RAJENDRA UNIVERSITY, BALANGIR, ODISHA

Model Curriculum for Three/Four-Year Degree Course

(With Multiple Entry /Exit Options)

Based on NEP-2020

(Effective from the Academic Sessions 2024-25)

Physics Syllabus

Odisha State Higher Education Council, Bhubaneswar
Government of Odisha

Contents

Course Structure of UG (Major Physics)

Three Year Degree Course with Single Major and Two Minors

Semester	Course to Opt	Course Name	Credit	Total Credit
I	Core-I	1-Mathematical Physics-1	3+1	22
		2-Mechanics	3+1	
	Core-II	Choose from Basket	4	
	MDC	Choose from Basket	3	
	AEC	Odia/Hindi/Sanskrit	4	
	VAC	Environmental studies & Disaster Management	3	
II	Core-I	3-Electricity & Magnetism	3+1	22
		4-Mathematical Physics -2	3+1	
	Core-III	Choose from Basket	4	
	MDC	Choose from Basket	3	
	AEC	English	4	
	SEC	Analytical Thinking and logical reasoning	3	

Semester	Course to Opt	Course Name	Credit	Total Credit
III	Core-I	5- Wave & Optics	3+1	22
		6- Mathematical Physics -3	3+1	
		7- Thermal Physics	3+1	
	Core-II	(As in Semester-I)	4	
	MDC	Choose from Basket	3	
	VAC	Indian Constitution/ Entrepreneurship and Start up	3	
IV	Core-I	8-Analog Systems	3+1	20
		9-Basic Instrumentations	3+1	
		10- Nuclear & Particle Physics	3+1	
	Core-III	(As in Semester-II)	4	
	Community engagement/ Internships	Internship Program or field work on community arts & Culture	4	

Semester	Course to Opt	Course Name	Credit	Total Credit
V	Core-I	11-Digital Systems	3+1	22
		12-Quantum Mechanics	3+1	
		13-Solid State Physics	3+1	
	Core-II	(As in Semester-I)	4	
	SEC	Introduction to statistics and data analysis / Personality Development	3	
	VAC	Research Methodology/ Intellectual Property Rights (IPR)/ Ethics and Values	3	
VI	Core-I	14-E.M. Theory	3+1	18
		15-Statistical Physics	3+1	
	Core-III	(As in Semester-II)	4	
	SEC	Computer Application/ ଗଣ ମାଧ୍ୟମ ଓ ଗଣ ଯୋଗାଯୋଗ / Election Studies and Public Opinion Poll	3	
	VAC	ଓଡ଼ିଶାର ସାଂସ୍କୃତିକ ପରିଚୟ / Creative writing	3	

Four Year Degree Course with Physics Major and Without Research

Semester	Course to Opt	Course Name	Credit	Total Credit
VII	Core-I	16-Mathematical methods in Physics	4	20
		17-Classical Mechanics	4	
		18- Q. M. -I	4	
		19-Computational Physics	4	
	Core-II	(As in Semester.-I)	4	
VIII	Core-I	20-Classical Electrodynamics	4	20
		21- Q. M. -II	4	
		22- Electronics	4	
		23-Optics & Modern Physics Lab	4	
	Core-II	(As in Semester.-I)	4	

- **Physics department offers the following papers as Core-II (Minor-I)**

  Paper-I: (1st Semester) 2-Mechanics
  Paper-II: (3rd Semester) 3-Electricity & Magnetism
  Paper-III: (5th Semester) 7-Thermal Physics
  Paper-IV: (7thSemester) 17-Classical Mechanics
  Paper-V: (8th Semester) 18-Quantum Mechanics-I

- **Students having Physics as Core-I (Major) may take the following subjects as**

  Core –II (Minor-I) and Core-III (Minor-II)

Core-II (Minor-I): Sanskrit, History, English, Economics, Philosophy, Home Science, Anthropology, Computer Science, Statistics, Chemistry (for physics & Botany Core-I students), Botany, Physics, Political Science (For affiliated colleges only), Education (For affiliated colleges only)

Core-III (Minor-II): Odia, Hindi, Geography, Psychology, Sociology, Political Science, Education, Mathematics, Zoology, Chemistry (For Mathematics, Computer Sc. & Zoology Core –I students)

For Multi-disciplinary courses (MDC): In 1st, 2nd and 3rd Semester, student can choose one subject from the basket of subjects provided.

Sl No	Semester	Department	Course Details
1	I	Odia	Tulanatmak Sahitya
		Political Science	Political Process in India
		Education	Historical bases of Indian Education
		Commerce	Organizational Behaviour
		Chemistry	Environmental Chemistry
2	II	English	Academic Writing
		Economics	Elements of Economics
		Philosophy	Philosophy of Bhagvad Gita
		Botany	Bio Fertilizers & Bio Pesticides
		Computer Science	Computer Fundamentals
		Statistics	Operation Research
3	III	Hindi	Hindi Sahitya Aur Cinema
		History	History of Education in Modern India
		Geography	Environmental Impact Assessment and Environmental Management Plant (EIV & EMP)
		Physics	Physics
		Zoology	Vermi-technology
		Sanskrit	Vedic Culture

N.B. The syllabus of Multidisciplinary Course "Physics" floated by Department of Physics is given in Page No. 57.

Ability Enhancement Course: (Odia/Hindi/Sanskrit and English are the compulsory courses under Semester-I/II respectively with 4 Credits each)

Skill Enhancement Courses(SEC): In 2nd , 5th and 6th semester, student can choose one subject from the basket of subjects provided.

Sl. No.	Semester	Course Details
1	2nd	Analytical Thinking and logical reasoning
2	5th	Introduction to statistics and data analysis/Personality development
3	6th	Computer Application/ ଗଣ ମାଧ୍ୟମ ଓ ଗଣ ଯୋଗାଯୋଗ / Election Studies and Public Opinion Poll

Value Added Courses (VAC): In 1st, 3rd , 5th and 6th semester, student can choose one subject from the basket of subjects provided.

Sl No	Semester	Course Details
1	1st	Environmental studies & Disaster Management
2	3rd	Indian constitution/ Entrepreneurship and start-up
3	5th	Research Methodology/ Intellectual Property Rights/ Ethics & Values
4	6th	ଓଡ଼ିଶାର ସାଂସ୍କୃତିକ ପରିଚୟ /Creative writing

PAPER-1 **MATHEMATICAL PHYSICS-I: Credit-3**

Course Objective:

The main emphasis of this course is to equip the student with calculus and vector algebra. Vector differentiation & integration, as well as the applications of Gauss, Green and Stokes theorems. They will learn the properties and use of Dirac delta function. They will be familiar with representation of vector operations in different co-ordinate systems. More over they will be able to write programming so solve a problem and can estimate the error.

Learning Outcomes:

After completing the course the student will be able to

- Apply calculus concepts, such as Taylor and binomial series and differential equations, to solve complex mathematical and physical problems
- Perform vector algebra operations and interpret scalar and vector products in terms of areas, volumes, and other physical applications
- Compute gradient, divergence, and curl of scalar and vector fields, and understand their significance in various geometrical and physical contexts and can do vector integration.
- Understand orthogonal curvilinear coordinates and its application in different areas..
- Understand the basic algorithm and application to functional algebra and error analysis.

UNIT-I

Calculus-I: Plotting of functions, Intuitive ideas of continuous, differentiable functions and plotting of curves, Approximation: Taylor and binomial series(statements only), First Order Differential Equations and Integrating Factor, Second Order Differential equations: Homogeneous Equations with constant coefficients, Wronskian and general solution, Statement of existence and Uniqueness Theorem for Initial Value Problems, Particular Integral.

Calculus-II: 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-II

Vector algebra: 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-III

Vector Integration: Ordinary Integrals of Vectors, Multiple integrals, Jacobian, Notion of infitesimal 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)

Dirac Delta function and its properties: Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function, Properties of Dirac delta function.

UNIT-IV

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates, Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems, Comparison of velocity and acceleration in cylindrical and spherical coordinate system.

Books Recommended:

- ✓ *Mathematical Methods for Physicists, G.B. Argken, H.J. Weber, F.E. Harris (2013, 7th Edn., Elsevier)*
- ✓ *Advanced Engineering Mathematics, Erwin Kreyszig (WileyIndia)*

Books for Reference:

- ✓ *Mathematical Physics C.Harper (Prentice Hall India)*
- ✓ *Complex Variable: Schaum's Outlines Series M.Spiegel(2ndEdition,Mc-Graw Hill Education)*
- ✓ *Complex variables and applications, J.W.Brown and R.V.Churchill*
- ✓ *Mathematical Physics, Satya Prakash (Sultan Chand)*
- ✓ *Mathematical Physics, B.D. Gupta(4th edition,VikasPublication)*
- ✓ *Mathematical Physics and Special Relativity, M.Das, P.K.Jena and B.K.Dash (Srikrishna Prakashan)*
- ✓ *Mathematical Physics–H.K.Das, Dr.Rama Verma (S.Chand Publishing)*
- ✓ *Mathematical Physics, B.S.Rajput,(Pragati Prakashana)*

PAPER-1 LAB: Credit-1

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

- Highlights the use of computational methods to solve physical problems.
- Evaluation done not on the programming but on the basis of formulating the problem.
- Aim at teaching students to construct the computational problem to be solved.
- Students can use any one operating system Linux or Microsoft Windows.

Introduction and Overview: Computer architecture and organization, memory and Input/output devices. Basics of scientific computing: Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow and overflow emphasize the importance of making equations in terms of dimensionless variables, Iterative methods. Algorithm Errors and error Analysis: Truncation and roundoff errors, Absolute and relative errors, Floating point computations. Systematic and Random Errors, Propagation of Errors, Normal Law of Errors, Standard and Probable Error.

Review of C and C++ Programming: Introduction to Programming, constants, Variables and Fundamentals data types, operators and Expressions, I/O statements, scanf and printf, cin and cout, Manipulators for data format-ting, Control statements (decision making and looping statements) (If Statement, Ifelse Statement, Nested If structure, ElseIf Statement, Ternary operator, Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays(1D and 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects.

Programs: Sum and average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search.

Random number generation: Area of circle, area of square, volume of sphere, value of π.

Books Recommended:

- ✓ *Introduction to Numerical Analysis, S.S.Sastry, 5thEdn.,2012,PHILearning Pvt.Ltd.*
- ✓ *Schaum's Outline of Programming with C++. J.Hubbard,2000,McGraw–HillPub.*
- ✓ *Numerical Recipes in C: The Art of Scientific Computing, W.H.Pressetal, 3rdEdn.2007, Cambridge University Press.*

Books for Reference:

- ✓ *A first course in Numerical Methods, U.M.Ascher and C.Greif,2012, PHILearning.*
- ✓ *Elementary Numerical Analysis, K.E.Atkinson, 3rdEdn.,2007, Wiley India Edition.*
- ✓ *Numerical Methods for Scientists and Engineers, R.W.Hamming,1973, Courier DoverPub.*
- ✓ *An Introduction to computational Physics, T.Pang,2ndEdn.,2006, Cam- bridge Univ.Press*

PAPER- 2 MECHANICS: Credit-3

Course Objective:

This course aims to provide students with a comprehensive understanding of classical mechanics and special relativity, focusing on the fundamental concepts of rotational dynamics, oscillations, elasticity, fluid motion, gravitation, central force motion, relativistic mechanics and Doppler effect. They will get insights into non-inertial systems, the behavior of bodies under the influence of forces, and the implications of relativistic effects. Students will develop problem-solving skills to analyze and interpret physical situations through mathematical formulations and physical laws.

Learning Outcomes:

After completing the course the student will be able to

- Comprehend the rotational dynamics, including angular momentum, moment of inertia and kinetic energy of rotation, and can apply systems having both translation and rotation.

- Understand the behavior of oscillatory systems, including damped and forced oscillations, and analyze resonance phenomena, power dissipation and quality
- Describe the concepts of elasticity and fluid motion, and solve problems involving torque, bending of beams, viscosity, and surface tension in liquids.
- Analyze gravitational forces and central force motion, solve two-body problems and apply Kepler's laws to planetary motion and satellite dynamics.
- Grasp the postulates of special theory of relativity, meaning of Lorentz transformations and understand mass-energy equivalence and the relativistic Doppler effect.

UNIT-I

Rotational Dynamics: Centre of Mass, Motion of CoM, Centre of Mass and Laboratory frames, Angular momentum of a particle and system of particles, Principle of conservation of angular momentum, Rotation about a fixed axis, Moment of Inertia, Perpendicular and Parallel Axis Theorems, Routh Rule, Calculation of moment of inertia for cylindrical and spherical bodies, Kinetic energy of rotation, Euler's Equations of Rigid Body motion, Motion involving both translation and rotation. Moment of Inertia of a Flywheel.

Non-Inertial Systems: Non-inertial frames and fictitious forces, uniformly rotating frame, Laws of Physics in rotating coordinate systems, Centrifugal force, Coriolis force.

