4
DSC	PHYB6020	Statistical Mechanics	4	0	0	30	70	100	4
DSE	**	Discipline Specific Elective-III	4	0	0	30	70	100	4
DSE	**	Discipline Specific Elective-IV	4	0/1	4/0	30	70	100	4
DSC	PHYB6011	Electromagnetic Theory Lab	0	0	4	15	35	50	2
DSC	PHYB6021	Statistical Mechanics Lab	0	0	4	15	35	50	2
DSE	**	Discipline Specific	0	0	4	15	35	50	2

		Elective-III Lab							
DSE	**	Discipline Specific Elective-IV Lab	0	1/0	0/4	15	35	50	2
		Total	**16**	**0**	**20**	**180**	**420**	**600**	**24**

PHYB6010	ELECTROMAGNETIC THEORY	4L:0T:0P	4 Credits

1. Course learning objectives:

The objectives of this course are

1. To make students learn Maxwells's equations and its applications.
2. To make students learn solutions of Maxwells equations and EM waves
3. To impart the knowledge of EM waves in matter.
4. To make students learn polarization of EM waves.
5. To provide a good understanding of waveguides/optical fibers.

2. Detailed Syllabus

Unit 1: **Maxwell Equations**: L:12

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

Unit 2: **EM Wave Propagation in Unbounded Media**: L:10

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

Unit 3: **EM Wave Propagation in bounded Media**: L:10

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

Unit 4: **Polarization of Electromagnetic Waves**: L:17

Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation.

Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter.

Unit 4: **Polarization of Electromagnetic Waves**: L:11

Planar optical wave guides. Planar dielectric wave guide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission.

Optical Fibres:- Numerical Aperture. Step and Graded Indices (Definitions Only). Single and Multiple Mode Fibres (Concept and Definition Only).

Text /Reference Books:

1. Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.
2. Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford University Press.
3. Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & Bartlett Learning
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. Electromagnetic field Theory, R.S. Kshetrimayun, 2012, Cengage Learning
6. Engineering Electromagnetic, Willian H. Hayt, 8th Edition, 2012, McGraw Hill.
7. Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
8. Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.
9. Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
10. Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

3. Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand Maxwell's equation and its applications.
2. Understand EM wave and its propagation.
3. Understand the nature of EM in matter.
4. Understand polarization of EM waves and its application.
5. Understand the basics of waveguides and transmission through optical fiber.

PHYB6011	**ELECTROMAGNETIC THEORY LAB**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. To verify the law of Malus for plane polarized light.
2. To determine the specific rotation of sugar solution using Polarimeter.

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

PHYB6020	STATISTICAL MECHANICS	4L:0T:0P	4 Credits

1. Course learning objectives:

The objectives of this course are

1. To impart the knowledge of classical statistics
2. To provide an understanding of classical and quantum theories of radiation.
3. To make students learn distribution statistics: M-B, B-E and F-D.

2. Detailed Syllabus

Unit 1**: Classical Statistics**: 18

Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to Specific Heat and its Limitations, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.

Unit 2**: Classical Theory of Radiation:**L: 8

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

Unit 3**: Quantum Theory of Radiation:**L:6

Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law.

Unit 4**: Bose-Einstein Statistics:**L:13

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

Unit 4**: Fermi-Dirac Statistics:**L:15

Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit.

Text /Reference Books:

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

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the concept of ensemble and thermodynamic probability.
2. Understand entropy and Maxwell-Boltzmann Distribution Law.
3. Understand classical theory of radiation, Stefan-Boltzmann Law and Wien's Displacement law.
4. Possess knowledge of quantum theory of radiation and their applications.
5. Have basic idea of Bose-Einstein Statistics and Bose-Einstein condensation.
6. Understand the Fermi-Dirac Statistics, Fermi energy, electron gas and specific heat of metals.

PHYB6021	STATISTICAL MECHANICS LAB	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

Use C/C^{++}/Scilab/other numerical simulations for solving the problems based on Statistical Mechanics like

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varyingthetotalnumberofparticlesNandtheinitialconditions:

a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations

b) Studyoftransientbehaviorofthesystem(approachtoequilibrium)

c) Relationship of large N and the arrow oftime

d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocitydistribution

e) Computationandstudyofmeanmolecularspeedanditsdependenceon particlemass

f) Computation of fraction of molecules in an ideal gas having speednear the most probablespeed

2. Computationofthepartitionfunction Z forexamplesofsystemswithafinitenumberofsingleparticlelevels(e.g.,2level,3level,etc.)andafinitenumberof non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose- Einstein Statistics:

3. Plot Planck's law for Black Body radiation and compare it with Raleigh-Jeans Law at high temperature and lowtemperature.

4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these twocases.

5. Plot the following functions with energy at differenttemperatures

a) Maxwell-Boltzmanndistribution

b) Fermi-Diracdistribution

c) Bose-Einsteindistribution

LIST OF GENERAL ELECTIVE SUBJECTS

List of Generic Electives Available for students of B.Sc. (Hons.) Physics

Semester	Offering Department	Course Code (T+P)	Course Name	(L-T-P)	Credits
I	Mathematics	MTHB1010	Algebra	5-1-0	6
II	Mathematics	MTHB2010	Differential Calculus & Vector Calculus	5-1-0	6
III	Mathematics	MTHB3010	Differential Equation	5-1-0	6
IV	Mathematics	MTHB4010	Numerical Analysis	4-1-1	6
I	Chemistry	CHYB1010 + CHYB1011	Inorganic Chemistry	4-0-4	6
II	Chemistry	CHYB2010 + CHYB2011	Organic Chemistry	4-0-4	6
III	Chemistry	CHYB3010 + CHYB3011	Physical Chemistry	4-0-4	6
IV	Chemistry	CHYB4010 + CHYB4011	Basic Analytical Chemistry	4-0-4	6

--MATHEMATICS--

MTHB1010	Algebra	5L:1T:0P	6 Credits

Course objectives:

The objectives of this course are

1. To understand the students concept of complex number.
2. To make student learn of set & functions.
3. To familiarize students with system of linear equations.
4. To impart the knowledge of linear transformation& eigen values,eigen vectors .

Unit 1: **Complex Number** L:15

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rationalindices and its applications.

Unit 2:**Set & Functions: L : 20**

Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

Unit 3:**Systems of linear equations:** L:20

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence

Unit 4:**Linear transformations:** L: 20

Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of R^n, dimension of subspaces of R^n and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.

Text /Reference Books:

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, Linear Algebra and its Applications,3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand and apply the complex number in problems.
2. understand the concept of set & functions & how to solve the problems .
3. How to solve linear equations using matrix.
4. Understand the concept of linear transformations.

MTHB2010	Differential Equation	5L:1T:0P	6 Credits

Course Objectives: The main objectives of this course are to introduce the students to the exciting world of Differential Equations, Mathematical Modeling and their applications.

Unit 1: **Differential Equations and Mathematical Modeling:** L:12

Differential equations and mathematical models, Order and degree of a differential equation, Exact differential equations and integrating factors of first order differential equations, Reducible second order differential equations, Application of first order differential equations to equations to acceleration-velocity model, Growth and decay model.

Unit 2: **Population Growth Models:** L:16

Introduction to compartmental models, Lake pollution model (with case study of Lake Burley Griffin), Drug assimilation into the blood (case of a single cold pill, case of a course of cold pills, case study of alcohol in the bloodstream), Exponential growth of population, Limited growth of population, Limited growth with harvesting.

Unit 3: **Second and Higher Order Differential Equations:** L:16
General solution of homogeneous equation of second order, Principle of superposition for a homogeneous equation; Wronskian, its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, Method of undetermined coefficients, Method of variation of parameters, Applications of second order differential equations to mechanical vibrations.

Unit 4: **Analysis of Mathematical Models:** L:12
Interacting population models, Epidemic model of influenza and its analysis, Predator-prey model and its analysis, Equilibrium points, Interpretation of the phase plane, Battle model and its analysis.

Course Learning Outcomes: The course will enable the students to:
1. Formulate Differential Equations for various Mathematical models.
2. Solve first order non-linear differential equation and linear differential equations of higher order using various techniques.
3. Apply these techniques to solve and analyze various mathematical models.

Text /Reference Books:

1. 1. Barnes, Belinda & Fulford, Glenn R. (2015). *Mathematical Modelling with Case Studies, Using* Maple *and* MATLAB (3rd ed.). CRC Press, Taylor & Francis Group.
2. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). *Differential Equation and Boundary Value Problems*: *Computing and Modeling* (5th ed.). Pearson Education.
3. Ross, Shepley L. (2004). *Differential Equations* (3rd ed.). John Wiley & Sons. India

MTHB3010	**Partial Differential Equation**	**5L:1T:0P**	**6 Credits**

Course Objectives: The main objectives of this course are to teach students to form and solve partial differential equations and use them in solving some physical problems.

Unit 1: **First Order PDE and Method of Characteristics:** L: 16
Introduction, Classification, Construction and geometrical interpretation of first order partial differential equations (PDE), Method of characteristic and general solution of first order PDE, Canonical form of first order PDE, Method of separation of variables for first order PDE.

