SYLLABUS

POST GRADUATE COURSE

PHYSICS

(With effect from 2021-2022)

Under Choice Based Credit System
with
Semester Pattern

DEPARTMENT OF PHYSICS
Maharaja Sriram Chandra BhanjaDeo University
Sriram Chandra Vihar
Takatpur, Baripada-757003

M.Sc. (PHYSICS) EXAMINATION

(Choice Based Credit System

Semester Pattern)

1. The course is of two years duration comprising of four semesters of theory and laboratory works.
2. There is one open elective paper in semester-II (Phy-412). This is exclusively open for the students of other departments.
3. Each student has to carry out project work from Semester-III and submit a dissertation before the commencement of Semester-IV theory examination.
4. The student can opt one elective course comprising of two papers in the 2^{nd} year of PG programme.
5. The examination system for each theory paper consists of one IAE of 20 marks and one semester exam of 80 marks. The IAE shall be one hour duration and shall cover at least two units. The semester examination shall be 3 hour duration and the question paper shall be of unit pattern with two alternatives from each unit having equal weight. However, in practical paper semester examination shall be 100 marks and of 6 hours duration.
6. A candidate must secure at least 40% marks in practical and 30% marks in individual theory paper to pass the semester examination.
7. The First Class First student shall receive the University Gold Medal in the concerned regular P.G. Course provided that he/she has cleared all the papers of the semester examinations in a single attempt.
8. If the candidate passes all the four semester examinations he/she will be declared to have passed the M.Sc. examination–in Physics. Further, under no circumstance a candidate shall be allowed to appear any Semester Examination after completion of the twice the duration of the course.
9. The student has to secure at least 75% of attendance to be eligible to appear at the University examination.

Programme Outcome:

- The students will acquire advanced conceptual knowledge and comprehensive understanding of the fundamental principles in physical science.
- They will be prepared to take up challenges as globally competitive physicists/researchers in diverse areas of theoretical as well as experimental physics.
- They will be equipped with enough technical and analytical skilled to pursue their further studies and develop continuous learning through their professional career.
- They will be trained to appear national level tests like UGC-CSIR NET, JEST, GATE, etc., successfully.
- They will acquire the sense of academic and social ethics.

Programme Specific outcome:

- The student will understand the core courses forming the basis of physics namely, Classical Mechanics, Quantum Mechanics, Mathematical Physics, Statistical Physics, Electromagnetic Theory, Atomic and Molecular Physics, Solid State Physics, Electronics, Nuclear and Particle Physics.
- They will learn computational physics to equip them to use computers as a tool for scientific computation and analysis.
- They will understand the basic concepts of certain sub fields through elective course such as solid state physics, and particle physics.
- They will motivate towards research in physics through the dissertation work in both theory and experimental stream.
- They will develop creative thinking and problem-solving capabilities encouraged through mentor system.
- They will learn through experimental skills in both the core and elective labs, designed to develop an appreciation for the fundamental concepts and working of devices used in scientific methods/tools of physics.
- They will be capable of taking up higher studies of interdisciplinary nature.

P.G. DEPARTMENT OF PHYSICS
COURSE STRUCTURE

SEMESTER - I

Code	Title	Credit	Marks		Total
			Internal	Semester	
Phy-401	Mathematical Physics	05	20	80	100
Phy-403	Classical Mechanics	05	20	80	100
Phy-405	Quantum Mechanics-I	05	20	80	100
Phy-407	Computer Application in Physics	05	20	80	100
Phy-409	Practical (Optics & Modern Physics)	05		100	100
Total		**25**	**80**	**420**	**500**

SEMESTER - II

Code	Title	Credit	Marks		Total
			Internal	Semester	
Phy-402	Basic Electronics	05	20	80	100
Phy-404	Quantum Mechanics-II	05	20	80	100
Phy-406	Statistical Mechanics	05	20	80	100
Phy-408	Classical Electrodynamics	05	20	80	100
Phy-410	Practical (Computational Physics)	05		100	100
Phy-412	Electronics & Instrumentation (Open Elective)	05	20	80	100
Total		**30**	**100**	**500**	**600**

SEMESTER - III

Code	Title	Credit	Marks		Total
			Internal	Semester	
Phy-501	Quantum Principles, Atomic & Molecular Spectra	05	20	80	100
Phy-503	Condensed Matter Physics	05	20	80	100
Phy-505	Advanced Quantum Mechanics	05	20	80	100
Phy-507	Elective – I	05	20	80	100
Phy-509	Practical (Electronics)	05		100	100
Total		**25**	**80**	**420**	**500**

SEMESTER - IV

Code	Title	Credit	Marks		Total
			Internal	Semester	
Phy-502	Basic Nuclear & Particle Physics	05	20	80	100
Phy-504	Elective – II	05	20	80	100
Phy-506	Practical (Elective)	05		100	100
Phy-508	Project work, Presentation and viva	05		100	100
	Total	**20**	**40**	**360**	**400**
	GRAND TOTAL	**100**			**2000**

Elective: The students can opt for any one out of Solid State Physics/Particle Physics.