UNIT-II

Oscillations: Damped oscillation. Equation of motion and solution(cases of oscillatory, critically damped and over damped) Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor, Bar Pendulum, Kater's Pendulum

Elasticity: Relation between Elastic constants, Twisting torque on a Cylinder or Wire, Bending of beams, External bending moment, Flexural rigidity, Single and double cantilever

Fluid Motion: Kinematics of Moving Fluids: Poiseuilles Equation for Flow of a Liquid through a Capillary Tube, Surface tension, Gravity waves and ripple

Viscosity: Poiseuille's Equation for Flow of a Liquid with corrections.

UNIT-III

Gravitation and Central Force Motion: Law of gravitation, Gravitational potential energy, Inertial and gravitational mass, Potential and field due to spherical shell and solid sphere, Motion of a particle under a central force field, Two-body problem and its reduction to one-body problem and its solution, Differential Equation of motion with central force and its solution, The first Integrals (two), Concept of power Law Potentials, Kepler's Laws of Planetary motion, Satellites. Geosynchronous orbits, Weightlessness, Basic idea of global positioning system (GPS).

UNIT-IV

Special Theory of Relativity: Michelson-Morley Experiment and its out-come, 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.

Books Recommended:

- ✓ *Mechanics, D.S.Mathur (S.Chand Publishing)*
- ✓ *Introduction to Special Relativity, R.Resnick (John Wiley)*

Books for Reference:

- ✓ *Introduction to Mechanics Daniel Klapnner and Robert Kolenkow, McgrawHill.*
- ✓ *Mechanics by K.R. Simon*
- ✓ *Mechanics, Berkeley Physics,vol.1,C.Kittel,W.Knight,etal(TataMcGraw-Hill)*
- ✓ *Physics, Resnick, Halliday and Walker(8/e.2008,Wiley)*
- ✓ *Theoretical Mechanics-M.R. Spiegel(Tata McGrawHill).*
- ✓ *Feynman Lectures, Vol.I, R.P.Feynman, R.B.Leighton, M.Sands(Pearson)*
- ✓ *Mechanics-M.Das, P.K.Jena and R.N.Mishra (Srikrishna Publications)*
- ✓ *Classical Mechanics, Gupta Kumar & Sharama,(Pragati Prakashan)*
- ✓ *Classical Mechanics, J.C. Upadhyaya,(Himalaya Publishing Home)*

PAPER-2 LAB: Credit-1

(Minimum 4 experiments are to be done):

1. To study surface tension by capillary rise method.
2. To determine the height of a building using a Sextant.
3. To study the Motion of Spring and calculate (a)Spring constant,(b)g and (c)Modulus of rigidity.
4. To determine the Moment of Inertia of a Flywheel.
5. To determine Coefficient of Viscosity of water by Capillary Flow Method(Poiseuilles method).
6. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
7. To determine the value of g using Bar Pendulum.
8. To determine the value of g using Kater's Pendulum.

Books for Reference:

- ✓ *Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971,Asia Publishing House.*
- ✓ *Advanced level Physics Practical's, Michael Nelson and JonM.Ogborn,4thEdition, reprinted1985, Heinemann Educational Publishers.*
- ✓ *A text book of Practical Physics, J. Prakash and Ramakrishna,11thEdn,2011,KitabMahal.*

PAPER-3 ELECTRICITY AND MAGNETISM : Credit-3

Course Objective:

The course aims to equip students with a thorough understanding of electrostatics, magnetism, dielectrics and electrical circuits. By studying electric and magnetic fields, the behavior of materials under the influence of electric and magnetic forces, and the principles governing AC and DC circuits, students. The way to simplify a complicated circuit with the use of different network theorems will be taught. This knowledge will form the foundation for further studies in electromagnetic theory and applications in various electrical systems.

Learning Outcomes:

Students are expected to

- Understand the concepts of electric fields and potentials, apply Gauss's law to symmetrical charge distributions. To find out potentials for different shapes of conductors.
- Know Lorentz force, Biot-Savart law, and Ampere's circuital law, to analyze magnetic fields produced by various current distributions and their applications.
- Describe the dielectric and magnetic properties of matter and analyze ferromagnetism, hysteresis, and electromagnetic induction using Maxwell's equations
- Apply network theorems to solve DC circuit problems, and analyze transient responses in RC and LR circuits involving current growth and decay.

UNIT-1

Electric Field and Electric Potential

Electric field: Electric field lines, Electric flux, Gauss Law with applications to charge distributions with spherical, cylindrical and planar symmetry, Conservative nature of Electrostatic Field.

Electric Potential: Electrostatic Potential, Potential and Electric Field of a dipole, Force and Torque on a dipole, Potential calculation in different simple cases, Laplace and Poisson equations, The Uniqueness Theorem, Method of Images and its application to (1)Plane Infinite Sheet and (2)Sphere. Electrostatic energy of system of charges, Electrostatic energy of a charged sphere, Conductors in an electrostatic Field, Surface charge and force on a conductor.

UNIT-II

Magnetic Field: Magnetic Force, Lorentz Force, Biot Savarts Law, Current Loop as a Magnetic Dipole and its Dipole Moment (analogy with Electric Dipole), Amperes Circuital Law and its application to (1)Solenoid (2)Toroid (3) Helmhotz coil, Properties of curl and divergence, Vector Potential, Ballistic Galvanometer: Torque on a current Loop, Current and Charge Sensitivity, Electromagnetic damping ,Logarithmic damping, CDR.

UNIT-III

Dielectric Properties of Matter: Electric Field in matter, Polarization, Polarization Charges, Electrical Susceptibility and Dielectric Constant, Capacitor(parallel plate, spherical, cylindrical)filled with dielectric, Displacement vector D, Relations between E, P and D, Gauss Law in dielectrics. Magnetic Properties of Matter: Magnetization vector(M), Magnetic Intensity(H), Magnetic Susceptibility and permeability, Relation between B, H, M, Ferromagnetism, B-H curve and hysteresis. Electromagnetic Induction: Faradays Law, Lenz's

Law, Self-Inductance and Mutual Inductance, Reciprocity Theorem, Energy stored in a Magnetic Field, Introduction to Maxwell's Equations.

UNIT-IV

Electrical Circuits: AC Circuits: Kirchhoffs laws for AC circuits, Complex Reactance and Impedance, Series LCR Circuit: (1)Resonance (2)Power Dissipation (3)Quality Factor, (4)Band Width, Parallel LCR Circuit.

Network theorems: Kirchoff's law for electrical circuits, Ideal Constant-voltage and Constant-current Sources. Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem, Applications to DC circuits. Transient Currents Growth and decay of current in RC and LR circuits.

Books Recommended:

- ✓ *Introduction to Electrodynamics– D.J. Griffiths (Pearson,4thedition,2015)*
- ✓ *Foundations of Electromagnetic Theory-Ritzand Milford(Pearson)*

Books for Reference:

- ✓ *Classical Electrodynamics, J.D. Jackson(Wiley)..*
- ✓ *Electricity and Magnetism D.C.Tayal (Himalaya Publishing house)*
- ✓ *Electricity, Magnetism and Electromagnetic Theory-S.Mahajan and Choudhury (Tata McGraw Hill)*
- ✓ *Feynman Lectures Vol.2, R.P.Feynman, R.B.Leighton, M.Sands(Pearson)*
- ✓ *Electricity and Magnetism, J.H.Fewkes and J.Yarwood.Vol.I(OxfordUniv.Press)*
- ✓ *Classical Electromagnetism, H.C.Verma, Bharati Bhawan*

PAPER-3 LAB: Credit-1

(Minimum of 6 experiments are to be done)

Use a Multimeter for measuring (a)Resistances, (b)AC and DC Voltages, c)DC Current, (d)Capacitances, and (e)Checking electrical fuses

1. To study the characteristics of a series RC Circuit.
2. To determine an unknown Low Resistance using Potentiometer.
3. To determine an unknown Low Resistance using Carey Fosters Bridge.
4. To compare capacitances using DeSauty's bridge.
5. Measurement of field strength B and its variation in a solenoid(determine dB/dx)
6. To verify the Thevenin and Norton theorems.
7. To determine self-inductance of a coil by Andersons bridge.
8. 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)Bandwidth.
9. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonance

frequency and (b)Quality factor Q

Books for Reference:

- ✓ *Advanced Practical Physics for students, B.L.Flintand H.T.Worsnop,1971,Asia Publishing House*
- ✓ *A Text Book of Practical Physics, I.Prakash and Ramakrishna,11thEd.,2011, KitabMahal*
- ✓ *Advanced level Physics Practicals, Michael Nelson and Jon M.Ogborn, 4thEdition, reprinted1985, Heinemann Educational Publishers*
- ✓ *A Laboratory Manual of Physics for undergraduate classes,D.P.Khandelwal,1985, VaniPub.*

PAPER-4 MATHEMATICAL PHYSICS-II: Credit-3

Course Objective:

This course introduces students to advanced mathematical techniques essential for solving problems. Through topics such as Fourier series, special functions, polynomials and partial differential equations, students will develop skills in analyzing complex systems. The course emphasizes the application of these mathematical tools to various physical phenomena, including wave motion, heat conduction and electromagnetic fields.

Learning Outcomes:

By the end of this course, students will be able to:

- Understand Fourier series and can expand periodic and non-periodic functions.
- Learn Frobenius method and solve special functions such as Bessel, Legendre, and Hermite polynomials. Students will know recurrence relations, orthogonality property, Rodrigues Formula and the Generating Function.
- Know the Special functions such as Spherical Bessel functions, Beta, Gamma, and Error functions and their use.
- Analyze and solve partial differential equations using separation of variables in problems with rectangular, cylindrical, and spherical symmetry.

UNIT-I

Fourier Series-I: 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 and Application, Summing of Infinite Series, Term-by-Term differentiation and integration of Fourier Series, Parseval Identity.

UNIT-II

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance, Singularities of Bessel's and Laguerre Equations, Frobenius method and its applications to differential equations: Bessel, Legendre and Hermite Differential Equations, Legendre and Hermite Polynomials: Rodrigues Formula, Generating Function, Orthogonality.

UNIT-III

Polynomials: Simple recurrence relations of Legendre and Hermite Polynomials, Expansion of function in a series of Legendre Polynomials, Associated Legendre Differential Equation, Associated Legendre polynomials, Spherical Harmonics. Spherical Bessel's Function (1^{st} and 2^{nd} kind).

Some Special Integrals: Beta and Gamma Functions and relation between them, Expression of Integrals in terms of Gamma Functions, Error Function (Probability Integral).

UNIT-IV

Partial Differential Equations: Solutions to partial differential equations using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. Conducting and dielectric sphere in an external uniform electric field. Wave equation and its solution for vibrational modes of a stretched string.

Books Recommended:

- ✓ *Mathematical Methods for Physicists, G.B.Arfken, H.J.Weber, F.E.Harris. (2013,7th Edn., Elsevier)*
- ✓ *Advanced Engineering Mathematics, Erwin Kreyszig (Wiley India)*

Books for Reference:

- ✓ *Mathematical Physics and Special Relativity, M.Das, P.K.Jena and B.K.Dash (Srikrishna Prakashan)*
- ✓ *Mathematical Physics–H.K.Dass, Dr.Rama Verma (S.Chand Publishing)*
- ✓ *Mathematical Physics C.Harper(Prentice Hall India)*
- ✓ *Complex Variable: Schaum's Outlines Series M.Spiegel (2nd Edition, McGraw Hill Education)*
- ✓ *Complex variables and applications J.W.Brown and R.V.Churchill*
- ✓ *Mathematical Physics, Satya Prakash (Sultan Chand)*
- ✓ *Mathematical Physics B.D.Gupta (4th edition, Vikas Publication)*
- ✓ *Mathematical Physics, B.S.Rajput, Pragati Prakashan*

PAPER-4 **LAB: Credit-1**

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

Topics

Introduction to Numerical computation software Scilab: Introductionto Scilab, Advantagesand disadvantages, Scilab computations oftware Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Sub array, Special values, Displaying output data, datafile, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting,2D and 3D plotting.

Branching Statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization. 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. An introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program.

Curve fitting, Least square fit, Goodness of fit, standard constant Deviation: Ohms law to calculate R, Hooke's law to calculate spring constant

Solution of Linear system of equations by Gauss elimination Solution method and Gauss Seidal method. Diagonalization matrices, Inverse of a matrix, Eigenvectors, problems: Solution of mesh equations of electric circuits(3meshes), Solution of coupled spring mass systems(3meshes).