Unit 2: **Mathematical Models and Classification of 2ndOrder Linear PDE:** L: 12
Gravitational potential, Conservation laws and Burger's equations, Classification of second order PDE, Reduction to canonical forms, Equations with constant coefficients, General solution.

Unit 3: **The Cauchy Problem and Wave Equations:** L: 16
Mathematical modeling of vibrating string, vibrating membrane. Cauchy problem for second order PDE, Homogeneous wave equation, Initial boundary value problems, Non-

homogeneous boundary conditions, Finite strings with fixed ends, Non-homogeneous wave equation, Goursat problem.

Unit 4: **Method of Separation of Variables:** L: 12
Method of separation of variables for second order PDE, Vibrating string problem, Existence and uniqueness of solution of vibrating string problem, Heat conduction problem, Existence and uniqueness of solution of heat conduction problem, Non-homogeneous problem.

Course Learning Outcomes: The course will enable the students to:

1. Formulate, classify and transform partial differential equations into canonical form.
2. Solve linear and non-linear partial differential equations using various methods; and apply these methods in solving some physical problems.

Text /Reference Books:

1. 1. Myint-U, Tyn & Debnath, Lokenath. (2007). *Linear Partial Differential Equation for Scientists and Engineers* (4th ed.). Springer, Third Indian Reprint, 2013.
2. Sneddon, I. N. (2006). *Elements of Partial Differential Equations*, Dover Publications. Indian Reprint.
3. Stavroulakis, Ioannis P & Tersian, Stepan A. (2004). *Partial Differential Equations*: *An Introduction with Mathematica and MAPLE* (2nd ed.). World Scientific.

MTHB4010	Numerical Analysis	4L:1T:0P	5 Credits

Course Objectives: To comprehend various computational techniques to find approximate value for possible root(s) of non-algebraic equations, to find the approximate solutions of system of linear equations and ordinary differential equations. Also, the use of Computer Algebra System (CAS) by which the numerical problems can be solved both numerically and analytically, and to enhance the problem solving skills.

Unit 1: **Methods for Solving Algebraic and Transcendental Equations:** L:12
Algorithms, Convergence, Bisection method, False position method, Fixed point iteration method, Newton's method, Secant method.

Unit 2: **Techniques to Solve Linear Systems:** L:12
Partial and scaled partial pivoting, LU decomposition and its applications, Iterative methods: Gauss-Jacobi, Gauss-Seidel and SOR methods.

Unit 3: **Interpolation:** L:16
Interpolation formulae, Newton’s forward and backward differences, Stirling’s formula,Lagrange’s interpolation formula, Piecewise linear interpolation.

Unit 4: **Numerical Differentiation and Integration:** L:16

First order and higher order approximation for first derivative, Approximation for second derivative. Numerical integration by closed Newton-Cotes formula: trapezoidal rule, Simpson's rule and its error analysis. Euler's method to solve ODE's.

Course Learning Outcomes: The course will enable the students to learn the following:

1. Some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.
2. Interpolation techniques to compute the values for a tabulated function at points not in the table.
3. Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.

Text /Reference Books:

1. Bradie, Brian. (2006). *A Friendly Introduction to Numerical Analysis*. Pearson Education, India. Dorling Kindersley (India) Pvt. Ltd. Third impression 2011.
2. Jain, M. K., Iyengar, S. R. K., & Jain, R. K. (2012). *Numerical Methods for Scientific and Engineering Computation*. (6th ed.). New Age International Publisher, India, 2016.
3. Gerald, C. F., & Wheatley, P. O. (2008). *Applied Numerical Analysis* (7th ed.). Pearson Education. India.

MTHB4011	**Numerical Analysis Lab**	**0L:0T:2P**	**1 Credits**

Practical/Lab work to be performed in Computer Lab:

Use of computer algebra software (CAS), for example Mathematica/MATLAB/Maple/ Maxima/Scilab etc., for developing the following numerical programs:

1. Bisection method
2. Newton Raphson method
3. Secant method
4. Regula Falsi method
5. LU decomposition method
6. Gauss-Jacobi method
7. SOR method
8. Gauss-Seidel method
9. Lagrange interpolation
10. Newton interpolation
11. Trapezoidal rule
12. Simpson's rule
13. Euler's method

Note: For any of the CAS: Mathematica /MATLAB/ Maple/Maxima /Scilab etc., data typessimple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

--CHEMISTRY--

CHYB1010	Inorganic Chemistry	4L:0T:0P	4 Credits

Course Learning Objectives:

The objective of this course is:

1. To make student learn about wave mechanics.
2. To study about periodic properties of S,P,D & F block elements
3. To impart knowledge of covalent and ionic bond.
4. To impart knowledge of metallic bonds and weak Chemical Forces
5. To make student learn about oxidation and reduction.

Unit 1: **Atomic Structure:** L:14

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Unit 2: **Periodicity of Elements:** L:16

s, *p*, *d*, *f* block elements, the long form of periodic table. Properties of the elements with reference to *s*&*p*-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) Ionic and crystal radii. Covalent radii (octahedral and tetrahedral) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. Electron gain enthalpy, trends of electron gain enthalpy. Electronegativity, Pauling's/ Mulliken's/Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.

Unit 3: **Chemical Bonding I:** L:16

Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipolemoment.

Unit 4: **Chemical Bonding II:** L:10

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

Unit 5:**Oxidation-Reduction:** L:4

Redox equations, Standard Electrode Potential and its application to inorganic reactions.

Text/Reference Books:

- Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
- Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
- Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
- Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

Course Outcomes:

At the end of this course students will be able to:

1. Understand the concept of wave mechanics.
2. Know the variations of periodic properties in S, P, D and F block elements.
3. Have knowledge of different types of bond nature.
4. Understand the weak chemical forces interactions.
5. To solve problems related to oxidation and reduction.

CHYB1010	Inorganic Chemistry Lab	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

(A) Titrimetric Analysis

(i) Calibration and use of apparatus

(ii) Preparation of solutions of different Molarity/Normality of titrants

(B) Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.
(iii) Estimation of free alkali present in different soaps/detergents

(C) Oxidation-Reduction Titrimetry

(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Reference text:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. To have knowledge of calibration of different glassware's.
2. To prepare different normal and molar solution.
3. To have knowledge of acid base reaction.
4. To Estimate free alkali present in different soaps/detergents.
5. Understand concept of oxidation and reduction based reactions.

CHYB2010	Organic Chemistry	4L:0T:0P	4 Credits

Course Learning Objectives:

The objective of this course is:

1. To impart knowledge of hybridization, Electronic Displacements reactions.
2. To make students learn about chemistry of alkanes.
3. To make students understand carbon-carbon pi bonds.
4. To impart knowledge of cycloalkanes and conformational Analysis.
5. To make students understand aromatic character of cyclic compounds.

Unit 1: **Organic Compounds:** L: 16

Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength. Homolytic and Heterolytic fission with suitable examples. Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocation's, Carbanion, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Unit 2: **Carbon-Carbon sigma bonds::**L: 8

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

Unit 3: **Carbon-Carbon pi bonds::**L: 14

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylicbromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

Unit 4: **Cycloalkanes and Conformational Analysis** : L: 10

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

Unit 5: **Aromaticity:** L: 12

Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

Text/Reference Books:

- Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Eliel, E. L. &Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London, 1994.
- Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Apply the knowledge of hybridization and molecular displacements in molecular modeling.
2. Learn the preparation and properties of alkanes.
3. Have knowledge of chemical reactions of alkenes and alkynes.
4. Understand the concept of Conformation analysis of alkanes.
5. Understand concept of aromaticity.

CHYB2011	Organic Chemistry Lab	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Checking the calibration of the thermometer

2. Purification of organic compounds by crystallization using the following solvents:

a. Water
b. Alcohol
c. Alcohol-Water

3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)

4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)

6. Chromatography

a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
b. Separation of a mixture of two sugars by ascending paper chromatography
c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)

Reference Books

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. To purify organic compounds by crystallization.
2. To determine the melting points of unknown organic compounds.
3. To determine mixed melting point of two unknown organic compounds
4. To determine boiling point of liquid compounds.
5. Separate a mixture of various compounds by the help of chromatography.

CHYB3010	Physical Chemistry	4L:0T:0P	4 Credits

Course Learning Objectives:

The objective of this course is:

1. To impart knowledge of phase and binary solutions.
2. Students will learn about molecularity, rate laws and kinetics of complex reactions.
3. To gain knowledge of collision theory of reaction rates and temperature dependence of reaction rates.
4. To impart knowledge of enzyme catalysis.
5. To make students learn about surface chemistry.

Unit 1: **Phase Equilibria:** L:28

Concept of phases, components and degrees of freedom, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, two and three component systems. *Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

Unit 2: **Chemical Kinetics I:** L:10

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions.

Unit 3: **Chemical Kinetics II:** L:8

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

Unit 4: **Catalysis:**L:8

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

Unit 5: **Surface chemistry:** L:6

Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.