SEMETSER-I

Phy-401 MATHEMATICAL PHYSICS 100(80+20) MARKS

Course Objective: This course is aimed to equip the students with the mathematical techniques for the application of mathematical methods used in various branches of physics.

Contents:

UNIT- I

Linear independence, Bases, Dimensionality, Inner product, linear transformations, Matrices, Inverse, orthogonal and unitary matrices, independent elements of a matrix, Eigen values & eigen vectors, Diagonalization, Complete orthonormal sets of functions, Definition of a Group and its representation: homomorphism, isomorphism, reducible and irreducible.

UNIT-II

Element of complex analysis, analytic function, Taylors and lorent series, poles, residues and evaluation of Integrals, Tensors and their ranks, outer product and contraction, kronecker Delta δ_{ij} and the Levi-civita tensor ε_{ijk}, vector analysis using tensor notation

UNIT–III

Laplace transform, solution of differential equations by laplace transformation, Inverse LT by partial functions, LT of derivative, Fourier series, FS of arbitrary period, Half wave expansions, Fourier integral & transforms, Green's function solution of inhomogeneous differential equation, Properties of Green's function in one dimension

UNIT – IV

Series expansion: Bessel, Hermite, Laguerre, Hypergeometric, Confluent, Hypergeometric equations, Generating function, Rodrigues formula, and recursion relation of Bessel, Hermite and laguerre polynomials.

Course Outcome: The student will understand the importance of special type of matrices and tensors complex analysis, method of contour integration to evaluate definite integrals of varying complexity. They have gained ability to apply group theory to physics problems, which is a pre-requisite for deeper understanding of crystallography, particle physics, quantum mechanics and energy bands in solids. They also learn how to solve different second order differential equations and their applications in Physics. They also learn the fundamentals and applications of Fourier series, Fourier and Laplace transforms required for solving various problems in different branch of Physics.

Recommended Books:

1. Mathematical Methods of Physics - G. Arfken
2. Mathematical methods of Physics - J. Mathew & R.L. Walker
3. Matrices & Tensor for Physicists - A.W. Joshi
4. Mathematical Physics - C. Harper
5. Mathematical Method - P.K. Chattopadhya
6. Hand book of Mathematical Function with Formulas, Graphs and Mathematical Tables -M.Abramowitz and I.A.Stegun

Phy-403 **CLASSICAL MECHANICS** 100(**80+20) MARKS**

Course Objectives: This course is aimed to provide basic and advanced concepts in classical mechanics. The course covers starting from basic Newton equation of motion up to advanced Hamilton-Jacobi theory and formalism.

Contents:

UNIT – I

Lagrangian, Homogeneity and isotropy of space and conservation of linear and angular momentum, Homogeneity of time and conservation of energy, Rigid body motion: The independent co-ordinates of a rigid body, orthogonal transformations, The Euler angles, The Cayley-Klein parameters, Euler's theorems on the motion of a rigid body, infinitesimal rotations, rate of change of a vector, The coriolis force.

UNIT – II

Angular momentum and kinetic energy of motion about a point, The inertia tensor and the momentum of inertia, the principal axis transformation, The Euler equation of motion**,** Torque-free motion of a rigid body, The Heavy symmetrical top with one point fixed.

UNIT – III

Legender transformation and Hamilton's equations of motion, Physical significance of the Hamiltonian, Derivation of Hamilton's equations from variational principle. The equations of canonical transformations, Integral invariant of Poincare, Lagrange and Poisson brackets as canonical invariants, The equations of motion, infinitesimal contact transformations and conservation theorems in the Poisson bracket formulation.

UNIT –IV

Hamiltonian-jacobi equation and application to harmonic oscillator, Action-angle variables, The Kepler problem, H-J theory, Geometrical optics and wave mechanics.

Problem of small oscillations, Normal co-ordinates and free vibration of a linear triatomic molecule.

Course Outcomes: Upon successful completion of this course, student will be able to understand that the conservation principles follow from the fundamental equation of motions and distinguish the number of generalized coordinates required for the description of configuration of rigid body motion under real as well as complex plane. Besides this they will have a deep understanding for canonical transformations. Most important thing student learned from this course is how to write Hamiltonian of a system and solve the wave equation for frequency and amplitude of oscillation using linear approximation.