Solution of ODE Firstorder Differential equation Euler, modifted Euler Runge-Kutta second methods Second order differential equation. Fixed difference method:

First order differential equation

- Radioactive decay
- Current in RC, LC circuits with DC source
- Newton's law of cooling
- Classical equations of motion

Second order Differential Equation

- Harmonic oscillator (no friction)
- Damped Harmonic oscillator
- Over damped
- Critical damped
- Oscillatory
- Forced Harmonic oscillator
- Transient and Steady state solution

- Apply above to LCR circuits also

Books for Reference:

- ✓ *Mathematical Methods for Physics and Engineers, K.FRiley, M.P.Hobson and S.J.20Bence, 3rd ed.,2006, Cambridge University Press.*
- ✓ *Complex Variables, A.S.Fokas and M.J.Ablowitz, 8th Ed.,2011, Cambridge Univ.Press.*
- ✓ *First course in complex analysis with applications, D.G.Zill and P.D.Shana-han,1940,Jones and Bartlett.*
- ✓ *Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V.Wouwer, P.Saucez, C.V.Fern-ndez.2014Springer.*
- ✓ *Scilab by example: M.Affouf 2012,ISBN:978-1479203444*
- ✓ *Scilab (A free software to Matlab):H.Ramchandran, A.S.Nair. 2011 S.Chand and Company*
- ✓ *Scilab Image Processing: Lambert M.Surhone. 2010 Betascript Publishing*

PAPER-5 WAVE AND OPTICS : Credit-3

Course Objective:

This course provides a detailed study of the fundamental concepts of optics, covering both geometrical and wave optics. Students will explore the principles governing the propagation, interference, and diffraction of light, as well as the behavior of optical systems such as lenses and interferometers. Through a combination of theoretical analysis and practical applications, students will gain a deeper understanding of how light interacts with matter and how optical devices are designed and used.

Learning Outcomes:

After completing the course, the student will be able to

- Apply the principles of geometrical optics, including Fermat's principle, matrix formulation, and cardinal points to analyze optical systems
- Understand the electromagnetic properties of light and describe wave phenomena such as coherence and superposition in both plane and spherical waves.
- Analyze interference phenomena using division of amplitude and wave front and will find the wave length of light and refractive indices using Newton's rings, Michelson and Fabry-Perot interferometers.
- Explain Fraunhofer and Fresnel diffraction, including single and double slit diffraction, the

resolving power of optical instruments and diffraction patterns for various apertures, zone plates and their use.

UNIT-I

Geometrical optics: Fermat's principle, reflection and refraction at plane interface, Matrix formulation of geometrical Optics, Cardinal points and Cardinal planes of an optical system, Idea of dispersion, Application to thick Lens and thin Lens, Ramsden and Huygens eyepiece. Wave Optics : Electromagnetic nature of light. Definition and properties of wave front, Huygens Principle. Temporal and Spatial Coherence.

UNIT-II

Wave Motion: Plane and Spherical Waves, Longitudinal and Transverse Waves, Plane Progressive (Traveling)Waves, Wave Equation, Particle and Wave Velocities, Differential Equation, Pressure of a Longitudinal Wave, Energy Trans- port, Intensity of Wave. Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods, Lissajous Figures (1:1and1:2) and their uses, Superposition of Harmonic waves.

UNIT-III

Interference: Division of amplitude and wave front, Young's double slit experiment, Lloyds Mirror and Fresnel's Bi-prism, Phase change on reflection: Stokes treatment, Interference in Thin Films: parallel and wedge-shaped films, Fringes of equal inclination(Haidinger Fringes),Fringes of equal thickness(Fizeau Fringes), Newton's Rings: Measurement of wavelength and refractive index. Interferometer: Michelson's 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-IV

Fraunhoffer 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.

Text Books:

- ✓ *A text book of Optics N.Subhramanyam and BrijLal (S.Chand Publishing).*
- ✓ *Optics-Ajoy Ghatak (McGraw Hill)*

Reference Books:

- ✓ *Optics-E.Hecht(Pearson).*
- ✓ *Fundamentals of Optics-F.A. Jenkins and H.E.White(McGraw-Hill).*
- ✓ *Geometrical and Physical Optics R.S. Longhurst(Orient Blackswan).*
- ✓ *The Physics of Vibrations and Waves-H.J. Pain(JohnWiley).*
- ✓ *Optics P.K. Chakraborty.*

- ✓ *Principles of Optics-Max Born and Emil Wolf (Pergamon Press)*
- ✓ *The Physics of Waves and Oscillations-N.K.Bajaj (McGraw Hill)*

PAPER-5 LAB: Credit-1

(Minimum 5 experiments are to be done)

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify 2-T law.
2. To plot the I-D curve and to determine the refractive index of a prism.
3. To determine refractive index of the Material of a prism using sodium source.
4. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
5. To determine wavelength of sodium light using Newton's Rings.
6. To determine wavelength of (1)Na source and (2)spectral lines of Hg source using plane diffraction grating.
7. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books:

- ✓ *Advanced Practical Physics for students, B.L.Flintand H.T.Worsnop,1971, Asia Publishing House.*
- ✓ *A Text Book of Practical Physics, I.Prakash and Ramakrishna, 11th Ed., 2011, KitabMahal.*
- ✓ *Advanced level Physics Practicals, Michael Nelson and JonM.Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers.*
- ✓ *A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985,Vani.*

PAPER-6 MATHEMATICAL PHYSICS–III: Credit-3

Course Objective:

This course aims to introduce students to advanced mathematical techniques used in solving complex physical problems. Focusing on complex analysis and integral transforms, the course will explore essential mathematical tools such as Fourier and Laplace transforms, as well as the application of complex variable functions and residue theorem. Students will learn to apply these methods in solving differential equations and integrals.

Learning Outcomes:

After completing the course, the student will be able to

- Understand the fundamentals of complex analysis, including complex numbers, Euler's formula, De Moivre's theorem, and apply these to solve problems involving complex variables, analyticity, singular functions, and contour integration.

- Use Cauchy's integral formula, Taylor and Laurent expansions, and the residue theorem to evaluate complex integrals and solve real definite integrals.
- Apply Fourier transforms to analyze trigonometric, Gaussian and wave functions and utilize these in solving differential equations such as wave and heat flow equations.
- Apply Laplace transforms to solve differential equations, analyze simple electrical circuits and damped harmonic oscillators and apply properties to various fields.

UNIT-I

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation Euler's formula, De – Moivre's theorem, Roots of complex Numbers, Functions of Complex Variables, Analyticity and Cauchy-Riemann Conditions, Examples of analytic functions, Singular functions: poles and branch points, order of singularity, branch cuts, Integration of a function of a complex variable, Cauchy's Inequality, Cauchy's Integral formula, Simply and multiply connected region, Laurent and Taylors expansion, Residues and Residue Theorem, Application in solving Definite Integrals.

UNIT-II

Integral Transforms-I: Fourier Transforms: Fourier Integral theorem, Fourier Transform, Examples, Fourier Transform of trigonometric, Gaussian, finite wave train and other functions, Representation of Dirac delta function as a Fourier Integral, Fourier transform of derivatives, Inverse Fourier Transform.

UNIT-III

Integral Transforms-II: Convolution theorem, Properties of Fourier Transforms (translation, change of scale, complex conjugation), Three dimensional Fourier transforms with examples, Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat flow Equations.

UNIT-IV

Laplace Transforms: Laplace Transforms(LT) of Elementary functions.

Properties of Laplace Transforms: Change of Scale Theorem, Shifting Theorem, LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions, Inverse LT, Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits.

Text Books:

- ✓ *Mathematical Methodsfor Physicists, G. B. Arfken, H. J. Weber, F. E. Harris (2013, 7th Edn., Elsevier).*
- ✓ *Advanced Engineering Mathematics, Erwin Kreyszig (Wiley India).*

Reference Books:

- ✓ *Mathematical Physics and Special Relativity –M. Das,P. K. Jena and B.K.Dash (Srikrishna Prakashan).*
- ✓ *Mathematical Physics–H.K.Dass, Dr.Rama Verma (S.Chand Publishing).*
- ✓ *Mathematical Physics C.Harper(Prentice Hall India).*
- ✓ *Complex Variable: Schaum's Outlines Series M.Spiegel (2nd Edition, Mc-GrawHill Education).*
- ✓ *Complex variables and applications J. W. Brown and R. V. Churchill.*
- ✓ *Mathematical Physics, Satya Prakash(Sultan Chand).*
- ✓ *Mathematical Physics B. D. Gupta(4th edition,Vikas Publication).*
- ✓ *Mathematical Physics B. S. Rajput, Pragati Prakashan.*
- ✓ *Mathematical physics-III, (University Physics), Dr. Ranjan Kumar Bhuyan, Himalaya Publishing House*

PAPER-6 LAB: Credit – 1

Scilab based simulations (XCos) experiments based on Mathematical Physics problems like
.

Solve simple differential equations like:

$\frac{dy}{dx} = e^{-x}$ with y(x=0)=0

$\frac{dy}{dx} + e^{-x} = x^2$ with y(x=0)=0

$\frac{d^2y}{d^2x} + 2\frac{dy}{dx} = -y$ with y(x=0)=0, y'(x=0)=1

$\frac{d^2y}{d^2x} + e^{-x}\frac{dy}{dx} = -y$ with y(x=0)=0, y'(x=0)=1

Dirac Delta Function:

Evaluate $\int_{-3}^{3} dx \frac{x-3}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-2)^2}{2\sigma^2}}$ for σ=0.1, 0.01, 0.001 and show that it tends to 5

Fourier Series:
Program to sum; evaluate the Fourier Coefficients of a given periodic function (Square Wave).

Frobenius Method and Special Functions:

$$\int_{-1}^{1} P_n(\mu)P_m\ (\mu)\ d\mu = \frac{2}{2n+1}\ \delta_{mn}$$

Plot $P_n(x)$, Legendre polynomial of degree n, and $J_n(x)$, Bessel function of first kind. Show Recursion relation.

Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
Calculation of least square fitting manually without giving weightage to error.
Confirmation of least square fitting of data through computer Programme.
Evaluation of trigonometric functions e.g. Sinθ, Given Bessel's function at N points, find its value at an intermediate point.
Complex analysis: Calculate $\int \frac{dx}{x^2+2}$ and check it with computer integration.
Integral transform: FFT of e^{-x^2}

Reference Books:

- ✓ *Mathematical Methods for Physics and Engineers, K. FRiley, M.P. Hobsonand S. J.Bence, 3rd ed.,2006, Cambridge University Press.*
- ✓ *Mathematics for Physicists, P.Dennery and A.Krzywicki, 1967, Dover Publications.*
- ✓ *Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientificand Engineering Applications: A. Vande Wouwer, P.Saucez, C.V. Fernndez. 2014SpringerISBN:978-3319067896.*
- ✓ *Scilab by example: M.Affouf,2012.ISBN:978-1479203444.*
- ✓ *Scilab (A free software to Matlab): H.Ramchandran, A.S.Nair. 2011 S.Chand And Company, Scilab Image Processing: Lambert M.Surhone. 2010 Betascript Publishing.*

PAPER-7 THERMAL PHYSICS: Credit-3

Course Objective:

The primary aim of this course is to make the students understand thermodynamics and kinetic theory, emphasizing the fundamental principles governing energy, heat, and work in physical systems and the different processes. Students will explore the laws of thermodynamics, entropy, thermodynamic potentials, phase transitions and the behavior of real gases. The course will cover velocity distributions, molecular collisions and transport phenomena.

Learning Outcomes:

After completing the course, the student will be able to

- Know the four laws of thermodynamics and analyze thermodynamic processes, the scales of temperatures, calculate entropy changes and understand the concept of absolute zero.

- Utilize thermodynamic potentials: internal energy, enthalpy, Helmholtz and Gibbs free energy in solving problems involving surface tension, magnetic work and cooling due to adiabatic demagnetization.
- Analyze first and second-order phase transitions, using Clausius-Clapeyron and Ehrenfest equations and apply Maxwell's thermodynamic relations to derive relation among thermodynamic variables
- Understand the kinetic theory of gases, including the Maxwell-Boltzmann distribution of velocities, molecular collisions, mean free path, and transport phenomena such as viscosity, thermal conductivity, and diffusion.
- Examine the behavior of real gases, including deviations from the ideal gas law, the Virial equation, Van der Waals equation of state, and Joule-Thomson effect, and apply these concepts to understand real gas behavior and experimental observations.

UNIT-I

Introduction to Thermodynamics: Recapitulation of Zeroth and First law of thermodynamics.
Second Law of Thermodynamics: Reversible and Irreversible process with examples, Kelvin-Planck and Clausius Statements and their Equivalence, Carnot's Theorem, Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale.
Entropy: 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 Principle of Increase of Entropy, Temperature Entropy diagrams for Carnot's Cycle, Third Law of Thermodynamics, Unattainability of Absolute Zero.

UNIT-II

Thermodynamic Potentials: Extensive and Intensive Thermodynamic Variables. Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy, Their Definitions, Properties and Applications, Surface Films and Variation of Surface Tension with Temperature, Magnetic Work, Cooling due to adiabatic demagnetization.
Phase Transitions: First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations.
Maxwells Thermodynamic Relations: Derivations and applications of Maxwells Relations, Maxwells Relations:(1)Clausius Clapeyron equation (2)Relation between *Cp and Cv (*3)TdS Equations, (4)Joule-Kelvin coefficient for Ideal and. Vander Waal Gases (5)Energy equations (6)Change of Temperature during Adiabatic Process.