Text/Reference Books:

- Peter Atkins & Julio De Paula, *Physical Chemistry 9th Ed.*, Oxford University Press (2010).
- Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
- McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.: New Delhi (2004).
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
- Zundhal, S.S. *Chemistry concepts and applications* Cengage India (2011).
- Ball, D. W. *Physical Chemistry* Cengage India (2012).
- Mortimer, R. G. *Physical Chemistry 3rd Ed.*, Elsevier: NOIDA, UP (2009).
- Levine, I. N. *Physical Chemistry 6th Ed.*, Tata McGraw-Hill (2011).
- Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill (2009).

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Students will learn about phase equilibria and binary solutions.
2. Will have idea of molecularity and rate laws.
3. Students will have idea about collision theory of reaction rates.
4. Students will understand about enzyme catalytic reaction.
5. Solve problems related to surface chemistry.

CHYB3011	Physical Chemistry Lab	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

I. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.

II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tube method:

a. simple eutectic and

b. congruently melting systems.

III. Distribution of acetic/ benzoic acid between water and cyclohexane.

IV. Study the equilibrium of at least one of the following reactions by the distribution method:

(i) $I_2(aq) + I^- \rightarrow I_3^-(aq)$

(ii) $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n^{2+}$

V. Study the kinetics of the following reactions.
1.Initial rate method: Iodide-persulphatereaction 2.Integrated rate method:

a. Acid hydrolysis of methyl acetate with hydrochloric acid.
b. Saponification of ethyl acetate. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate.

VI. Adsorption
Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

Text/Reference Books:

- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry8th Ed.*; McGraw-Hill: New York (2003).
- Halpern, A. M. &McBane, G. C. *Experimental Physical Chemistry3rd Ed.;* W.H. Freeman & Co.: New York (2003).

CHYB4010	Basic Analytical Chemistry	4L:0T:0P	4 Credits

Course Learning Objectives:
The objective of this course is:
1. To introduce students about analytical chemistry and its concept.
2. To impart knowledge of analysis of soil and water.
3. To make students study about food products and preservatives.
4. To make students learn about chromatography and constituents of cosmetics.
5. To study the use spectrophotometer and flame photometer for performing different experiments.

Unit 1: **Introduction:** L: 5
Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.
Unit 2: **Analysis of soil and water:**L: 7 Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators Determination of pH of soil samples. Estimation of Calcium and Magnesium ions as Calcium carbonate by Complexometric titration. Analysis of water: Definition of pure water, sources

responsible for contaminating water, water sampling methods, water purification methods.Determination of pH, acidity and alkalinity of a water sample.Determination of dissolved oxygen (DO) of a water sample.

Unit 3: **Analysis of food products**: L:6
Nutritional value of foods, idea about food processing and food preservations and adulteration.
Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.

Unit 4: **Analysis of preservatives and colouring matter:** L: 6
Ion-exchange: Column, ion-exchange chromatography etc. Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible). Analysis of cosmetics: Major and minor constituents and their function. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by Complexometric titration.

Unit 5: **Suggested Applications(Any one):** L:6
To study the use of phenolphthalein in trap cases.
To analyze arson accelerants.
To carry out analysis of gasoline.
Suggested Instrumental demonstrations:
Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.

Text/ Reference Books:

1. Willard, H. H. *Instrumental Methods of Analysis*, CBS Publishers.
2. Skoog &Lerry. *Instrumental Methods of Analysis*, Saunders College Publications, New York.
3. Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6th Ed.*, Saunders College Publishing, Fort Worth (1992).
4. Harris, D. C. *Quantitative Chemical Analysis*, W. H. Freeman.
5. Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.
6. Day, R. A. & Underwood, A. L. *Quantitative Analysis*, Prentice Hall of India.
7. Freifelder, D. Physical Biochemistry *2nd Ed.*, W.H. Freeman and Co., N.Y. USA (1982).
8. Cooper, T.G. *The Tools of Biochemistry*, John Wiley and Sons, N.Y. USA. 16 (1977).
9. Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7th Ed.*, Prentice Hall.
10. Vogel, A. I. Vogel's *Quantitative Chemical Analysis6th Ed.*, Prentice Hall.
11. Robinson, J.W. *Undergraduate Instrumental Analysis 5th Ed.*, Marcel Dekker, Inc., New York (1995).

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. To develop the knowledge of analytical chemistry.
2. To analyse composition and concepts of soil and water.
3. To understand some food products and identification of some common food items.
4. To develop the knowledge of ion exchange chromatography.
5. Handle flame photometer and spectrophotometer.

CHYB4011	**Basic Analytical Chemistry Lab**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. Determination of pH of soil samples.
2. Estimation of Calcium and Magnesium ions as Calcium carbonate by Complexometric titration.
3. Determination of pH, acidity and alkalinity of a water sample.
4. Determination of dissolved oxygen (DO) of a water sample.
5. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
6. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.
7. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
8. Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.

Generic Electives offered by Department of Physics for students in B.Sc. (Hons.) in Allied Programmes (Chemistry, Mathematics, Geology, Psychology etc.)

Semester	Course Code (T+P)	Course Name	(L-T-P)	Credits
I	PHYB1010+PHYB1011	Mechanics	4-0-4	6
II	PHYB2010+PHYB2011	Thermal Physics	4-0-4	6
III	PHYB3010+PHYB3011	Waves and Optics	4-0-4	6
IV	PHYB4010+PHYB4011	Elements of Modern Physics	4-0-4	6

*** Detailed Syllabus for these courses are the same as the courses of the same names and codes offered as DSC courses of the B.Sc. (Hons.) Physics Programme.**

List of Discipline Specific Elective Papers: (Credit: 06 each)

Semester	Course Code (T+P)	Course Name	(L-T-P)	Credits
V	PHYB5310+PHYB5311	Experimental Techniques	4-0-4	6
V	PHYB5320+PHYB5321	Devices and Instruments	4-0-4	6
V	PHYB5330+PHYB5331	Advanced Mathematical Physics-I	4-0-4	6
V	PHYB5340+PHYB5341	Communication Electronics	4-0-4	6
V	PHYB5350	Classical Dynamics	5-0-1	6
VI	PHYB6310	Nuclear and Particle Physics	5-0-1	6
VI	PHYB6320+PHYB6321	Astronomy and Astrophysics	4-0-4	6
VI	PHYB6330	Advanced Mathematical Physics-II	5-1-0	6
VI	PHYB6340	Atmospheric Physics	5-0-1	6
VI	PHYB6350	Applied Dynamics	5-0-1	6
VI	PHYB6360+PHYB6361	Nanomaterials and Applications	4-0-4	6
VI	PHYB6370+PHYB6371	Physics of the Earth	4-0-4	6
VI	PHYB6380	Biophysics	5-0-1	6
VI	PHYB6393	Dissertation*	-	6

* Optional Dissertation or project work in place of one Discipline Specific Elective paper (DSE-4)(6 credits) in 6th Semester

Department-Specific Electives offered by Department of Physics for students in B.Sc. (PCM)

Semester	Course Code (T+P)	Course Name	(L-T-P)	Credits
V	PHYB5010+PHYB5011	Quantum Mechanics and Applications	4-0-4	6
V	PHYB5020+PHYB5021	Solid State Physics	4-0-4	6
VI	PHYB6010+PHYB6011	Electromagnetic Theory	4-0-4	6
VI	PHYB6010+PHYB6011	Statistical Mechanics	4-0-4	6

*** Detailed Syllabus for these courses are the same as the courses of the same names and codes offered as DSC courses of the B.Sc. (Hons.) Physics Programme.**

PHYB5310	Experimental Techniques	4L:0T:0P	4 Credits

Course Learning Objective:

The objectives of this course are:

1. To impart the basic ideas of measurement and errors.
2. To make students learn about signal systems and responses.
3. To impart the knowledge of shielding and grounding.
4. To impart the knowledge of transducers and industrial instrumentation.
5. To convey the knowledge of vacuum systems and their applications.

Detailed Syllabus

Unit 1:L: 8

Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Types of errors: Gross error, systematic error, random error. Statistical analysis of data (Arithmetic mean, deviation from mean, average deviation, standard deviation, chi-square) and curve fitting. Guassian distribution.

Unit 2: L:8

Signals and Systems: Periodic and aperiodic signals. Impulse response, transfer function and frequency response of first and second order systems. Fluctuations and Noise in measurement system. S/N ratio and Noise figure. Noise in frequency domain. Sources of Noise: Inherent fluctuations, Thermal noise, Shot noise, 1/f noise

Unit 3: L:8

Shielding and Grounding: Methods of safety grounding. Energy coupling. Grounding. Shielding: Electrostatic shielding. Electromagnetic Interference.

Unit 4: L: 24

Transducers & industrial instrumentation (working principle, efficiency, applications): Static and dynamic characteristics of measurement Systems. Generalized performance of systems, Zero order first order, second order and higher order systems. Electrical, Thermal and Mechanical systems. Calibration. Transducers and sensors. Characteristics of Transducers. Transducers as electrical element and their signal conditioning. Temperature transducers: RTD, Thermistor, Thermocouples, Semiconductor type temperature sensors. Inductance change transducer. Comparison of analog and digital instruments. Block diagram of digital multimeter, principle of measurement of I, V, C. Accuracy and resolution of measurement.