Recommended Books:

1. Classical Mechanics - H. Goldstein
2. Mechanics - Landau and Litshitz
3. Classical Dynamics - Marion & Thornton
4. Classical Mechanics - Corben & Stehle

Phy-405 QUANTUM MECHANICS-I 100(80+20) MARKS

Course Objective: This course is aimed to introduce the foundations of quantum mechanics together with problems

Contents:

UNIT – I

Linear vector space, ket and bra vectors, scalar product of vectors and their properties, linear operators, Adjoint operator, unitary operator, Expectation values of dynamical variables and physical interpretation, Hermitian operators, Eigen values and eigen vectors, othonormality of eigen vectors, probability interpretation, Degeneracy, Schmidt method of orthogonalization. Expansion theorem, completeness and closure property of the basis set, co-ordinate, momentum and energy representations. Compatible and incompatible observables, commutators algebra, uncertainty relation as a consequence of noncomutability, minimum uncertainty wavepacket.

UNIT - II

Representation of ket and bra vectors and operators in the matrix form, unitary transformations of basis vectors and operators. Different types of pictures in quantum mechanics and their equation of motion, Solution of Harmonic Oscillator (Operator method)

Rotation Matrix, Angular momentum operators as the generators of rotation, L_x,L_y,L_z and L^2 and their commutator relations, raising and lowering operators (L_+ and L_-), L_x,L_y,L_z and L in spherical polar co-ordinates, Eigen values and Eigen functions of L_z, L^2 (OP method), Spherical harmonics, Matrix representation of L_+, L_-, and L^2.

UNIT III

Spin ½ particles, Pauli spin matrices and their properties, Eigenvalues and Eigenfunction, Spinor transformation under rotation.Total angular momentum J, Eigen value problem of J_z and J^2. Angular momentum matrices, Addition of angular momenta and C.G. Co-efficients, Angular momentum states for composite system in the angular momenta (1/2,1/2) and (1,1/2).

UNIT – IV

Hydrogen atom, Reduction to equivalent one body problem, Radial equation, Energy eigenvalues and eigen functions, degeneracy, radial probability distribution.

Free particle problem, incoming and outgoing spherical waves, expansion of plane waves in terms of spherical waves, Bound states of a 3-d square well, particle in a sphere.

Course Outcomes: Students will learn: the importance of studying quantum mechanics at microscopic level, the concepts of basis and operators along with vector spaces, Hilbert space formalism employing Dirac notation, the theory of angular momenta and their matrices, the Clebsh-Gordan Coefficient and various tools to calculate eigenvalues of some basic quantum systems.

Recommended Books:

1. Quantum Physics - L.I. Schiff
2. Introduction to Quantum mechanics - R.H. Dicke & J.P. Witke
3. Quantum Physics - S. Gassiorowick
4. Quantum Mechanics - B. Craseman & J.D. Powell
5. Quantum Mechanics - E. Merzbacker

Phy-407 COMPUTER APPLICATION IN PHYSICS 100(**80+20) MARKS**

Course Objectives: This course provides introduction to numerical methods, programming in FORTRAN and introduction to MATLAB.

Contents:

UNIT – I

Numerical method error and Algorithm: Numerical method, characteristics of numerical commuting, decimal system, binary system, limitations of representing numbers in computer, Absolute, relative and percentage errors, significant digits in approximation, General formula for errors, Application of the error formula, truncation error, order of error, propagation of error

Introduction to FORTRAN-77,
Flow charts, Algorithms, Integer and Floating point, Arithmetic, Precision, Variable types, Arithmetic statements, Input & output statements

UNIT – II

Control statements, Do loops, While structure, Arrays, Subscripted, Subroutines, Sub program, Data files

UNIT – III

Newton and lagrange interpolation, Bisection and Newton-Rapson methods, Matrix & Linear equations: Pivotal Condensational method, Gauss elimination method, gauss-Jordan elimination method

UNIT –IV

Matrix inversion, Numerical integration: Simpson, Trapezoidal methods, Runge-Kutta method for solutions of differential equations

Introduction to Math lab
What is Matlab, where do I get Matlab, Matlab windows,on line help,input output,file types, to learn how to do simple arithmetic calculation, how to assign values to variable, how to suppress screen output, how to quit Matlab, calculating and working with arrays of numbers, creating and printing simple plots, creating, saving and executing a script file

Course Outcomes: Students learning this course get fundamental and theoretical ideas of computers about learning basics involved in FORTRAN 77 that helps them frame programs on mathematical problems of various kinds. The skill of developing programme for computational work and analysis helps students getting employability in different branches of physics and engineering.