UNIT-III
Kinetic Theory of Gases
Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification, Sterns Experiment, Mean, RMS and Most Probable

Speeds, Degrees of Freedom, Law of Equipartition of Energy(No proof required), Specific heats of Gases.

Molecular Collisions: Mean Free Path, Collision Probability, Estimates of Mean Free Path.

Transport Phenomenon in Ideal Gases: (1)Viscosity (2)Thermal Conductivity and (3)Diffusion. Brownian Motion and its Significance.

UNIT-IV

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation, The Virial Equation, Andrews Experiments on CO_2 Gas. Critical Constants, Continuity of Liquid and Gaseous State Vapour and Gas, Boyle Temperature, Vander Waals Equation of State for Real Gases, Values of Critical Constants, Law of Corresponding States, Comparison with Experimental Curves, P-V Diagrams, Joules Experiment, Free Adiabatic Expansion of a Perfect Gas, Joule-Thomson Porous Plug Experiment, Joule-Thomson Effect for Real and Vander Waal Gases, Temperature of Inversion, Joule-Thomson Cooling.

Text Books:

- ✓ *Thermal Physics, A.B.Gupta(Books and alliedLtd).*
- ✓ *Heat and Thermodynamics, M.W.Zemansky, Richard Dittman(McGraw-Hill).*

Reference Books:

- ✓ *Theory and experiments on thermal Physics, P.K.Chakrabarty (Newcen- tral book agency limited).*
- ✓ *Thermodynamics, Kinetic Theory and Statistical Thermodynamics-Sears and Salinger(Narosa).*
- ✓ *A Treatise on Heat-Meghnad Saha and B.N.Srivastava(TheIndian Press)*
- ✓ *Heat, and thermodynamics and Statistical Physics, N.Subrahmanyam and BrijLal (S. Chand Publishing).*
- ✓ *Thermal and Statistical Physics M.Das, P.K.Jena, S.Mishra, R.N.Mishra(ShriKrishna Publication).*
- ✓ *Heat, Thermodynamics and statistical physics, Brijlal, Subhramanyam and Hemne,S. Chand Publication.*

PAPER – 7 LAB:Credit-1

(Minimum 5 experiments are to be done)

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barnes constant flow method.
2. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.

3. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
4. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
5. To determine J by Caloriemeter.
6. To determine the specific heat of liquid by the method of cooling.
7. To determine the specific heat of solid by applying radiation of correction.

Reference Books:

- ✓ *Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop,1971, Asia Publishing House.*
- ✓ *A Text Book of Practical Physics, I.Prakashand Ramakrishna,11th Ed.,2011, Kitab Mahal.*
- ✓ *Advanced level Physics Practicals, Michael Nelson and JonM.Ogborn,4th Edition, reprinted1985, Heinemann Educational Publishers.*
- ✓ *A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal,1985,VaniPub*

PAPER-8 ANALOG SYSTEMS: Credit-3

Course Objectives:

This course aims to provide students with a comprehensive understanding of the fundamental principles of semiconductor devices and their applications in electronic circuits. It introduces semiconductor diodes, bipolar junction transistors (BJTs), amplifiers, and operational amplifiers (Op-Amps). The course will explore the working mechanisms of diodes and transistors, analyze rectifiers, amplifiers, and oscillators, and cover the operation and design of different amplifier configurations. Additionally, students will learn about the practical applications of Op-Amps in various electronic systems.

Learning Outcomes:

By the end of this course, students will be able to:

- Explain the working principles and characteristics of semiconductor diodes, transistors and their applications in rectifiers, voltage regulation and amplification.
- Analyze the operation of various transistor configurations (CB, CE, CC) and understand the current flow mechanisms, load line analysis and biasing techniques.
- Classify and differentiate between Class A, B, and C amplifiers and evaluate the performance of RC-coupled amplifiers in terms of frequency response.
- Understand the principles of feedback in amplifiers and design oscillators such as RC, phase shift, Hartley, and Colpitts oscillators based on the Barkhausen criterion.
- Apply operational amplifiers (Op-Amps) in circuit designs for inverting/non-inverting amplifiers, adders, subtractors, differentiators, integrators, and oscillators.

UNIT-I

Semiconductor Diodes: P and N type semiconductors, energy level diagram, conductivity and Mobility, Concept of Drift velocity, PN junction fabrication (simple idea), Barrier formation in PN Junction Diode, Static and Dynamic Resistance, Current flow mechanism in Forward and Reverse Biased Diode, Drift velocity, derivation for Barrier Potential, Barrier Width and current Step Junction.

Two terminal device and their applications: (1)Rectifier Diode: Half-wave Rectifiers. center-tapped and bridge type Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, L and C Filters (2) Zener Diode and Voltage Regulation, Principle and structure of LEDS, Photodiode (3) Solar Cell.

UNIT-II

Bipolar Junction Transistors: n-p-n and p-n-p transistors, Characteristics of CB,CE and CC Configurations, Current gain and b ,Relation between and b ,Load line analysis of Transistors, DC Load line and Q-point, Physical mechanism of current flow, Active, Cut-off and Saturation Regions.

Transistor Biasing: Transistor Biasing and Stabilization circuits, Fixed Bias and Voltage Divider Bias.

Amplifiers: Transistors 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.

UNIT-III

Classification of class A, B and C amplifiers, Push-pull amplifier (class B).

Coupled Amplifier: RC-coupled amplifier and its frequency response.

Feedback in Amplifiers: Effect of Positive and Negative Feedback on Input Impedance, Output Impedance, Gain Stability, Distortion and Noise. Sinusoidal Oscillations: Barkhausen's criterian for self- sustained oscillations. RC Phase shift oscillator, determination of Frequency, Hartley and Colpitt's oscillators.

UNIT-IV

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical OP-AMP (IC741). Open-loop and Closed loop Gain. Frequency Response. CMRR, Slew Rate and concept of virtual ground.

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

Text Books:

- ✓ *Foundations of Electronics-Raskhit and Chattopadhyay (New age International Publication)*
- ✓ *Concept of Electronics- D.C.Tayal (Himalay Publication)*

Reference Books:

- ✓ *Electronic devices and circuits R. L. Boylstad (Pearson India)*
- ✓ *Electronic Principles- A.P. Malvino (Tata McGraw Hill)*
- ✓ *Principles of Electronics-V. K .Mehta and Rohit Mehta (S. Chand Publication)*
- ✓ *OP-Amps and Linear Integrated Circuit- R. A. Gayakwad (Prentice Hall)*
- ✓ *Physics of Semiconductor devices, Donald A Neamen (Prentice Hall)*
- ✓ *Analog System and Application: Gupta Kumar, Pragati Prakashan*

PAPER-8 LAB: Credit-1

(Minimum 5 experiments are to be done)

1. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
2. Study of V-I and power curves of solar cells, and find maximum power point and efficiency.
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 a non-amp.
7. To design a phase shift oscillator of given specifications using BJT.
8. To study the Colpitt's oscillator.

Reference Books:

- ✓ *Modern Digital Electronics, R. P .Jain, 4th Edition, 2010, Tata McGraw Hill.*
- ✓ *Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1994, McGraw Hill.*
- ✓ *Microprocessor Architecture Programming and applications with 8085, R.S.Goankar, 2002, Prentice Hall.*
- ✓ *Microprocessor 8085: Architecture, Programming and interfacing,A. Wadhwa, 2010, PHI Learning.*

PAPER-9 BASIC INSTRUMENTATION: Credit-3

Course Objectives:

The course aims to provide students with a thorough understanding of the principles and working of various electronic measuring instruments. Students will explore the concepts of accuracy, precision, and errors in measurement. The course covers the operational principles and block diagrams of key devices such as multimeters, oscilloscopes, signal generators and digital instruments. Students will gain practical knowledge of the construction, specifications and applications of these instruments, preparing them to apply this knowledge in real-world scenarios and laboratory environments.

Learning Outcomes:

By the end of the course, students will be able to:

- Understand and differentiate between various measurement parameters such as accuracy, precision, sensitivity and resolution and analyze the sources of errors in measurements.
- Explain the working principles and significance of different types of multimeters (analog and digital) for measuring voltage, current, and resistance, along with their specifications.
- Describe the construction and operation of Cathode Ray Oscilloscopes (CROs), including their applications in measuring voltage, current, frequency, and phase difference.
- Interpret the block diagrams and working principles of signal generators including low-frequency signal generators, pulse generators and distortion factor meters.
- Compare digital and analog instruments and explain the working of digital multimeters, voltmeters, and frequency counters, with an understanding of time-base stability, accuracy, and resolution.

UNIT-I

Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects.

Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance.

AC millivoltmeter: Type of AC millivoltmeters: Amplifier-rectifier, and rectifier-amplifier. Block diagram of ac millivoltmeter, specifications and their significance.

UNIT-II

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

Applications of CRO: (1) Study of Wave Form, (2) Measurement of Voltage, Current, Frequency and Phase Difference. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: Block diagram and principle of working.

UNIT-III

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

UNIT-IV

Digital Instruments: Principle and working of digital meters, Comparison of analog and digital instruments, Characteristics of a digital meter, Working principles of digital voltmeter.

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

Text books:

- ✓ *A Text Books book of electrical technology- B.L.Theraja (S.Chand Publishing)*
- ✓ *Digital circuits and systems Venugopal (Tata McGraw Hill)*

Reference Books:

- ✓ *Digital Electronics-Subrata Ghoshal (Cengage Learning)*
- ✓ *Electronic Devices and circuits-S.Salivahanan and N.S.Kumar (Tata Mc-Graw Hill)*
- ✓ *Electronic Devices-Thomas L.Floyd (Pearson)*

PAPER-9 LAB: Credit-1

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

1. Use of an oscilloscope.
2. CRO as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment.
4. Use of Digital multimeter/VTVM for measuring voltages.
5. Circuit tracing of Laboratory electronic equipment.

6. Winding a coil/transformer.
7. Study the layout of receiver circuit.
8. Troubleshooting a circuit.
9. Balancing of bridges.

Laboratory Exercises:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q-meter.
4. Measurement of voltage, frequency, time period and phase angle using CRO.
5. Measurement of time period, frequency, average period using universal counter/frequency counter.
6. Measurement of rise, fall and delay times using a CRO.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R, L and C using a LCR bridge/universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter)

More emphasis should be given on hands-on experiments.

Additional Reference Books for Practical papers:

1. *Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop (Asia Publishing House)*
2. *Practical Physics-B.B.Swain (Kitab Mahal)*
3. *Practical Physics-B.Ghosh (Vol.I and II)*
4. *A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal (Vani Publication)*
5. *B.Sc. Practical Physics- C.L.Arora (S.Chand Publishing)*
6. *B.Sc. Practical Physics H.Singh and P.S.Hemne (S.Chand Publishing)*

PAPER-10 NUCLEAR AND PARTICLE PHYSICS: Credit-3

Course Objectives:

This course aims to provide students with a comprehensive understanding of atomic and nuclear physics, focusing on the behavior of atoms in electric and magnetic fields, the structure and forces within the atomic nucleus, and various nuclear models. Students will explore key phenomena like the Zeeman Effect, nuclear stability, radioactive decay, and nuclear reactions, as well as delve into the fascinating world of particle physics, including the classification of particles and fundamental forces. The course also introduces advanced concepts such as the Higgs boson, dark matter, and energy, providing a broad overview of both established theories and cutting-edge discoveries in modern physics.

Learning Outcomes:

By the end of this course, students will be able to:

- Analyze the behavior of atoms in external electric and magnetic fields and explain the Zeeman and Stark effects.
- Describe the structure and properties of the atomic nucleus, including nuclear forces, nuclear stability and energy production.
- Explain the mechanisms of radioactive decay and the applications of radioisotopes in various fields.
- Apply nuclear models like the liquid drop and shell models to explain nuclear behavior and reactions, including fission and fusion.
- Understand the classification of subatomic particles, conservation laws and the significance of quarks and the Higgs boson in particle physics.

UNIT-I

Atoms in Electric and Magnetic Fields: Electron angular momentum. Space quantization, Electron Spin and Spin Angular Momentum, Larmor's Theorem, Spin Magnetic Moment, Stern-Gerlach Experiment, Vector Atom Model, L-S and J-J coupling, Zeeman Effect, Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magnetron. Atoms in External Magnetic Fields: Normal and Anomalous Zeeman Effect, Paschen back and Stark-Effect (qualitative Discussion only).