Unit 5: L:12

Vacuum Systems: Characteristics of vacuum: Gas law, Mean free path. Application of vacuum. Vacuum system- Chamber, Mechanical pumps, Diffusion pump & Turbo Modular pump, Pumping speed, Pressure gauges (Pirani, Penning, ionization).

Text /Reference Books:

1. Measurement, Instrumentation and Experiment Design in Physics and Engineering,
2. Sayer and A. Mansingh, PHI Learning Pvt. Ltd.
3. Experimental Methods for Engineers, J.P. Holman, McGraw Hill
4. Introduction to Measurements and Instrumentation, A.K. Ghosh, 3rd Edition, PHI Learning Pvt. Ltd.
5. Transducers and Instrumentation, D.V.S. Murty, 2nd Edition, PHI Learning Pvt. Ltd.
6. Instrumentation Devices and Systems, C.S. Rangan, G.R. Sarma, V.S.V. Mani, Tata McGraw Hill
7. Principles of Electronic Instrumentation, D. Patranabis, PHI Learning Pvt. Ltd.
8. Electronic circuits: Handbook of design & applications, U.Tietze, Ch.Schenk, Springer.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand and apply measurement techniques.
2. Understand the principles of signal, response and fluctuations and noise.
3. Exhibit sound understanding of transducers and industrial sensors.
4. Understand the basic ideas of shielding and grounding of electrical equipment.
5. Understand vacuum systems and pumps.

PHYB5311	Experimental Techniques Lab	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Measurement of level using capacitive transducer.
2. To study the characteristics of a Thermostat and determine its parameters.
3. Study of distance measurement using ultrasonic transducer.
4. Calibrate Semiconductor type temperature sensor (AD590, LM35, or LM75)
5. To measure the change in temperature of ambient using Resistance Temperature Device (RTD).
6. Create vacuum in a small chamber using a mechanical (rotary) pump and measure the chamber pressure using a pressure gauge.
7. Comparison of pickup of noise in cables of different types (co-axial, single shielded, double shielded, without shielding) of 2m length, understanding of importance of grounding using function generator of mV level & an oscilloscope.
8. To design and study the Sample and Hold Circuit.

9. Design and analyze the Clippers and Clampers circuits using junction diode
10. To plot the frequency response of a microphone.
11. To measure Q of a coil and influence of frequency, using a Q-meter.

Reference Books:

1. Electronic circuits: Handbook of design and applications, U. Tietze and C. Schenk, 2008, Springer
2. Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1990, Mc-Graw Hill
3. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer and A. Mansingh, 2005, PHI Learning.

Course outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand working with lab instruments.
2. Take measurements with various transducers.
3. Understand working circuits and principles of temperature and pressure sensors.
4. Understand effect of shielding on noise and fluctuation.

PHYB5320	Device and Instruments	4L:0T:0P	4 Credits

Course Learning Objective:

The objectives of this course are:

1. To convey basic ideas of electronic devices and their applications.
2. To impart the knowledge of power supply, filters and multivibrators.
3. To convey the knowledge of processing of devices and fabrications.
4. To impart the knowledge of communication systems.

Detailed Syllabus

Unit 1: L: 14

Devices: Characteristic and small signal equivalent circuits of UJT and JFET. Metal-semiconductor Junction. Metal oxide semiconductor (MOS) device. Ideal MOS and Flat Band voltage. SiO_2-Si based MOS. MOSFET– their frequency limits. Enhancement and Depletion Mode MOSFETS, CMOS. Charge coupled devices. Tunnel diode.

Unit 2: L 9

Power supply, filters and multivibrators: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators, Line and load regulation, Short circuit protection. Active and Passive Filters, Low Pass, High Pass, Band Pass and band Reject Filters.Multivibrators: Astable and Monostable Multivibrators using transistors.

Unit 3: L:12

Processing of Devices: Basic process flow for IC fabrication, Electronic grade silicon. Crystal plane and orientation. Defects in the lattice. Oxide layer. Oxidation Technique for Si. Metallization technique. Positive and Negative Masks. Optical lithography. Electron lithography. Feature size control and wet anisotropic etching. Lift off Technique. Diffusion and implantation.

Unit 4: L: 8

Digital Data Communication Standards:

Serial Communications**:** RS232, Handshaking, Implementation of RS232 on PC.

Universal Serial Bus (USB): USB standards, Types and elements of USB transfers. Devices (Basic idea of UART).

Parallel Communications: General Purpose Interface Bus (GPIB), GPIB signals and lines, Handshaking and interface management, Implementation of a GPIB on a PC. Basic idea of sending data through a COM port.

Unit 5: L:17

Communication systems: Block diagram of electronic communication system, Need for modulation. Amplitude modulation. Modulation Index. Analysis of Amplitude Modulated wave. Sideband frequencies in AM wave. CE Amplitude Modulator. Demodulation of AM wave using Diode Detector. basic idea of Frequency, Phase, Pulse and Digital Modulation including ASK, PSK, FSK.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the characteristics and application of transistor devices.
2. Understand the design and usage of power supply and filter circuits.
3. Understand design and manufacturing of semiconductor devices and integrated circuits.
4. Understand methods and techniques of digital communication.

Reference Books:

1. Physics of Semiconductor Devices, S.M. Sze & K.K. Ng, 3rd Ed.2008, John Wiley & Sons
2. Electronic devices and integrated circuits, A.K. Singh, 2011, PHI Learning Pvt. Ltd.
3. Op-Amps & Linear Integrated Circuits, R.A.Gayakwad,4 Ed. 2000,PHI Learning Pvt. Ltd
4. Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.
5. Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
6. Introduction to Measurements & Instrumentation, A.K. Ghosh, 3rd Ed., 2009, PHI Learning Pvt. Ltd.
7. Semiconductor Physics and Devices, D.A. Neamen, 2011, 4th Edition, McGraw Hill
8. PC based instrumentation; Concepts & Practice, N.Mathivanan, 2007, Prentice-Hall of India

PHYB5321	Device and Instruments Lab	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain
4. Design and Verification of op-amp as integrator and differentiator
5. To design a power supply using bridge rectifier and study effect of C-filter.
6. To design the active Low pass and High pass filters of given specification.
7. To study the output and transfer characteristics of a JFET.
8. To design a common source JFET Amplifier and study its frequency response.
9. To study the output characteristics of a MOSFET.

10. Design the 1st order active low pass and high pass filters of given cutoff frequency
11. Design a Wein`s Bridge oscillator of given frequency.
12. Design clocked SR and JK Flip-Flop`s using NAND Gates

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Apply the knowledge of devices to design op-amps, power supply and filter circuits
2. Understand the Thevenin and Norton's theorem and their applications.
3. Design amplifier circuits using BJT and FETs.
4. Design and measure frequency response of amplifier circuits.
5. Understand the working principle of flip-flops

Reference Books:

1. Basic Electronics:A text lab manual, P.B. Zbar, A.P. Malvino, M.A.Miller,1994, Mc-Graw Hill
2. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
3. Electronics : Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.
4. OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edn., 2000, Prentice Hall.
5. Introduction to PSPICE using ORCAD for circuits & Electronics, M.H. Rashid, 2003, PHI Learning.
   PC based instrumentation; Concepts & Practice, N.Mathivanan, 2007, Prentice-Hall of India

PHYB5330	**Advanced Mathematical Physics-I**	**4L:0T:0P**	**4 Credits**

Course Learning Objective:

The objectives of this course are:

1. To impart the knowledge of linear vector spaces
2. To make students learn operations with matrices
3. To convey the basics of tensors and their applications
4. To impart the knowledge of operation of tensors

Detailed Syllabus

Unit 1: L:12

Linear Vector Spaces: Abstract Systems. Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices.

Unit 2: L:18

Matrices: Addition and Multiplication of Matrices. Null Matrices. Diagonal, Scalar and Unit Matrices. Upper-Triangular and Lower-Triangular Matrices. Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrices. Trace of a Matrix. Inner Product. Eigen-values and Eigenvectors. Cayley- Hamiliton

Theorem. Diagonalization of Matrices. Solutions of Coupled Linear Ordinary Differential Equations. Functions of a Matrix.

Unit 3 : L:20

Cartesian Tensors: Transformation of Co-ordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Invariant Tensors : Kronecker and Alternating Tensors. Association of Antisymmetric Tensor of Order Two and Vectors. Vector Algebra and Calculus using Cartesian Tensors : Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Vector Identities. Tensorial Formulation of Analytical Solid Geometry : Equation of a Line. Angle Between Lines. Projection of a Line on another Line. Condition for Two Lines to be Coplanar. Foot of the Perpendicular from a Point on a Line. Rotation Tensor (No Derivation). Isotropic Tensors. Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors : Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law.

Unit 4: L:10

General Tensors: Transformation of Co-ordinates. Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Algebra of Tensors. Sum, Difference & Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Anti-symmetric Tensors. Metric Tensor.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the theories and usage of linear vector space in physics problems.
2. Understand basic and advance application of various properties of matrices.
3. Understand Tensors in Cartesian coordinate and their applications in physics laws.
4. Understand the general operation of tensors.