UNIT-II

Nuclear Physics- : Nuclear composition, charge, size, shape, mass and density of the nucleus; Nuclear angular momentum; Nuclear magnetic dipole moment; Electric quadrupole moment; Mass defect; Packing fraction and Binding energy; Stability of nuclei (N vs Z curve), Binding energy curve. Semiempirical mass formula; Nuclear Forces: General concept of nuclear force; Yukawa Meson field theory of nuclear forces; Properties of Nuclear forces.
Radioactive disintegration; Properties of alpha, beta, gamma rays; law of radioactive decay; successive radioactive decay; radioactive equilibrium; Radio isotopes; application of radioactivity (Agriculture, Medicinal, Industrial and Archaeological).

UNIT-III

Nuclear models: Liquid Drop model; Shell model; magic number in the nucleus; Alpha decay: Alpha particles spectra; Gamow's theory of Alpha decay; Beta decay: Shape of Beta ray spectrum; Explanation of Beta decay on the basis of Neutrino and Antineutrino hypothesis; Fermi theory of Beta decay; Selection rules; Gamma ray emission,

Nuclear reactions: Kinds of Nuclear reactions; Nuclear reaction kinematics; Q- value; Compound Nucleus and concept of direct reactions; Conservation laws; Nuclear reaction cross-sections. Nuclear energy: Nuclear Fission; Chain reaction and Critical Mass; Nuclear Reactors and its basic components; Nuclear Fusion; Condition for the maintained Fusion reactions; Energy production in stars; Fusion reaction in Sun, Principle of atomic bomb and hydrogen bomb.

UNIT-IV

Particle Physics

Classification of particles-antiparticles and their interactions; Conservation laws; Charges; Isospin; Baryon number; Lepton number; Strangeness; Hypercharge; Parity; Charge conjugation; CPT theorem; Conservation laws; Quark as the building blocks of Hadrons; Quark Model; Colour degree of freedom, Symmetry Classification of elementary particles; Higgs Boson Particle (God particle), elementary idea on Large Hadron collider(LHC),The future of universe, Dark matter and dark energy.

Text Books:

- ✓ *Concepts of Modern Physics Arthur Beiser (McGraw Hill)*
- ✓ *Modern Physics Murugeshan and Sivaprasad (S.Chand)*
- ✓ *Cohen B.L.,"Concepts of Nuclear Physics", McGraw Hill Education.*
- ✓ *Tayal D.C.,"Nuclear Physics", Himalaya Publishing House.*
- ✓ *Patel S.B.,"Nuclear Physics: An Introduction", New Age International Publishers.*
- ✓ *Singh Jahan, "Fundamental of Nuclear Physics", Pragati Publications*

Reference Books:

- ✓ *Quantum Mechanics: Theory and Applications, A. K. Ghatak and S. Lokanathan,*
- ✓ *(Macmillan)*
- ✓ *Introduction to Quantum Theory, David Park (Dover Publications)*
- ✓ *Theory and Problems of Modern Physics, Schaum's outline, R.Gautreau and*
- ✓ *W.Savin- (Tata McGraw-Hill)*
- ✓ *Modern Physics-Serway (CENGAGE Learnings)*
- ✓ *Physics of Atoms and Molecules Bransden and Joachim (PearsonIndia)*
- ✓ *Atomic and Nuclear Physics-A.B.Gupta (New Central)*
- ✓ *Theoretical Nuclear Physics, J.M.Blatt and V.F. Weisskopf (Springer)*

PAPER-10 LAB: Credit-1

(Minimum 4 experiments are to be done)

1. Study of photoelectric effect.
2. Basics of GM counter characteristics and counting statistics.
3. Study of Gamma ray spectroscopy by SCA and MCA.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
6. To set up the Millikan oil drop apparatus and determine the charge of an electron.

Reference Books:

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

PAPER-11 DIGITAL SYSTEMS: Credit-3

Course objective:

This course introduces students to the fundamentals of integrated circuits, digital electronics, and computer organization. Covering the principles of analog and digital circuits, Boolean algebra, data processing circuits, and basic components of computer systems, the course provides students with a foundational understanding of how digital systems are designed, analyzed, and implemented. The course also includes practical applications of various components and circuits used in modern electronic systems.

Learning outcomes:

After completing the course, the students will be able to

- Understand IC's, there scales of Integration and its drawbacks.
- Interconvert among binary, decimal, octal, and hexadecimal number systems and implement basic digital logic gates (AND, OR, NOT, NAND, NOR, XOR, XNOR) using diodes and transistors.
- Apply Boolean algebra and De Morgan's theorems to simplify logic circuits, use Karnaugh maps for SOP and POS simplification, and implement universal logic functions using the

universal gates -NAND and NOR gates.

- Design basic data processing circuits including multiplexers, de-multiplexers, decoders, and encoders, and arithmetic circuits such as binary adders, subtractors, and 4-bit binary adder/subtractors.
- Understand the organization of computers, including input/output devices, data storage, memory organization and interfacing and design shift registers and counters

UNIT-I

Integrated Circuits (Qualitative treatment only): Active and 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.

Digital Circuits: Difference between Analog and Digital Circuits, Binary Numbers, Decimal to Binary and Binary to Decimal Conversation, 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.

UNIT-II

Boolean algebra: De Morgan's Theorems: Boolean Laws, Simplification of Logic Circuit using Boolean Algebra, Fundamental Products, Idea of Minterms and Maxterms, Conversion of truth table into Karnaugh Map and SOP and POS simplification. Universal logic implementation (NAND&NOR).

UNIT-III

Data Processing Circuits: Basic Idea of Multiplexers, De-multiplexers, Decoders, Encoders.

Arithmetic Circuits: Binary Addition. Binary Subtraction using 2s complement. Half and Full Adders. Half and Full Subtractors, 4bit binary Adder/Subtractor.

Timers : IC 555:block diagram and application is Astable multivibrator and Monostable multivibrator.

UNIT-IV

Introduction to Computer Organization: Input/output Devices, Data storage (idea of RAM and ROM), Computer memory, Memory organization and addressing, Memory Interfacing, Memory Map.

Shift registers: Serial-in-serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out. Shift Registers(only upto 4bits)

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

Books recommended:

- ✓ *Digital Circuits and Logic design: Samuel C.Lee (PrinticeHall)*
- ✓ *Digital Principles and Applications- A.P.Malvino, D.P.Leachand Saha(TataMcGraw)*

Books for reference:

- ✓ *The Art of Electronics by Paul Horowitz and Wilfield Hill ,Cambridge University*
- ✓ *Electronics by AllanR. Hambley, Prentice Hall*
- ✓ *Principles of Electronics V.K.Mehta and Rohit Mehta (S.Chand Publishing)*
- ✓ *Digital Logic and Computer design M.Morris Mano(Pearson)*
- ✓ *.Concepts of Electronics D.C.Tayal (Himalaya Publishing house)*
- ✓ *Digital System and Application, Gupta Kumar, Pragati Prakashan*

PAPER-11 LAB: Credit-1

(minimum 6 experiments are to be done)

1. To measure (a)Voltage, and (b)Timeperiod of a periodic wave form using CRO and totesta Diode and Transistor using a Millimeter.
2. To design a switch(NOT gate) using a transistor
3. To verify and design AND, OR, NOT and XOR gates using NAND gates.
4. Half Adder, Full Adderand 4-bitbinaryAdder.
5. Half Subtractor, Full Subtractor, Adder-Subtractor using FullAdder I.C.
6. To build Flip-Flop (RS,Clocked-RS,D-type and JK)circuits using NAND gates.
7. To design an astable multivibrator of given specifications using 555Timer.
8. To design a monostable multivibrator of given specifications using555Timer.

Books for reference:

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

PAPER-12 QUANTUM MECHANICS AND APPLICATIONS: Credit-3

Course objective:

The objective of this course is to provide students with a foundational understanding of quantum mechanics, focusing on the formulation and solutions of the Schrödinger equation, both time-dependent and time-independent, in one, two, and three dimensions. Students will gain a comprehensive understanding of wave functions, probability densities, and operators, as well as the significance of eigenvalues and eigenfunctions. The course will introduce key quantum phenomena such as wave-particle duality, uncertainty relations, and quantum tunneling, with practical applications to one-dimensional quantum systems, including quantum dots, harmonic oscillators, and potential barriers. Through this, students will develop a deeper understanding of quantum mechanics' theoretical framework and its physical implications.

Learning outcomes:
After completing the course the students will be able to

- Understand Properties and physical interpretation of wave function and its application, knowledge in probability current density, significance of momentum space transformation and time dependent Schrödinger equation.
- Explain Time independent Schrödinger equation, Eigenvalue, Eigenfunction, generalized solution of stationary states, knowledge in wave function and discrete energy level.
- Basic knowledge in quantum mechanical operators, Eigen value and Eigen function, Uncertainty relation and Gaussian wave packet.
- Acquire the knowledge in application of Schrödinger equation in different potential barriers, concept of simple harmonic oscillator.
- Apply the acquired knowledge to solve various numerical problems.

UNIT-I

Schrodinger equation: Time dependent Schrodinger equation, Properties of Wave Function, Physical interpretation of wave function, Wave function of a free particle, Normalization, Probability current and probability current densities in three dimensions, Linearity and Superposition Principle, Wave Packet, Fourier Transform Theorem ,Momentum space wave function and its significance, Representation of position vector in momentum space. Schrodinger equation in momentum space.

UNIT-II

Time Independent Schrodinger equation in1-D, 2-D and 3-D, Hamiltonian, stationary states and energyEigenvalues,expansionofanarbitrarywavefunctionasalinearcombinationofenergyEigenfunctions, General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states. General Discussion of Bound states in an arbitrary potential: Continuity of wave function, Boundary condition and emergence of discrete energy levels.

UNIT-III

Operators: Operators, Commutator Algebra, Position ,Momentum, Angular Momentum and Energy operators, Hermitian Operators, Expectation Value, Expectation values of position and momentum, Ehrenfest Theorem, Eigen values and Eigen functions of Hermitian Operator, Energy Eigen Spectrum, Degeneracy, Orthonormality of Eigen functions, Linear Dependance, Orthogonalisation, Uncertainty Relation-Uncertainty product, minimum uncertainty wave packet-Gaussian Wave Packet.

UNIT-IV

Application to one dimensional problem-One dimensional infinitely rigid Box- Energy Eigen values and Eigen functions, normalization, quantum dot as an example, Quantum mechanical scattering and tunneling in one dimension across a Potential Step and Rectangular Potential Barrier, Finite Square well potential, Quantum mechanics of simple Harmonic Oscillator-Energy Levels and Energy Eigen functions, ground state, zero point energy.

Books recommeneded:

- ✓ *Introduction to Quantum Theory David Park (Dover Publications)*
- ✓ *Introduction to Quantum Theory, D.J.Griffiths(Pearson)*
- ✓ *Quantum Mechanics: Concepts and applications, N.Zettili,Wiley*

Books for reference:

- ✓ *Quantum Mechanics, Theory and applications A.Ghatak and S.Lokanathan (McMillan India)*
- ✓ *Quantum Mechanics- G.Aruldhas (Printice Hall of India)*
- ✓ *Quantum Physics– S.Gasiorowicz(Wiley)*
- ✓ *Quantum Mechanics- G.R.Chatwal and S.K.Anand*
- ✓ *Introduction to Quantum Mechanics M.Das and P.K.Jena(Shri Krishna Publication).*

PAPER-12 **LAB: Credit-1**

Use C/C++/Scilab for solving the following problems based on Quantum mechanics like

(Use finite difference method, matrix method, ODE Solver method in all cases)

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:
$$\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E], V(r) = -\frac{e^2}{r}$$
where, m is the reduced mass of the electron.
Obtain the energy eigen values and plot the corresponding wave functions. The ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $\sqrt{eV\text{Å}}$, ħc = 1973 eVÅ and m = 0.511x10^6 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:
$$\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$
where m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential as

$$V(r) = -\frac{e^2}{r} e^{-r/a}$$

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

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

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

For the anharmonic oscillator potential

$$V(r) = \frac{kr^2}{2} + \frac{br^3}{3}$$

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

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

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

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

$$V(r) = D(e^{-2\alpha r} - e^{-\alpha r})$$

Where r=r-r_o. Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function with. m = 940x10^6 eV/c^2, D = 0.755501 eV, α = 1.44, r_o = 0.131349 Å

Laboratory based experiment:

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

Books for reference:

- ✓ *Schaum's outline of Programming with C++. J.Hubbard, 2000, McGraw–Hill Publication*
- ✓ *Numerical Recipes in C: The Art of Scientific Computing, W.H.Press etal.,3rd Edn.,2007, Cambridge University Press.*
- ✓ *An introduction to computational Physics, T.Pang, 2ndEdn.,2006, Cam-bridge Univ.Press*
- ✓ *Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A.VandeWouwer, P.Saucez, C.V.Fernndez. 2014 Springer.*
- ✓ *Scilab (A Free Software to Matlab): H.RamchandranA.S.Nair.2011S.ChandandCo.*
- ✓ *Scilab Image Processing: L.M.Surhone.2010 Betascript Publishing ISBN: 9786133459274*

PAPER-13 SOLID STATE PHYSICS: Credit-3

Course objective:

This course provides an in-depth exploration of solid-state physics, focusing on the fundamental concepts of crystal structure, lattice dynamics and electronic band theory. Students will know X-ray diffraction and Braggs law, Lattice with different basis, unit cell and reciprocal lattice. They will explore about phonon, specific heats of solids, Kroning-Penny model, semiconductors, Hall effect and dvanced topics such as lasers and superconductivity.

Learning outcomes;

After completing the course, the students will be able to

- Understand the Concept of crystal structure, miller indices, X-ray Diffraction, Bragg's and Laue's condition, Reciprocal Lattice, Brillouin zones etc.
- Explain Lattice vibration, Einstein and Debye specific heat theories of solids, describe the behavior of conductors, semiconductors, and insulators,
- Analyze the magnetic and dielectric properties of materials, employing classical theories to explain phenomena such as ferromagnetism, Curie's law, and electrical polarization.
- Comprehend and differentiate laser operations and principles of stimulated emission and evaluate the functioning of various laser systems, including Ruby and He-Ne lasers.
- Explore and explain superconductivity concepts, such as the Meissner effect, type-I and type-II superconductors, the basics of the BCS theory and the London's Equation

UNIT-I

Crystal Structure: Solids, Amorphous and Crystalline Materials, Lattice translation Vectors, Lattice with a Basis. Central and Non-Central Elements. Unit Cell, Miller Indices, Types of Lattices, Reciprocal Lattice,

Brillouin zones, Diffraction of X- rays by crystals, Bragg's Law, Laue's Condition, Atomic and Geometrical Factor.

UNIT-II

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear, Mono atomic and Diatomic Chains, Acoustical and Optical Phonons, Qualitative Description of the phonon spectrum in solids, Dulong and Petits Law, Einstein and Debye theories of specific heat of solids, T^3 Law.

Elementary band theory: Kroning-Penny model of band Gap, Conductor, Semiconductor (P and N type) and insulator, Conductivity of Semiconductor, mobility, Hall Effect, Measurement of conductivity (four probe method)and Hall Co-efficient.

UNIT-III

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferro-magnetic Materials, Classical Langevins theory of dia and Paramagnetic Domains, Curies law, Weiss Theory of

Ferromagnetism and Ferromagnetic Domains, Discussion of B-H Curve, Hysteresis and Energy Loss.

Dielectric Properties of Materials: Polarization Local Electrical Field atan Atom, Depolarization Field, Electric Susceptibility, Polarizability, Clausius Mosotti Equation, Classical theory of Electronic Polarizability.

UNIT-IV

Lasers: Einstein's A and B co-efficients, Metastable States, Spontaneous and Stimulated emissions, Optical Pumping and population Inversion, Three Level and Four Level Lasers, Ruby Laser and He-Ne Laser.

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).

Book recommended:

- ✓ *Introduction to Solid State Physics-Charles Kittel (Wiley India)*
- ✓ *LASERS: Fundamentals and Applications- Thyagarajan and Ghatak(McMillan India)*

Reference books :

- ✓ *Solid State Physics-N.W.Ashcroft and N.D.Mermin(Cengage)*
- ✓ *Solid State Physics-R.K.Puri andV.K.Babbar (S.Chand Publication)*
- ✓ *Solid State Physics S.O.Pillai(New Age Publication)*
- ✓ *Lasers and Non-linear Optics B.B.Laud(Wiley Eastern)*
- ✓ *Elements of Solid State Physics-J.P.Srivastava (Prentice Hall of India)*
- ✓ *Elementary Solid State Physics-AliOmar(AddisonWiley)*
- ✓ *Solid State Physics, Gupta and Kumar, Pragati Prakashan*

PAPER-13 LAB:Credit-1

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 adielectric Materials with frequency
4. To determine the Hall coefficient of a semiconductor sample.
5. To draw the BH curve of Fe using solenoid and to determine the energy loss from Hysteresis
6. To measure the band gap of a given semiconductor by four-probe method.

Reference books :

- ✓ *Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971,Asia Publishing House.*
- ✓ *Advanced level Physics Practicals, Michael Nelson and JonM.Ogborn, 4th Edition, reprinted1985, Heinemann Educational Publishers.*
- ✓ *A Text Book of Practical Physics, I.Prakash and Ramakrishna,11Ed.,2011 ,KitabMahal*
- ✓ *Elements of Solid State Physics, J.P.Srivastava,2nd Ed.,2006, Prentice-Hall of India*

PAPER-14 ELECTROMAGNETIC THEORY:Credit-3

Course objective:

The objective of an Electromagnetic Theory course is to provide students with a comprehensive understanding of the fundamental principles governing electric and magnetic fields and their interactions. This course typically covers topics such as Maxwell's equations, electromagnetic wave propagation and the behavior of fields in various media. By integrating theoretical concepts with practical applications, students are expected to develop the analytical skills necessary to solve complex problems in electromagnetics.

Learning outcomes:
After completing the course, the students will be able to,

- Understand physical significance of Maxwell Equations and their applications to different media, Lorentz and Coulomb gauge, pointing theorem, concept of energy density.
- Understand relaxation time, skin depth, Electrical conductivity of ionized gases, plasma frequency and propagation of EM wave through ionosphere
- Know the polarization of EM wave, construction and use of Nicol Prism, the Laurents half-shade polarimeter to find specific rotation.
- Understand Babinets Compensator, Brewster's law and verify in the laboratory.

UNIT-I

Maxwell Equations: Maxwell's equations, Displacement Current, Vector and Scalar Potentials, Gauge Transformations: Lorentz and Coulomb Gauge, Wave Equations, Plane Waves in free space and characteristics, Poynting Theorem and Poynting Vector, Electromagnetic (EM) Energy Density, Physical Concept of Electromagnetic Field Energy Density.

UNIT-II

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

UNIT-III

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization, uniaxial and biaxial crystals, light propagation in uniaxial crystal, double refraction, polarization by double refraction, Nicol Prism, Ordinary and extraordinary refractive indices, Production and detection of Plane, Circularly and Elliptically polarized light,

Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinets Compensator and its Uses, Analysis of Polarized Light.

Rotatory Polarization: Optical Rotation, Biots Laws for Rotatory Polarization, Fresnels Theory of optical rotation, Calculation of angle of rotation, Experimental verification of Fresnels theory, Specific rotation, Laurents half-shade polarimeter.

UNIT-IV

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

Books recommeneded:

- ✓ *Introduction to Electrodynamics, D.J.Griffiths(Pearson)*
- ✓ *Principles of Optics-MaxBorn and E.Wolf*

Reference Books:

- ✓ *Classical Electrodynamics by J.D.Jackson*
- ✓ *Foundation of electromagnetic theory: Ritzand Milford(Pearson).*
- ✓ *Electricity and Magnetism: DCTayal (HimalayaPublication)*
- ✓ *Optics: A.K.Ghatak*
- ✓ *Electricity and Magnetism: Chattopadhyaya, Rakhit(NewCentral)*
- ✓ *ElectromagneticTheory,GuptaandKumar,PragatiPrakashan*

PAPER-14 LAB: Credit-1

(Minimum 4 experiments are to be done):

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

3. To analyze elliptically polarized Light by using a Babinets compensator.
4. To determine the refractive index of liquid by total internal reflection using Wollastons air-film.
5. To determine the refractive Index of (1)glass and (2)a liquid by total internal reflection using a Gaussian eyepiece.
6. To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
7. To verify the Stefan's law of radiation and to determine Stefan's constant.
8. To determine the Boltzmann constant using V-I characteristics of PN junction diode.

Reference Books:

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

PAPER-15 STATISTICAL MECHANICS: Credit-3

Course objective:

The main motive of a Statistical Physics course is to equip students with a deep understanding of the principles and methods used to analyse and predict the behaviour of large systems composed of many particles. This course typically explores topics such as probability theory, thermodynamics and statistical ensembles, emphasizing how microscopic interactions lead to macroscopic phenomena like temperature, pressure and entropy. Through this framework, students learn to connect microscopic properties with observable macroscopic properties, which is essential for advancing in fields such as material science, nuclear physics, chemistry, condensed matter physics etc.

Learning outcomes;

After completing the course, the students will be able to,

- Understand the concept of ensembles and its partition function, phase space and thermodynamic relations, MB distribution law.

- Addition of entropy & Sackur Tetrode equation, Law of equipartition of Energy and its application. Basic postulates and different distributions for Fermi and Dirac particles and the B-E condensation.
- Know Blackbody radiation, Concept of different laws of radiation and their experimental verification.
- Apply the acquired knowledge for analyze the laws radiation and different distribution functions using computational analysis

UNIT-I

Classical Statistics-I: Macrostate and Microstate, Elementary Concept of Ensemble, Microcanonical, Canonical and Grand Canonical ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function.

UNIT-II

Classical Statistics-II: Thermodynamic Functions ofan 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 atwo energy levels system, Negative Temperature.

UNIT-III

Quantum Statistics: Identical particles, macro states and microstates, Fermions and Bosons, Bose Einstein distribution function and Fermi-Dirac distribution function. Bose-Einstein Condensation, Bose deviation from Planck's law, Effect of temperature on Fermi-Dirac distribution function, degenerate Fermi gas, Density of States Fermi energy.

UNIT-IV

Radiation: Properties of Thermal Radiation, Blackbody Radiation, Pure Temperature dependence, Kirchhoff's law, Stefan Boltzmann law: Thermodynamic proof, Radiation Pressure, Wein's Displacement law, Wien's distribution Law, Saha's Ionization Formula, Rayleigh Jeans Law, Ultra Violet catastrophe.

Planck's Law of Blackbody Radiation: Experimental verification, Deduction of (1) Wien's Distribution Law, (2)Rayleigh Jean's Law, (3)Stefan Boltzmann Law, (4)Wein's Displacement Law from Planck's Law.

Books Recommended:

- ✓ *Introduction to Statistical Physics by Kerson Huang (Wiley).*
- ✓ *Statistical Physics, Berkeley Physics Course, F.Reif(Tata McGraw-Hill)*

Reference Books:

- ✓ *Statistical Mechanics, B.K.Agarwal and Melvin Eisner(New Age Inter-national)*
- ✓ *Thermodynamics, Kinetic Theory and Statistical Thermodynamics: Francis W.Searsand GerhardL.Salinger(Narosa)*
- ✓ *Statistical Mechanics: R.K.Pathria and PaulD.Beale (Academic Press)*
- ✓ *Statistical Mechanics: Sharma and Satyal, Kalyani Publishing*
- ✓ *Basic Statistical Mechanics, Gupta and Kumar, PragatiPrakashan*

PAPER-15 LAB:Credit-1

Use C/C++/Scilab for solving the problems based on Statistical Mechanics like

1. Plot Planck's law for Black Body radiation and compare it with Wein's, Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
2. Plot Specific Heat of Solids by comparing (a)Dulong-Petitlaw, b)Einstein distribution function, (c)Debye distribution function for high temperature(room temperature) and low temperature and compare them for these two cases
3. Plot Maxwell-Boltzmann distribution function versus temperature.
4. Plot Fermi-Dirac distribution function versus temperature.
5. Plot Bose-Einstein distribution function versus temperature.

Reference Books:

- ✓ *ElementaryNumericalAnalysis,K.E.Atkinson,3rdEdn.2007,WileyIndiaEdition*
- ✓ *Statistical Mechanics, R.K.Pathria, Butterworth Heinemann: 2nd Ed.,1996, Oxford University Press.*
- ✓ *Thermodynamic, Kinetic Theory and Statistical Thermodynamics, Fran-cis W.Sears and Gerhard L.Salinger,1986, Narosa.*
- ✓ *Modern Thermodynamics with StatisticalMechanics, CarlS.Helrich,2009, Springer*
- ✓ *Simulation of ODE/PDE Models with MATLAB, OCTAVE and SCILAB: Scientific and Engineering Applications: A.VandeWouwer, P.Saucez,C.V. Fernndez. 2014 Springer ISBN:978-3319067896*
- ✓ *Scilab by example:M.Affouf,2012.ISBN:978-1479203444*
- ✓ *Scilab Image Processing: L.M.Surhone.2010, BetascriptPub.,ISBN:978613345927*

PAPER-16 MATHEMATICAL METHODS IN PHYSICS: Credit-4

Course Objective:

This course provides a comprehensive study of advanced mathematical techniques and their applications in physics. It covers complex variables, tensor algebra, group theory and special functions. Students will gain a deep understanding of analytic functions, contour integration, tensor analysis and the mathematical tools used in symmetry and transformations. The course aims to equip students with the mathematical foundation necessary for tackling complex physical problems and theories.

Learning Outcomes:

After completing the course, the student will be able to

- Gain a comprehensive understanding of complex variables and contour integration techniques, including their applications in mathematical analysis and physics.
- Acquire knowledge and proficiency in working with tensors, a fundamental mathematical tool in physics used to describe physical quantities and their transformations.
- Develop a deep understanding of group theory and its role in physics, including applications in symmetry analysis and quantum mechanics.
- Master specialized functions commonly used in physics to solve complex problems, enhancing problem-solving skills and expanding mathematical techniques.