Reference Books:

1. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
2. Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970, Elsevier.
3. Modern Mathematical Methods for Physicists and Engineers, C.D. Cantrell, 2011, Cambridge University Press
4. Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
5. Linear Algebra, W. Cheney, E.W.Cheney & D.R.Kincaid, 2012, Jones & Bartlett Learning
6. Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
7. Mathematical Methods for Physicis & Engineers, K.F.Riley, M.P.Hobson, S.J.Bence, 3rd Ed., 2006, Cambridge University Press

PHYB5331	**Advanced Mathematical Physics-I Lab**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

Mathematica/Scilab/MATLAB/ C^{++} based simulations experiments based on Mathematical Physics problems like

1. Linear algebra:
- Multiplication of two 3 x 3 matrices
- Eigenvalue and Eigenvector of complex matrices
2. Orthogonal polynomials as eigenfunctions of Hermitian differential operators.
3. Determination of the principal axes of moment of inertia through diagonalization.
4. Vector space of wave functions in Quantum Mechanics: Position and momentum differential operators and their commutator, wave functions for stationary states as eigenfunctions of Hermitian differential operator.
5. Lagrangian formulation in Classical Mechanics with constraints.
6. Study of geodesics in Euclidean and other spaces (surface of a sphere, etc).
7. Estimation of ground state energy and wave function of a quantum system.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Code basic and advanced mathematical problems using C++/SciLab/Mathematica programming
2. Solve various mathematical problem numerically using iterative methods.
3. Understand the formulation of classical and quantum mechanical problem into programming language.
4. Apply the knowledge of physics to solve problems with computational techniques.

Reference Books:

1. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
2. Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
3. Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978- 6133459274

PHYB6330	Advanced Mathematical Physics-II	5L:1T:0P	6 Credits

Course Learning Objective:

The objectives of this course are:

1. To impart the knowledge of calculus of variations
2. To impart the knowledge of canonical variables
3. To convey the basics of group theory
4. To impart the knowledge of advanced probability theory

Detailed Syllabus

Unit 1: L:17

Calculus of Variations:

Variable Calculus: Variational Principle, Euler's Equation and its Application to Simple Problems. Geodesics. Concept of Lagrangian. Generalized co-ordinates. Definition of canonical moment, Euler-Lagrange's Equations of Motion and its Applications to Simple Problems (e.g., Simple Pendulum and One dimensional harmonic oscillator).

Unit 2: L:8

Canonical variables

Definition of Canonical Momenta. Canonical Pair of Variables. Definition of Generalized Force: Definition of Hamiltonian (Legendre Transformation). Hamilton's Principle. Poisson Brackets and their properties. Lagrange Brackets and their properties.

Unit 3 : L:25

Group Theory:

Review of sets, Mapping and Binary Operations, Relation, Types of Relations.

Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Co-sets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of group. Normal and conjugate subgroups, Completeness and Kernel.

Some special groups with operators. Matrix Representations: Reducible and Irreducible

Unit 4: L: 25

Advanced Probability Theory:

Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Expectation and Variance, Special Probability distributions: The binomial distribution, The poisson distribution, Continuous distribution: The Gaussian (or normal) distribution, The principle of least squares.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand variational calculus and its applications
2. Understand the role of canonical variable pairs in physical motion equations.
3. Understand and apply set theory to practical problems.
4. Understand the probability theory and it's advanced applications.

Reference Books:

1. Mathematical Methods for Physicists: Weber and Arfken, 2005, Academic Press.
2. Mathematical Methods for Physicists: A Concise Introduction: Tai L. Chow, 2000, Cambridge Univ. Press.
3. Elements of Group Theory for Physicists by A. W. Joshi, 1997, John Wiley.
4. Group Theory and its Applications to Physical Problems by Morton Hamermesh, 1989, Dover
5. Introduction to Mathematical Physics: Methods & Concepts: Chun Wa Wong, 2012, Oxford University Press
6. Introduction to Mathematical Probability, J. V. Uspensky, 1937, Mc Graw-Hill.

PHYB5340	Communication Electronics	4L:0T:0P	4 Credits

Course Learning Objective:

The objectives of this course are:

1. To impart the knowledge of electronic communication'
2. To make student learn the theories and applications of analog and digital modulation
3. To convey basic knowledge of communication and navigational system.
4. To impart introductory knowledge on mobile telephony.

Detailed Syllabus

Unit 1: L:10

Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals. Concept of Noise, signal-to-noise (S/N) ratio.

Unit 2: L:20

Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver **,** Channel capacity, Sampling theorem, Basic Principles- PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing.

Unit 3: L:10

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

Unit 4 : L: 10

Introduction to Communication and Navigation systems:

Satellite Communication– Introduction, need, Geosynchronous satellite orbits,geostationary satellite advantages of geostationary satellites. Satellite visibility, transponders (C - Band), path loss, ground station, simplified block diagram of earth station. Uplink and downlink.

Unit 5 : L : 10

Mobile Telephony System – Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only). GPS navigation system (qualitative idea only)

Course Outcomes:

At the end of this course students will demonstrate the ability to:

5. Understand the means and techniques of electronic communication.
6. Understand the principles of various modulation techniques and their applications.

7. Understand the techniques of satellite communication and navigation systems.
8. Understand mobile telephony and various concepts related to it.

Reference Books:

1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2. Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
3. Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
4. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
5. Communication Systems, S. Haykin, 2006, Wiley India
6. Electronic Communication system, Blake, Cengage, 5th edition.
7. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

PHYB5341	**Communication Electronics Lab**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Design and analyse transistor-based modulator circuits.
2. Design and study multiplexer circuits.
3. Understand the working principles of ASK, PSK, and FSK modulators and their characteristics.

Reference Books:

1. Electronic Communication systems, G. Kennedy, 1999, Tata McGraw Hill.
2. Electronic Communication system, Blake, Cengage, 5th edition.

PHYB5350	**Classical Dynamics**	**5L:1T:0P**	**6 Credits**

Course Learning Objective:

The objectives of this course are:

1. To impart the knowledge of classical mechanics and its theories.
2. To impart the knowledge of dynamics of oscillations
3. To provide a basic understanding of general theory of relativity.
4. To provide introductory knowledge on fluid dynamics.

Detailed Syllabus

Unit 1: L:22

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

Unit 2: L: 10

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

Unit 3: L:33

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

Unit 4: L : 10

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

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand advanced classical mechanics
2. Solve problem related to classical motion of particles.
3. Understand and express various physics problems in terms of small harmonic oscillations.
4. Understand the techniques to apply the special theory of relativity.
5. Understand the basics of fluid dynamics.

Reference Books:

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

PHYB6350	Applied Dynamics	4L:0T:0P	4 Credits

Course Learning Objective:

The objectives of this course are:

1. To impart the knowledge of dynamical systems.
2. To convey the problem solving skills regarding dynamics problems.
3. To provide the basic ideas of chaos and fractal theory
4. To impart the knowledge of elementary fluid dynamics

Detailed Syllabus

Unit 1: L:14

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space, flows and trajectories. Simple mechanical systems as first order dynamical systems : the free particle, particle under uniform gravity, simple and damped harmonic oscillator. Sketching flows and trajectories in phase space; sketching variables as functions of time, relating the equations and pictures to the underlying physical intuition.

Unit 2: L : 12

Examples of dynamical systems: –In Biology: Population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits

In Chemistry: Rate equations for chemical reactions e.g. auto catalysis, bistability In Economics: Examples from game theory.Illustrative examples from other disciplines.Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems, with applications to the above examples.Computing and visualizing trajectories on the computer using software packages. Discrete dynamical systems. The logistic map as an example.

Unit 3: L:20

Introduction to Chaos and Fractals: Examples of 2-dimensional billiard, Projection of the trajectory on momentum space. Sinai Billiard and its variants. Computational visualization of trajectories in the Sinai Billiard. Randomization and ergodicity in the divergence of nearby

phase space trajectories, and dependence of time scale of divergence on the size of obstacle. Electron motion in mesoscopic conductors as a chaotic billiard problem. Other examples of chaotic systems; visualization of their trajectories on the computer.
Self similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure. Fractals in dynamics – Serpinski gasket and DLA. Chaos in nonlinear finite-difference equations- Logistic map: Dynamics from time series. Parameter dependence- steady, periodic and chaos states. Cobweb iteration. Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period- Doubling route to chaos.
Nonlinear time series analysis and chaos characterization: Detecting chaos from return map. Power spectrum, autocorrelation, Lyapunov exponent, correlation dimension.

Unit 4: L 14

Elementary Fluid Dynamics: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis- concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform & non-uniform flows, viscous & inviscid flows, incompressible & compressible flows, laminar and turbulent flows, rotational and irrotational flows,separated & unseparated flows. Flow visualization - streamlines, pathlines, Streaklines.

Course Outcomes:

At the end of this course students will demonstrate the ability to:
1. Understand the basic concepts of dynamical systems.
2. Identify and solve various dynamical problems in multidisciplinary field.
3. Understand chaos theory and the mathematics of fractals.
4. Understand basic principles of Fluid Dynamics

Reference Books

1. Nonlinear Dynamics and Chaos, S.H. Strogatz, Levant Books, Kolkata, 2007
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
4. Fluid Mechanics, 2nd Edition, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

PHYB6351	**Applied Dynamics Lab**	**0L:0T:4P**	**2 Credits**

LIST OF EXPERIMENTS:

Laboratory/Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.

4. To study population models e.g. exponential growth and decay, logistic growth, species competition, predator-prey dynamics, simple genetic circuits.
5. To study rate equations for chemical reactions e.g. auto catalysis, bistability.
6. To study examples from game theory.
7. Computational visualization of trajectories in the Sinai Billiard.
8. Computational visualization of trajectories Electron motion in mesoscopic conductors as a chaotic billiard problem.
9. Computational visualization of fractal formations of Deterministic fractal.
10. Computational visualization of fractal formations of self-similar fractal.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
12. Computational Flow visualization - streamlines, pathlines, Streaklines.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Apply coding of Scilab to solve complex dynamics problems
2. Use various softwares to formulate and solve dynamics problems.
3. Understand the coding and application of game theory
4. Program computational visualization of fractals.
5. Program to visualize trajectory of particles and fluid flows.

Reference Books

1. Nonlinear Dynamics and Chaos, Steven H. Strogatz, Levant Books, Kolkata, 2007
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. An Introduction to Fluid Dynamics, G.K.Batchelor, Cambridge Univ. Press, 2002
4. Fluid Mechanics, 2nd Edn, L.D.Landau & E.M. Lifshitz, Pergamon Press, Oxford, 1987
5. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN: 978-3319067896
6. Scilab by example: M. Affouf, 2012, ISBN: 978-1479203444
7. Scilab Image Processing: L.M.Surhone. 2010, Betascript Pub., ISBN: 978-6133459274

PHYB6310	**Nuclear and Particle Physics**	**5L:1T:0P**	**6 Credits**

Course Objective:

The objectives of this course are:

1. To provide the basic ideas of general properties of nuclei.
2. To impart the knowledge of nuclear models.
3. To impart the knowledge of nuclear radiation.
4. To make students learn about nuclear interaction with matters.
5. To impart the knowledge of particle physics and accelerators.

Detailed Syllabus

Unit 1: L:10

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

Unit 2: L: 12

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

Unit 3 : L : 18

Radioactivity decay and Nuclear Reactions:(a) Alpha decay: basics of α-decay processes, theory of α- emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) □-decay: energy, kinematics for □-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

Unit 4: L: 16

Interaction of Nuclear Radiation with matter, detectors: Energy loss due to ionization (Bethe- Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter, photoelectric effect, Compton scattering, pair production, neutron interaction with matter. Gas detectors: estimation of electric field, mobility of particle, for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.

Unit 5 : L: 19

Particle Physics and Accelerators: Particle interactions; basic features, types of particles and its families. Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, concept of quark model, color quantum number and gluons. Accelerator facility available in India: Van-de Graff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the structure of nuclei and their properties.
2. Understand various model of nuclei
3. Understand the process of radioactive nuclear decay and reaction of nuclei
4. Understand nuclear interaction with matter and detection of radioactivity.
5. Grow a concept of subatomic particles and accelerator technology.

Reference Books:

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

PHYB6320	Astronomy and Astrophysics	5L:1T:0P	6 Credits

Course Objective:

The objectives of this course are:

1. To convey the basic ideas of astronomical scales.
2. To impart the knowledge of astronomical techniques.
3. To impart the knowledge regarding the Sun and the Milky Way
4. To provide and understanding on the physical parameters of the galaxies and other large scale systems.

Detailed Syllabus

Unit 1: L:24

Astronomical Scales: Astronomical Distance, Mass and Time, Scales, Brightness, Radiant Flux and Luminosity, Measurement of Astronomical Quantities Astronomical Distances, Stellar Radii, Masses of Stars, Stellar Temperature. Basic concepts of positional astronomy:Celestial Sphere, Geometry of a Sphere, Spherical Triangle,Astronomical Coordinate Systems, Geographical Coordinate Systems, Horizon System, Equatorial System, Diurnal Motion of the Stars, Conversion of Coordinates. Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Calendar. Basic Parameters of Stars: Determination of Distance by Parallax Method; Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Determination of Temperature and Radius of a star; Determination of Masses from Binary orbits; Stellar Spectral Classification, Hertzsprung-Russell Diagram.

Unit 2 : L : 20

Astronomical techniques and the Sun: 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).Gravitation in Astrophysics (Virial Theorem, Newton versus Einstein), Systems in Thermodynamic Equilibrium. Solar Atmosphere, Chromosphere. Corona, Solar

Activity, Basics of Solar Magneto-hydrodynamics. Helioseismology). Solar System: Facts and Figures, Origin of the Solar System: The Nebular Model, Tidal Forces and Planetary Rings, Extra-Solar Planets.
Stellar spectra and classification Structure (Atomic Spectra Revisited, Stellar Spectra, Spectral Types and Their Temperature Dependence, Black Body Approximation, H R Diagram, Luminosity Classification)

Unit 3 : L : 14
The milky way: Basic Structure and Properties of the Milky Way, Nature of Rotation of the Milky Way (Differential Rotation of the Galaxy and Oort Constant, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Stars and Star Clusters of the Milky Way, Properties of and around the Galactic Nucleus.

Unit 4: L : 17
Galaxies and Large Scale Structures: Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms. Large scale structure & expanding universe:Cosmic Distance Ladder (An Example from Terrestrial Physics, Distance Measurement using Cepheid Variables), Hubble's Law (Distance- Velocity Relation), Clusters of Galaxies (Virial theorem and Dark Matter).

Course Outcomes:
At the end of this course students will demonstrate the ability to:
1. Understand the concept of astronomical scale and measurements.
2. Understand the experimental and mathematical techniques in astronomy and astrophysics.
3. Understand the structure and properties of the Milky Way.
4. Understand the nature and composition of large scale structures.

Reference Books:

1. Modern Astrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
2. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
3. The physical universe: An introduction to astronomy, F.Shu, Mill Valley: University Science Books.
4. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
5. K.S. Krishnasamy, 'Astro Physics a modern perspective,' Reprint, New Age International (p) Ltd, New Delhi,2002.
6. Baidyanath Basu, 'An introduction to Astro physics', Second printing, Prentice -
7. Hall of India Private limited, New Delhi,2001.
8. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.

PHYB6340	Atmospheric Physics	4L:0T:0P	4 Credits

Course Objective:

The objectives of this course are:

1. To provide a basic understanding of the features of the Earth's atmosphere.
2. To impart the knowledge of atmospheric dynamics.
3. To convey the knowledge of atmospheric waves.
4. To impart the knowledge of atmospheric radars and lidars.

Detailed Syllabus

Unit 1: L: 12

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations, including RS/RW, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms.

Unit 2 : L : 12

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi- annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.

Unit 3: L : 12

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration.

Unit 4 : L: 12

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.

Unit 5 :L : 12

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand general feature of the Earth's atmosphere.

2. Understand the forces acting on the atmospheric layers and its corresponding dynamics.
3. Understand the nature of atmospheric waves.
4. Interpret the readings of atmospheric radars and Lidars.
5. Understand the formation and impact of atmospheric aerosols.

Reference Books:

1. Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press;3rd edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

PHYB6341	Atmospheric Physics Lab	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

Scilab/C^{++} based simulations experiments based on Atmospheric Physics problems like

1. Numerical Simulation for atmospheric waves using dispersion relations
(a) Atmospheric gravity waves (AGW)
(b) Kelvin waves
(c) Rossby waves, and mountain waves

2. Offline and online processing of radar data
(a) VHF radar,
(b) X-band radar, and
(c) UHF radar

3. Offline and online processing of LIDAR data

4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.

5. Handling of satellite data and plotting of atmospheric parameters using radio occultation technique

6. Time series analysis of temperature using long term data over metropolitan cities in India – an approach to understand the climate change

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Use the knowledge of C++ / SciLab programming to simulate various problems related to atmospheric phenomena.
2. Simulate various atmospheric waves.
3. Interpret and process radar and LIDAR data.
4. Process satellite data and visualize atmospheric parameters
5. Process time-dependent atmospheric data to predict climate and climate change.

Reference Books:

1. Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – J.T. Houghton; Cambridge Univ. Press; 3^{rd} edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

PHYB6360	Nanomaterials and Applications	4L:0T:0P	4 Credits

Course Objective:

The objectives of this course are:

1. To provide basic understanding of nanoscale systems.
2. To impart the knowledge of synthesis of nanostructure materials.
3. To impart the knowledge of optical properties.
4. To impart the knowledge of electron transport and application of nanoparticles.

Detailed Syllabus

Unit 1: L: 10

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

Unit 2 : L : 16

Synthesis And Characterization 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.X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy.

Unit 3: L : 14

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 heterostrctures and nanostructures.

Unit 4 : L : 8

Electron Transport: Carrier transport in nanostrcutures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects.

Unit 5: L : 12

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

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the unique properties of nanoscale materials.
2. Understand various techniques of synthesis and characterization of nanoscale systems.
3. Understand optical properties of functional nanomaterials.
4. Understand the mechanism of electron transport in nanoscale systems.
5. Have a sound idea on the application of these materials.