Unit-I

Complex Variables: Analytic functions, Contour integrals, Cauchy's integral theorem, Laurent's series, singular points, residues and the Residue Theorem, Evaluation of real definite and indefinite integrals by contour integration, indented semi-circular contour, evaluation of single and multi-valued functions, branch points and branch cuts, Contour integration involving branch point.

Unit-II

Tensors: Introduction, Types of tensor, Invariant tensor, epsilon tensor, Pseudo tensor, the algebra of tensor, Quotient law, Metric Tensor, Covariant derivative of tensor, Fundamental Tensor, artesian tensor, Christoffel symbol.

Unit-III

Group Theory: Definitions of groups, subgroups and classes, Isomorphism, Homomorphism, Cayley's theorem, Group representations, Orthogonality theorem, characters, Orthogonality relation for group character, Character table, Preliminary idea about infinite group, calculation of generator, Calculation of generator associated with SU(2)and SO (3) group.

Unit-IV

Special Functions: Legendre Polynomials, generating functions, Recurrence formulae, Orthogonality properties of Legendre's polynomial of 1stkind, Bessel generating function, Bessel function of 1^{st} and 2^{nd} Kind, Recurrence formulae, Orthogonality properties of Bessel's polynomials, Spherical Bessel functions, Fourier and Laplacetransformation.

Text books:

- ✓ *Mathematical Methods of Physics by Mathews and Walker(W. A.BenjaminInc.).*
- ✓ *Matrices and Tensors in physics by A.W.Joshi(New Age International Publisher).*
- ✓ *Mathematical Methods in the physical Science by Mary L. Boas(Wiley-India)*

Reference Books:

- ✓ *Mathematical Methods for Physicist by G.Arfken and H.Weber, Academic Press (Elsevier).*
- ✓ *Elements of Group Theory by A.W.Joshi(New Age International Publisher).*
- ✓ *Mathematical Physics by H.K.Das and Dr.R.Verma (S.Chand & Company L.T.D.).*
- ✓ *Mathematical Physics by P. K. Chattopadhyaya(New Age International).*

PAPER-17 CLASSICAL MECHANICS: Credit-4

Course Objective:

This course explores advanced topics in classical mechanics, focusing on the kinematics of rigid body motion, Hamiltonian formulation, canonical transformations, and small oscillations. It aims to provide a detailed understanding of rigid body dynamics, variational principles and the mathematical tools required for analyzing complex mechanical systems. Students will learn to apply these principles to solve practical problems in mechanics.

Learning Outcomes:

After completing the course, the student will be able to

- Analyze kinematics of rigid body motion, including Eulerian angles, orthogonal transformations and inertial tensors. Understand and apply Euler's equations of motion and the principles of torque-free motion for rigid bodies.
- Apply Hamiltonian formulation techniques, including calculus of variations, Euler-Lagrange's equations and Hamilton's principle including their use.
- Utilize canonical transformations and Poisson brackets to analyze mechanical systems. Understand the conditions for canonical transformations, apply Poincare's integral invariance, and use the Hamilton-Jacobi theory to solve problems like the harmonic oscillator and Kepler problem.

- Solve problems involving small oscillations and normal modes of vibration, including practical examples such as linear triatomic molecules and coupled oscillators. Understand the theory of small oscillations and the concept of normal coordinates.

Unit-I

KINEMATICS OF RIGID BODY MOTION: Independent coordinates of a rigid body, Orthogonal transformations, Eulerian angles, infinitesimal rotations, rate of change of vector, Coriolis force, angular momentum and kinetic energy of motion about a point, inertial tensor and the moment of inertia, Eigen values of Inertial tensor and the principal axis transformation, methods of solving rigid body problems and Euler's equations of motion, torque free motion of a rigid body. Heavy symmetrical top with one point fixed.

Unit-II

HAMILTONIAN FORMULATION: Calculus of Variations and Euler-Lagrange's Equation, Brachistochrone Problem, Hamilton's Principle, Extension of Hamilton's Principle to Nonholonomic Systems, Legendre Transformation and the Hamilton Equations of Motion, Physical Significance of Hamiltonian, Derivation of Hamilton's Equations of Motion from a Variational Principle, Routh's Procedure, Principle of Least Action.

Unit-III

CANONICAL TRANSFORMATIONS: Canonical Transformation, Types of Generating Function, conditions for canonical transformation, Integral Invariance of Poincare, Poisson Bracket, Poisson's Theorem, Lagrange Bracket, Poisson and Lagrange Brackets as Canonical Invariant, Infinitesimal Canonical transformation and Conservation Theorems, Liouville's Theorem Hamilton Jacobi Theory: Hamilton-Jacobi Equation for Hamilton's Principal Function, Harmonic Oscillator and Kepler problem by Hamilton-Jacobi Method, Action-Angle Variables for completely Separable System, Kepler Problem in Action-Angle Variables.

Unit-IV

SMALL OSCILLATION: Problem of Small Oscillations, Example of linear triatomic molecule and two coupled Oscillator, General Theory of Small Oscillations, Normal Coordinates and Normal Modes of Vibration.

Test Books:

- ✓ *Classical Mechanics-by H.Goldstein (Addison-Wesley).*

Reference books:

- ✓ *Classical Mechanics by S.N.Biswas, Books and Allied Publisher Ltd.*
- ✓ *Classical Mechanics by J.C.Upadhay, Himalaya Publishing House.*
- ✓ *Classical Mechanics by Landau and Liftshitz (Butter Worth).*

PAPER-18 QUANTUM MECHANICS-I :Credit-4

Course Objective:

This course aims to provide a comprehensive understanding of quantum mechanics by covering fundamental principles and advanced topics. Students will gain insights into the general principles of quantum mechanics, including operators, eigenvalues, and the Dirac notation, which are essential for describing quantum systems. They will explore quantum dynamics through different pictures of time evolution and problem-solving techniques such as matrix representations and operator methods. The course will delve into rotational and orbital angular momentum, focusing on commutation relations and the use of spherical coordinates. Additionally, students will study spin angular momentum, including Pauli matrices and Clebsch-Gordan coefficients, to understand the addition of angular momenta and their implications in quantum systems.

Learning Outcomes:

After completing the course, the student will be able to

- Master the foundational principles of quantum mechanics, including the Dirac notation, operators, expectation values, and the physical interpretation of Hermitian operators, eigenvalues and eigenfunctions, orthonormality, expansion theorems and completeness relations in different quantum mechanical representations.
- Analyze time evolution through the Schrödinger, Heisenberg and Interaction pictures. Students will be able to use operator methods and matrix representations to address problems such as the harmonic oscillator and understand the behavior of creation and annihilation operators.
- Understand rotational and orbital angular momentum concepts, the use of rotation matrices and angular momentum operators, commutation relations, eigenvalues, and eigenfunctions of orbital angular momentum operators.
- Explore spin angular momentum for spin-1/2 particles, master Pauli spin matrices and their properties. Students will understand the relationship between spin and rotations, solve eigenvalue problems involving spin operators.
- Apply quantum mechanical techniques to problems involving total angular momentum, including the addition of angular momenta and the use of Clebsch-Gordan coefficients.

Unit- I

GENERAL PRINCIPLES OF QUANTUM MECHANICS: Postulates of Quantum Mechanics and meaning of measurement, Operators and their expectation values. Dirac Notations, Linear vector space, Ket and Bra vectors, Scalar product of vectors and their properties, Dirac delta function, linear operators, Adjoint operators, Unitary Operators, Expectation values of dynamical variables and physical interpretation of Hermitian operators, Eigen values and eigen vectors, orthonormality of eigenvectors, probability interpretation, Degeneracy, Schmidt method of orthogonalization, Expansion theorem, Completeness and closure properties of the basis set, Coordinate and momentum representations, compatible and Incompatible observables, Commutator algebra, uncertainty relation as a consequence of non-commutability, minimum uncertainty wave packet, Representations of Ket and Bra vectors and operators in matrix form, Unitary transformation of basis vectors and operators.

Unit– II

QUANTUM DYNAMICS: Time evolution of quantum states, Time evolution operator and its properties, Schrödinger, Heisenberg and Interaction picture, Equations of motion, Operator method solution of Harmonic oscillator problem, Matrix representation and time evolution of creation and annihilation operator.

Unit – III

ROTATION AND ORBITAL ANGULAR MOMENTUM: Rotation Matrix, Orbital angular momentum operators as generators of rotation, L_x, L_y, L_z and L^2 and their Commutation relations, Raising and Lowering operators (L_+ and L_-), L_x, L_y, L_z and L^2 in Spherical Polar coordinates, Eigen values and Eigen functions of L_z and L^2 (operator method), Matrix representation of L_x, L_y, L_z and L^2.

Unit – IV

SPIN ANGULAR MOMENTUM: Spin½ particles, Pauli spin matrices and their properties, Eigen values and Eigen functions, Spin and rotations. Total angular momentum: Total angular momentum J, Eigen value problem of J_z and J^2, Angular momentum matrices, Addition of angular momentum and Clebsch-Gordan Coefficients for the states with(i)j_1=½ and j_2=½ (ii)j_1=1 and j_2=½.

Textbooks:

- ✓ *Quantum Mechanics: Concepts and Applications by Nouredine Zettile John Wiley and sons.*

Reference Books:

- ✓ *Quantum Mechanics by L.I.SchiffL.I 3rdEd, Mc Graw Hill Book Co.*
- ✓ *Quantum Mechanics by E.Merzbacher, 2nd Ed., JohnWiley& Sons.*
- ✓ *Quantum Physics by S. Gasiorowicz JohnWiley.*
- ✓ *A Text Book of Quantum Mechanics by P. M. Mathews and Venkatesan, Tata Mc GrawHill.*
- ✓ *Introduction to Quantum Mechanics ,by D. J. Griffiths,2nd edition, Pearson Publications.*
- ✓ *Lectures on Quantum Mechanics, Ashok Das, University of Rochester, USA (second edition; Hindustan Book Agency.*

PAPER-19 LABORATORY: COMPUTATIONAL PHYSICS: CREDITS-4

The main goal of this laboratory is to utilize programming languages such as C/C++, Fortran, Matlab, and Scilab to tackle straight forward problems in the fields of classical mechanics, quantum mechanics, and statistical mechanics.

1. Introduction to the programming language(e.g.C/ C++/Fortran/Matlab / Scilab).The introduction is accompanied by examples in the following general areas, (a)Sorting Algorithms- selection sort, Quick sort etc. (b)Solution of equation- Newton's method, Secant method etc.(c) Simple numerical integrations-Trapezoidal rule, simpson1/3rule.
2. Classical mechanics (2nd order ODE, initial value problems). Euler method, Modified-Euler(predictor-corrector) method, Runge-Kutta method, Leapfrog method, Verlet method, Velocity Verlet method, each with and without velocity dependent drag terms, harmonic oscillator with damping ,forced one, realistic projectile motion with air drag, realistic planetary orbit calculation.
3. Quantum Mechanics (2nd order ODE, boundary value and eigenvalue problems). Shooting method and Numerov's method, examples of boundstatescalculationfor1Dwells, quantum harmonic oscillators. Eigen value problem in matrix form(finite dimensional basis), and exact (Lanczos) diagonalization, Variational calculation with orthogonal basis states. Time-dependent Schrodinger equation, wave equation.
4. Statistical Mechanics (Stochastic and Monte Carlo Methods). Uniform random number generation, Random walk and diffusion, MonteCarlo Integration—advantage in higher dimension, error analysis. Importance sampling and detailed balance. Generation of random numbers from a Gaussian distribution-- Box Miller method, using central limit theorem, Sampling points from arbitrary distributions –Metropolis sampling and examples.

Reference Text books:

- ✓ *Computational Physics, N.J.Giordano and H.Nakanishi, Pearson PrenticeHall(2006).*
- ✓ *Introduction to Computational Physics, PaoTang, Cambridge University Press.*
- ✓ *Computational Physics, S.E.Koonin and D.C.Meredith, Addison-Wesley Publishing Company.*
- ✓ *Computational Physics, J.M.Thijssen, Cambridge University Press.*

PAPER- 20 CLASSICAL ELECTRODYNAMICS: CREDIT- 4

Course Objectives:
This course aims to provide a comprehensive understanding of electrodynamics with a focus on its covariant formulation. It will equip students with the skills to work with Maxwell's equations in their relativistic form and understand the implications of electromagnetic field tensors. The course also covers wave equations for electromagnetic potentials, radiation fields and wave propagation in rectangular waveguides. Students will

explore radiation from accelerated charges, including classical radiation processes such as bremsstrahlung and Cherenkov radiation, and will gain insight into the phenomena of scattering, dispersion and radiation damping in various physical contexts.

Learning Outcomes:

Upon completion of this course, students will be able to:

- Formulate Maxwell's equations in a covariant form using tensors and apply Lorentz transformations to electromagnetic systems.
- Solve inhomogeneous wave equations and analyze radiation fields, including electric dipole and multipole radiation.
- Derive Lienard-Wiechart potentials and describe the electromagnetic fields of uniformly moving and accelerated charges.
- Analyze wave propagation in rectangular waveguides and understand the principles of electromagnetic wave transmission.
- Understand and apply the principles of radiation damping, scattering, Rayleigh scattering and dispersion relations in different media.

UNIT- I:

Covariant formulation of electrodynamics: Lorentz transformation; Scalars, vectors and Tensors; Maxwell's equations and equations of continuity in terms of $A\mu$ and $J\mu$; Electromagnetic field tensor and its dual; Covariant form of Maxwell's equations; Lagrangian for a charged particle in presence of external electromagnetic field and Maxwell's equation as Euler-Lagrange equations.

The Inhomogeneous Wave equation: Wave equations for potentials, solution by Fourier analysis, Radiation field, Radiation energy, Hertz potential, Computation of radiation fields by Hertz method, electric dipole radiation, multipole-radiation.

UNIT–II

Lienard-Wiechart potential and Field of a uniformly moving electron: Lienard- Wiechart potential, Fields of a charge in uniform motion, Direct solution of the wave equation, Convection potential, Virtual photon concept.

Waveguides, Propagation of electromagnetic waves in rectangular waveguides.

UNIT–III

Radiation from Accelerated Charges: Radiation from an accelerated charge, Fields of an accelerated charge radiation at low velocity, Case of velocity parallel to acceleration, radiation from circular orbits, Radiation with no restrictions on the acceleration or velocity, Classical cross section for bremsstrahlung in a Coulomb field, Cherenkov radiation.

Unit–IV

Radiation, scattering and dispersion: Radiative damping of a charged harmonic oscillator, forced vibrations, scattering by an individual free electron, scattering by a bound electron, absorption of radiation by an oscillator, equilibrium between an oscillator and a radiation field, effect of a volume distribution of scatters, scattering from a volume distribution, Rayleigh scattering, the dispersion relation.

Text Book:
- ✓ *"Classical Electricity and Magnetism" by Wolf gang K.H. Panofsky and Melba Philips, Second Edition*

Reference books:
- ✓ *"Classical Electrodynamics", Jakson J D, John Wiley.*
- ✓ *"Introduction to Electrodynamics", Griffiths D J, Prentice Hall.*

PAPER- 21 QUANTUM MECHANICS-II: CREDIT- 4

Course Objectives:

This course aims to provide a comprehensive understanding of quantum mechanical systems and their applications. Students will explore the motion of particles in a spherically symmetric field, with particular emphasis on the hydrogen atom, free-particle problems, and bound states. The course will delve into various approximation methods, including perturbation theories, variational methods, and the WKB approximation, to solve complex quantum systems. Additionally, the course will cover advanced concepts like scattering theory, focusing on scattering amplitudes, cross-sections, and the behavior of identical particles. Through these topics, students will develop the skills to solve complex quantum mechanical problems and gain insight into the mathematical tools used in quantum physics.

Learning Outcomes:

By the end of the course, students will be able to:

- Analyze the motion of quantum particles in spherically symmetric fields, solving radial equations and interpreting energy eigen values.
- Apply various approximation methods, including perturbation theory and variational methods, to solve non-degenerate and degenerate quantum systems.
- Understand and use the WKB approximation method to solve one-dimensional quantum problems and study phenomena like cold emission.
- Calculate scattering amplitudes and cross-sections, and apply the Born approximation and partial wave analysis in scattering problems.
- Distinguish between the scattering behavior of identical particles and use symmetric and anti-symmetric wave functions in quantum analysis.

UNIT-I

Motion in a spherically symmetric field: The hydrogen atom, Reduction to equivalent one body problem, radial equation, Energy eigen values and eigen functions, Degeneracy, Radial probability distribution, free-particle problem, Expression of plane waves in terms of spherical waves. Bound states of a 3-D square well.

UNIT-II

Approximate methods: Stationary perturbation theory, Rayleigh Schrodinger method for non-degenerate case, first and second order perturbation, anharmonic oscillator, general theory for the degenerate case, removal of degeneracy, linear Stark effect, normal Zeeman effect.

UNIT-III

Variational method: Ground State, First Excited State and Second Excited State of H- atom One-Dimensional Harmonic Oscillator, and He-atom.

W.K.B. method: Connection formulas, Bohr-Somerfield quantization rule, Harmonic oscillator and cold emission.

Time-dependent perturbation theory: Transition probability, constant and harmonic perturbation, Fermi Golden rule

UNIT-IV

Scattering amplitude and scattering cross section: Born approximation, application to Coulomb and screened Coulomb potentials. Partial wave analysis for scattering, optical theorem, scattering from a hard sphere, resonant scattering from a square well potential. Identical particles, Symmetric and anti symmetric wave function, Scattering of identical particles.

Text Book:

- ✓ *"Quantum Mechanics: Concepts and Applications" by Nouredine Zettile John Wiley and sons.*

Reference Books:

- ✓ *"Quantum Mechanics", L.I. Schiff 3rd Ed, McGraw Hill Book Co.*
- ✓ *"Quantum Mechanics" E. Merzbacher, 2nd Ed., John Wiley & Sons.*
- ✓ *Quantum Physics", S. Gasiorowicz John Wiley.*
- ✓ *"A Text Book of Quantum Mechanics" by P.M.Mathews and Venkatesan, Tata McGraw Hill.*
- ✓ *"Introduction to Quantum Mechanics", by D.J.Griffiths,2nd edition, Pearson Publications.*

PAPER-22 ELECTRONICS: CREDIT- 4

Course Objectives:

This course aims to provide students with a solid foundation in the analysis and design of electronic circuits, including both analog and digital systems. The course covers fundamental principles of network analysis, including the application of Thevenin and Norton theorems and explores the characteristics and biasing of BJTs, FETs, and MOSFETs.

It introduces students to operational amplifiers, their configurations, and applications. The course also focuses on oscillator circuits, digital logic, and the use of logic gates in electronic systems. Furthermore, students will gain an understanding of optoelectronic devices, such as LEDs, laser diodes, and optical detectors, along with their applications in modern electronics

Learning Outcomes:

By the end of the course, students will be able to:

- Apply different network theorems, to analyze and simplify complex circuits. Also can design circuits using BJTs, FETs, and MOSFETs, and understand the impact of feedback on electronic circuit performance.
- Design and implement operational amplifier circuits, including differentiators, integrators, and comparators, for practical applications in signal processing.
- Understand and design oscillator circuits, including phase-shift, Wien-Bridge, and crystal-controlled oscillators, using feedback criteria and Nyquist principles.
- Develop digital circuits using logic gates and flip-flops, and understand the fundamentals of analog-to-digital and digital-to-analog conversion processes.
- Explain the working principles of optoelectronic devices such as LEDs, laser diodes, and photodetectors, and analyze their performance in optical communication and energy conversion systems.

UNIT-I

Network Analysis: Superposition principle The venin and Norton Theorems, BJT, FET, MOSFET: characteristic, biasing- parameter analysis Feedback Circuits. Operational Amplifiers: The differential amplifier, D.C. and A.C. signal analysis, integral amplifier, rejection of common mode signals, CMMR, The operational amplifier, input and output impedances, Application of operational Amplifiers unit gain buffer, summing, integrating amplifier, Comparator, Operational amplifier as a differentiato**r.**

UNIT-II

Oscillator circuits: Feedback criteria for oscillation, Nyquist criterion, Phaseshift, Wien-Bridge oscillator, Crystal controlled oscillator

UNIT-III

Digital Circuits: Logic fundamentals, Boolean theorem, logic gates: AND, OR, NOT, NOR, NAND, XOR, and EXNOR. RTL, DTL and TTL logic, Flip-flop, RS-and JK-Flipflop, A/D and D/A Convertors

UNIT-IV

Optoelectrics Device: Principle of optical sources, Source material, Choice of materials, Internal and external quantum efficiency of L.E.D., Structures, Types of L.E.D.: Surface emitting L.E.D., Edge emitting L.E.D., Modulation capability, emission pattern, power bandwidth product, laser Diode Modes, Threshold condition, resonant frequency, Laser Diode Structure, Brief description of principle of optical detectors, Photomultipliers P.I.N. and A.P.D. configuration, Solar Cell.

Textbooks and reading materials

- ✓ *Electronic fundamental and application by J.D.Ryder, PHI, Learning Pvt Ltd.*
- ✓ *Electronics: Circuits and Analysis, D.C. Dubey, Alpha Science*
- ✓ *R. P. Khare, Fiber Optics and Optoelectronics, Oxford University Press*

Reference Books:

- ✓ *Foundation of electronics– Chattopadhyay, Rakshit, Saha and Purkait, New age International publisher*
- ✓ *Electronics principles-Albert Malvino, Tata McGraw-Hill Edition*
- ✓ *Modern Digital Electronics- R.P Jain, Tata Mc Graw-Hill Edition*

PAPER- 23 LABORATORY: OPTICS AND MODERN PHYSICS : CREDIT- 4

The main objectives of this laboratory course are:

1. To apply the principles of optics, electronics, and modern physics in conducting experiments.
2. To gain a better understanding of theoretical principles through hands-on experimentation.

N.B: Following is the list of some experiment however, the college can add any other experiments as per the convenience.

Optics & Modern Physics:

1. Determination of Boltzmann constant using V-I characteristics of PN diode.
2. Determination of Planck's constant using LEDs at least four colors.
3. Determination of e/m by Bar magnet/ magnetic focus sung
4. Study of photo-electric effect.
5. Study of diffraction pattern of single and double slits using laser source and determination of its Wave length.
6. Study the electrical resistance as a function of temperature.
7. Experiments with Michelson interferometer: Determination of A and α Thickness of mica sheet
8. Fabry Perot interferometer Polarization Experiments Babinet compensator Edsar-Butler bands
9. Quarter wave plate Mallus Law Study of elliptical polarized light
10. Constant Deviation Spectrography Calibration Zeeman effect

11. Babinet Quartz Spectrography
12. Any other suitable experiments
13. Any other experiments that may be set up from time to time.

Reference Books:

- ✓ *Elements of Modern Physics: Laboratory (BPHEL-142, Prepared by: Ignou: school of science (https://egyankosh.ac.in)*
- ✓ *Modern Physics Lab (PHYS340) Prepared by: Purdue University, (https://www.physics.putrdue.edu*

Multidisciplinary Course (MDC):

Physics: Credit-3

Course objective:
The course has objectives to provide Basic knowledge of Physics like Kirchhoff's laws, use of Wheatstone Bridge, N-type & P-Type Semiconductor, biasing a PN junction, transistors and their connections, Students will be able to do load line analysis of any transistors..

Course Outcome:
After completion of this course, the students will be able to

- Understand the basic idea of drift velocity and the origin of resistivity. They will be able to find out the unknown resistance using a wheatstone bridge and can understand the difference of cells connected in Series and in Parallel
- Get ideas regarding majority and minority charge carriers and the effect of temperature on resistivity of a semiconductor.
- Know the forward and reverse biasing and the operating conditions of junction diodes.
- Solve problems on common transistor connections, their leakage currents and will understand different uses of semiconductor devices.

UNIT-I
Electric Current, Electric Currents in Conductors, Ohm's law, Drift of Electrons and the Origin of Resistivity, Limitations of Ohm's Law, Resistivity of Various Materials, Temperature Dependence of Resistivity, Electrical Energy, Power, Cells, emf, Internal Resistance, Cells in Series and in Parallel, Kirchhoff's Rules, Wheatstone Bridge

UNIT-II
Semiconductor: Bonds in Semiconductors, Crystals, Commonly Used Semiconductors, Energy Band Description of Semi-conductors, Effect of Temperature on Semi-conductors, Hole Current, Intrinsic & Extrinsic Semiconductor, N-type & P-Type Semiconductor, Charge on n- type and p-type Semiconductors, Majority and Minority, Carriers.

UNIT-III

Properties of pn-Junction, Applying D.C. Voltage across pn- Junction or Biasing a pn- Junction, Current Flow in a Forward Biased pn-Junction, Volt-Ampere Characteristics of pn Junction, Important Terms, Limitations in the Operating Conditions of pn- Junction.

UNIT-IV

Transistor, Some Facts about the Transistor, Transistor Symbols, Transistor Connections, Characteristics of Common Base Connection, Measurement of Leakage Current, Common Collector Connection, Commonly Used Transistor Connection, Transistor Load Line Analysis, Practical Way of Drawing CE Circuit, Performance of Transistor, Amplifier, Power Rating of Transistor, Semiconductor Devices Numbering System

Text Books:

✓ *PHYSICS PART – I TEXTBOOK FOR CLASS XII*

Reference Books:

✓ *Principles of Electronics by V K Mehta & Rohit Mehta*