Reference books:

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

PHYB6361	Nanomaterials and Applications	0L:0T:4P	2 Credits

LIST OF EXPERIMENTS:

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. XRD pattern of nanomaterials and estimation of particle size.
4. To study the effect of size on color of nanomaterials.
5. To study temperature-dependency of electrical conductivity of metal nanoparticles.
6. To study magnetic susceptibility of nanoparticles using Gouy's method.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Synthesize metal nanoparticles using chemical route.
2. Interpret XRD patterns to estimate nanoparticle size.
3. Understand the role of size on the colour of the nanoparticles.
4. Understand the methods to measure the effect of electric and magnetic fields on nanoparticles.

Reference Books:

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

PHYB6370	Physics of the Earth	5L:1T:0P	6 Credits

Course Objective:

The objectives of this course are:

1. To impart the knowledge regarding the origin of the Earth and the Universe.
2. To impart the knowledge of the structure of the Earth.
3. To impart the knowledge of the dynamical processes within the Earth.
4. To impart the knowledge of evolution.
5. To convey the ideas of disturbing the earth systems and climate change.

Detailed Syllabus

Unit 1: L: 17

The Earth and the Universe: Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences.General characteristics and origin of the Universe. The Milky Way galaxy, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Meteorites & Asteroids. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.Energy and particle fluxes incident on the Earth.The Cosmic Microwave Background.

Unit 2 : L : 18

Structure: The Solid Earth: Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior? The Hydrosphere: The oceans, their extent, depth, volume, chemical composition. River systems.The Atmosphere: variation of temperature, density and composition with altitude, clouds.The Cryosphere: Polar caps and ice sheets. Mountain glaciers.The Biosphere: Plants and animals. Chemical composition, mass. Marine and land organisms.

Unit 3 : L : 18

Dynamical Processes:The Solid Earth: Origin of the magnetic field. Source of geothermal energy. Convection in Earth's core and production of its magnetic field. Mechanical layering of the Earth. Introduction to geophysical methods of earth investigations. Concept of plate tectonics; sea-floor spreading and continental drift. Geodynamic elements of Earth: Mid Oceanic Ridges, trenches, transform faults and island arcs. Origin of oceans, continents, mountains and rift valleys. Earthquake and earthquake belts. Volcanoes: types products and distribution.The Hydrosphere: Ocean circulations. Oceanic current system and effect of coriolis forces. Concepts of eustasy, tend – air-sea interaction; wave erosion and beach processes. Tides. Tsunamis.The Atmosphere: Atmospheric circulation. Weather and climatic changes. Earth's heat budget. Cyclones.Climate.

Unit 4: L : 18

Evolution: Nature of stratigraphic records, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Introduction to geochronological methods in their application in geological studies. History of development in concepts of uniformitarianism, catastrophism and neptunism. Law of superposition and faunal succession. Introduction to the geology and geomorphology of Indian subcontinent.

Unit 5 : L : 4

Disturbing the Earth – Contemporary dilemmas: Human population growth, Atmosphere: Green house gas emissions, climate change, air pollution, Hydrosphere: Fresh water depletion.Geosphere: Chemical effluents, nuclear waste.Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the origin of the earth and the universe.
2. Understand the structure of the earth.
3. Understand various dynamical processes in different layers of the earth;s spheres.
4. Understand the process of evolution of life form on the earth.
5. Understand the impact of modern industries and climate change,

Reference Books:

1. Planetary Surface Processes, H. Jay Melosh, Cambridge University Press, 2011.
2. Consider a Spherical Cow: A course in environmental problem solving, John Harte. University Science Books
3. Holme's Principles of Physical Geology. 1992. Chapman & Hall.
4. Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

PHYB6380	Biophysics	5L:1T:0P	6 Credits

Course Objective:

The objectives of this course are:

1. To provide the overview of the scope and prospects of biophysics.
2. To impart the knowledge of organic molecules and their properties related to life.
3. To convey the ideas related to the complexity of life.
4. To impart the knowledge of evolution.

Detailed Syllabus

Unit 1: L: 9

Overview:

The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Universality of microscopic processes and diversity of macroscopic form. Types of cells. Multicellularity. Allometric scaling laws.

Unit 2: L : 22

Molecules of life:

Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling.Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell.Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways. Random walks and applications to biology. Mathematical models to be studied analytically and computationally.

Unit 3 : L : 30

The complexity of life: (30 lectures)

At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Complex networks of molecular interactions: metabolic, regulatory and signaling networks. Dynamics of metabolic networks; the stoichiometric matrix. Living systems as complex organizations; systems biology. Models of cellular dynamics. The implausibility of life based on a simplified probability estimate, and the origin of life problem.At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cell types as distinct attractors of a dynamical system. Stem cells and cellular differentiation. Pattern formation and development.

Brain structure: neurons and neural networks. Brain as an information processing system. Associative memory models. Memories as attractors of the neural network dynamics.At the level of an ecosystem and the biosphere: Foodwebs: Feedback cycles and self- sustaining ecosystems.

Unit 4 : L : 14

Evolution: (14 lectures)

The mechanism of evolution: variation at the molecular level, selection at the level of the organism. Models of evolution. The concept of genotype-phenotype map. Examples.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the basic functions of the organic life and the physics of exchange of matter and energy between the organic body and the environment.
2. Indentify the complex chemical compounds related to organic life.
3. Understand the physics of the organic body and its complexity.
4. Understand the process of evolution and various models of it.

Reference books

1. Physics in Molecular Biology; Kim Sneppen & Giovanni Zocchi (CUP 2005)

2. Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman & Co, NY, 2004)
3. Physical Biology of the Cell (2nd Edition), Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013)
4. An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013)
5. Evolution; M. Ridley (Blackwell Publishers, 2009, 3rd edition)

List of Skill Enhancement Course (any Two, 1 in each Sem III & Sem IV) (Credit: 02 each)

Semester	Course Code	Course Name	(L-T-P)	Credits
III	PHYB3211	Physics Workshop Skills	1-0-2	2
III	PHYB3221	Computational Physics Skills	1-0-2	2
III	PHYB3231	Electrical circuits and Network Skills	1-0-2	2
IV	PHYB4211	Renewable Energy and Energy harvesting	1-0-2	2
IV	PHYB4220	Radiation Safety	2-0-0	2
IV	PHYB4230	Weather Forecasting	2-0-0	2

PHYB3211	Physics Workshop Skill	1L:0T:2P	2 Credits

Course Objective:

The objectives of this course are:

1. To impart the knowledge of measurement techniques.
2. To provide the students with proper mechanical skill and good practices.
3. To provide the students with electrical and electronics skill.
4. To impart the knowledge of mover instruments.

Detailed Syllabus

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: L:4

Introduction: Measuring units. conversion to SI and CGS. Familiarization with meter scale, Vernier callipers, 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, etc.

Unit 2 : L: 10

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 and alloy, wood. 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. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.

Unit 3: L : 10

Electrical and Electronic Skill: Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay. (10 Lectures)

Unit 4 : L : 6

Introduction to prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment. (6 Lectures)

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Exhibit a good concept of measurement and instruments
2. Exhibit a sound understanding of mechanical workshop tools and their usage.
3. Understand usage of electronic measurement instrument.
4. Understand the mechanism of mover machines.

Reference Books:

1. A text book in Electrical Technology - B L Theraja – S. Chand and Company.
2. Performance and design of AC machines – M.G. Say, ELBS Edn.
3. Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
4. Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732]
5. New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN: 0861674480]

PHYB3221	**Computational Physics**	**1L:0T:2P**	**2 Credits**

Course Objective:

The objectives of this course are:

1. To provide the basic idea of computer programming.
2. To impart the knowledge of algorithm and flowcharts.
3. To convey skills of scientific programming.
4. To impart the knowledge of control statements.
5. To impart the knowledge of scientific editing.

Detailed Syllabus:

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

- *Highlights the use of computational methods to solve physical problems*
- *Use of computer language as a tool in solving physics problems (applications)*
- *Course will consist of hands on training on the Problem solving on Computers.*

Unit 1 : L : 4

Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution**.** Usage of linux as an Editor. Algorithms and Flowcharts**:** Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

Unit 2 : L :5

Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problem.

Unit 3 : L : 6

Control Statements and programming: Types of Logic (Sequential, Selection, Repetition), Branching Statements (Logical **IF**, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO-CONTINUE, DO-ENDDO, DO- WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

Programming:

1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x=1

Unit 4 : L : 6

Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. **Equation representation:** Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

Visualization: Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

Unit 5 : L : 9

Hands on exercises:

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the formulation and solving of numerical problems with programming.
2. Understand the methods and tools of scientific programming.
3. Exhibit knowledge of control statements and logic-based programming.
4. Edit, plot and visualize to represent data and prepare scientific documentation.

Reference Books:

1. Introduction to Numerical Analysis, S.S. Sastry, 5^{th} Edn., 2012, PHI Learning Pvt. Ltd.
2. Computer Programming in Fortran 77”. V. Rajaraman (Publisher: PHI).

3. LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley, 1994).
4. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
5. Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill Book Co.
6. Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi(1999)
7. A first course in Numerical Methods, U.M. Ascher and C. Greif, 2012, PHI Learning
8. Elementary Numerical Analysis, K.E. Atkinson, 3[rd] Edn . , 2 007, Wiley India Edition.

PHYB3231	**Electrical Circuits and Network skills**	**1L:0T:2P**	**2 Credits**

Course Objective:

1. To impart the knowledge of general electrical circuits.
2. To impart the knowledge of generator, transformer and motors.
3. To convey the basics of electrical protection and wiring.

Detailed Syllabus:

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: L : 11

Electrical Circuits: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC Electricity and DC Electricity. Familiarization with multimeter, voltmeter and ammeter. Circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

Unit 2: L : 7

Generator, transformers and motors: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

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

Unit 3 : L : 3

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

Unit 4: L : 9

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

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

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Design various electrical circuit and obtain desired function.
2. Understand the working mechanism of transformers, generators and motors.
3. Understand and utilize solid state devices.
4. Obtain proper precautionary measure regarding electrical wirings.

Reference Books:

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

PHYB4211	Renewable Energy and Energy Harvesting	0L:0T:2P	2 Credits

Course Objective:

1. To impart the knowledge of fossil fuels and alternate energy.
2. To impart the knowledge of solar, wind and ocean energy harvesting.
3. To impart the knowledge of harvesting hydro and geothermal energy.

Detailed Syllabus:

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: L : 3

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, 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, Hydroelectricity.Environmental issues and Renewable sources of energy, sustainability.

Unit 2: L : 8

Solar and energy harvesting: Solar energy, its importance, 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, absorption air conditioning. Need and characteristics of photovoltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

Unit 3: L : 8

Ocean and Geothermal Energy Harvesting

Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass. Geothermal Resources, Geothermal Technologies. Hydropower resources, hydropower technologies, environmental impact of hydro power sources.

Unit 4 : L :5

Piezoelectric and Electromagnetic Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezoelectricity,

Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power. Linear generators, physics mathematical models, recent applications.

Unit 5 : L : 6

Demonstrations and Experiments

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage using thermoelectric modules.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the needs to replace fossil fuel and its limitations.
2. Understand the principles of solar energy harvesting.
3. Exhibit good knowledge on harvesting of wind, hydro, ocean and geothermal energy.
4. Understand harvesting of piezoelectric and electromagnetic energy efficiently.

Reference Books:

1. Non-conventional energy sources - G.D Rai - Khanna Publishers, New Delhi
2. Solar energy - M P Agarwal - S Chand and Co. Ltd.
3. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
4. Godfrey Boyle, "Renewable Energy, Power for a sustainable future", 2004, Oxford University Press, in association with The Open University.
5. Dr. P Jayakumar, Solar Energy: Resource Assesment Handbook, 2009
6. J.Balfour, M.Shaw and S. Jarosek, Photovoltaics, Lawrence J Goodrich (USA).

PHYB4220	**Technical drawing**	**2L:0T:0P**	**2 Credits**

Course Objective:

1. To familiarize students with drafting techniques and instruments.
2. To impart the skills of projections of objects.
3. To impart the knowledge of CAD drawing and programming.

Unit 1: L : 6

Introduction: Drafting Instruments and their uses. lettering: construction and uses of various scales: dimensioning as per I.S.I. 696-1972. Engineering Curves: Parabola: hyperbola: ellipse: cycloids, involute: spiral: helix and loci of points of simple moving mechanism.2D geometrical construction. Representation of 3D objects. Principles of projections.

Unit 2: L : 8

Projections: Straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids.Orthographic projection. Interpenetration and intersection of solids. Isometric and oblique parallel projection of solids.

Unit 3 : L : 16

CAD Drawing: Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD- specific skills (graphical user interface. Create, retrieve, edit, and use symbol libraries. Use inquiry commands to extractdrawing data). Control entity properties. Demonstrating basic skills to produce 2-D and 3-Ddrawings. 3D modeling with Auto CAD (surfaces and solids), 3D modeling with sketch up, annotating in Auto CAD with text and hatching, layers, templates & design center, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. basic printing, editing tools, Plot/Print drawing to appropriate scale.

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Draft basic designs.
2. Understand create projection of objects.
3. Create basic drawings with CAD.

Reference Books:

1. K. Venugopal, and V. Raja Prabhu. Engineering Graphic, New Age International
2. AutoCAD 2014 & AutoCAD 2014/Donnie Gladfelter/Sybex/ISBN:978-1-118-57510-9
3. Architectural Design with Sketchup/Alexander Schreyer/John Wiley & Sons/ISBN: 978-1-118-12309-6

PHYB4230	Radiation Safety	2L:0T:0P	2 Credits

Course Objective:

1. To make students learn the basics of atomic and nuclear physics.
2. To impart the knowledge of interaction of radiation with matter.
3. To impart the knowledge of radiation detection.
4. To make students aware of radiation safety management and training.

Detailed Syllabus

The aim of this course is for awareness and understanding regarding radiation hazards and safety. The list of laboratory skills and experiments listed below the course are to be done in continuation of the topics

Unit 1: L : 6

Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.

Unit 2: L : 7

Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, **Interaction of Photons** - Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, **Interaction of Charged Particles:** Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channeling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), **Interaction of Neutrons**- Collision, slowing down and Moderation.

Unit 3: L : 7

Radiation detection and monitoring devices: Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Basic concept and working principle of *gas detectors* (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Gieger Muller Counter), *Scintillation Detectors* **(**Inorganic and Organic Scintillators), *Solid States Detectors* and *Neutron Detectors, Thermo luminescent Dosimetry*.

Unit 4: L : 5

Radiation safety management: *Biological effects of ionizing radiation*, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitation, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.

Unit 5: L: 5

Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. *Industrial Uses:* Tracing, Gauging, Material Modification, Sterization, Food preservation.

Experiments:

Characteristics of Geiger Muller (GM) Counter:

1) Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
2) Study of counting statistics using background radiation using GM counter.
3) Study of radiation in various materials (e.g. KSO4 etc.). Investigation of possible radiation in different routine materials by operating GM at operating voltage.
4) Study of absorption of beta particles in Aluminum using GM counter.
5) Detection of α particles using reference source & determining its half life using spark counter
6) Gamma spectrum of Gas Light mantle (Source of Thorium)

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the basics of atomic and nuclear physics.
2. Understand the interaction of radiation with matter and radiation damage.
3. Understand the working principles of radiation detecting instruments.
4. Exhibit awareness of radiation safety management.

Reference Books:

1. W.E. Burcham and M. Jobes – Nuclear and Particle Physics – Longman (1995)
2. G.F.Knoll, Radiation detection and measurements
3. Thermoluninescense Dosimetry, Mcknlay, A.F., Bristol, Adam Hilger (Medical Physics Handbook 5)
4. W.J. Meredith and J.B. Massey, "Fundamental Physics of Radiology". John Wright and Sons, UK, 1989.
5. J.R. Greening, "Fundamentals of Radiation Dosimetry", Medical Physics Hand Book Series, No.6, Adam Hilger Ltd., Bristol 1981.
6. Practical Applications of Radioactivity and Nuclear Radiations, G.C. Lowental and P.L. Airey, Cambridge University Press, U.K., 2001
7. A. Martin and S.A. Harbisor, An Introduction to Radiation Protection, John Willey & Sons, Inc. New York, 1981.
8. NCRP, ICRP, ICRU, IAEA, AERB Publications.
9. W.R. Hendee, "Medical Radiation Physics", Year Book – Medical Publishers Inc. London, 1981

PHYB4240	Weather Forecasting	2L:0T:0P	2 Credits

Course Objective:

1. To make students learn about the atmosphere and atmospheric parameters.
2. To make students aware of the measurement and processing techniques of atmospheric parameters.

3. To impart the knowledge of data processing and weather forecasting.
4. To make students aware of issues related to climate change.

The aim of this course is not just to impart theoretical knowledge to the students but to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomenon and basic forecasting techniques

Detailed syllabus

Unit 1 : L : 9

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement; cyclones and anticyclones: its characteristics.

Unit 2 : L : 7

Measuring the weather and special systems: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

Unit 3: L : 6

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution; aerosols, ozone depletion, acid rain, environmental issues related to climate.

Unit 4 : L : 8

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

Demonstrations and Experiments:

1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:

(a) To calculate the sunniest time of the year.
(b) To study the variation of rainfall amount and intensity by wind direction.
(c) To observe the sunniest/driest day of the week.
(d) To examine the maximum and minimum temperature throughout the year.
(e) To evaluate the relative humidity of the day.

(f) To examine the rainfall amount month wise.

3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.

4. Formats and elements in different types of weather forecasts/ warning (both aviation and non aviation)

Course Outcomes:

At the end of this course students will demonstrate the ability to:

1. Understand the nature of the atmosphere and the parameters to predict it.
2. Understand the measurement techniques of atmospheric data.
3. Comprehend and analyze atmospheric data, leading to climate change.
4. Understand the construction of climate and climate change.
5. Predict weather patterns based on historical data.

Reference books:

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books

2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.

3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.

4. Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.

5. Why the weather, Charls Franklin Brooks, 1924, Chpraman & Hall, London.

6. Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

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