Recommended Books

1. Fortran 77 and Numerical methods - C. Xavier
2. Computer programming in FORTRAN 77 - V. Rajaraman
3. Numerical Computational Methods- P.B. Patil, U.P. Verma
4. Numerical Analysis - B.P. Acharaya & R. N. Das
5. Computer Application in Physics - Suresh Chandra
6. Getting started with Matlab - Rudra Pratap, Oxford University press

Phy-409 **PRACTICALS** **100 MARKS**

Experiments on Optics and Modern Physics

Course Objectives: This course provides an overview of practical skills in optics and Morden physics sector

Contents:

1. Michelson Interferometer.
2. Measurement of Rydberg Constant.
3. E/M measurement by Braun tube.
4. E/M measurement by magnetron valve.
5. Dielectric constant of solid (wax) by Letcher's wire.
6. Magnetic field measurement by search coil.
7. Determination of e by Millikan's oil drop experiment.
8. Verification of Brewster's law using spectrometer
9. Verification of Richardson's T2 law.
10. Determination of wavelength of LASER source.
11. Stefans Constant
12. Photovoltaic Cell
13. Determination of Plank's const

Course Outcomes:

Student will familiarize with the basic experimental on modern physics and optics like Interferometer, verification of Brewsters law, dielectric constants using Letcher/s wire etc. It will help them to realize its correspondence with the theory.

SEMESTER-II

Phy-402 BASIC ELECTRONICS 100(80+20) MARKS

Course Objectives: This course is aimed to introduce the students with the basic knowledge of working, characteristics and applications of electronics passive as well as active components.

Contents:

UNIT – I

PN junction: construction and working principle, properties of pn junction. Zener diode: working principle and properties, zener diode as voltage stabiliser. Transistor: structure, principle of operation and static characteristics of bipolar junction transistor (common base and common emitter connection only), structure, principle of operation and characteristics of Field effect transistor.

UNIT– II

Operational amplifier: Introduction to Op amplifier, the 741OP amplifier. Inverting and Non-inverting amplifier: voltage gain, input and output impedance.
Applications of Operational amplifier: Summing amplifier, differential amplifier, Integrating amplifier, differentiator amplifier, Barkhausen criterion of oscillation, Hartley oscillator, Colpitts oscillator.

UNIT- III

Basic digital concepts: Binary logic states, Binary Arithmetic.
Logic gates and Combinational logics: Gate types and truth table of AND, OR, NOT, NAND, NOR, XOR, XNOR. Converter: Analog to digital and digital to analog. Boolean algebra and Demorgan's theorems. Boolean theorems: Aalgebrically, Venn diagram and induction table. Half and Full adder, Half and Full subtractor, flip flop (RS and JK).

UNIT-IV

Modulation: Amplitude modulation, frequency modulation, phase modulation and demodulation.
Radio wave propagation: Surface wave, space wave, tropospheric wave and sky wave. AM/FM radio transmitters and receivers (Block diagram only). Elementary principles of TV.
Introduction to microprocessor, A simple microprocessor (μp) based system, Architecture of intel 8085, Pinout diagram of 8085, Interfacing, The 8085 instruction set, Programming a microprocessor, Microprocessor applications.

Course Outcomes: On completion of this course the student will learn about PN junction Diodes, Transistors, Field Effect Transistors, their principles and applications, Basic operational amplifier characteristics, OPAMP parameters, applications as adder, subtractor inverter, integrator, differentiator, Oscillators etc. They also learn basics of major digital devices. The students will acquire fundamental knowledge on AM/FM transmitter and receiver, TV etc. which helps them to get job in electronic industry.

Recommended Books:

1. Fundamental Principle of Electronics - B. Ghosh
2. Electronic Fundamental and application - J. D. Ryder
3. Integrated Electronics - Milliman and Halkias
5. Electronic: Principle & Application - A. P. Malvino

Phy-404 QUANTUM MECHANICS - II 100 (80+20) MARKS

Course Objectives: This course describes a thorough conceptual understanding of advanced quantum mechanics covering perturbation theory, vibrational principle and scattering

Contents:

UNIT – I

Stationary perturbation theory, Rayleigh Schroedinger method for non-degenerator case, First and second order perturbation, application to anharmonic oscillator, General theory for the degenerate case, Removal of degeneracy, Linear and quadratic stark effect, Normal and anamolus, Zeeman effect.

UNIT-II

Variational Principle, Ground state of He-atom.

Connection formulas, Bohr Sommerfeld quantization rule, Application to Harmonic oscillator.

UNIT – III

Transition probability, Constant and harmonic perturbation, Fermi's golden rule, Electric dipole radiation and selection rules, Spontaneous emission Einstein's A,B –coefficients, Basic principles of Laser.

UNIT – IV

Scattering amplitude and cross section, Born approximation, Application to coulomb and screened coulomb potential.

Partial wave analysis for elastic and inelastic scattering effective range and scattering length, optical theorem, scattering from a hard sphere and square well potential.

Course Outcomes: Students will learn: the application of approximation methods, basics of perturbation theory and radiative transitions, the theory of scattering, optical theorem, Born approximation, partial wave analysis etc., interaction of an atom with the electromagnetic field and various tools to calculate eigenvalues of some quantum systems.

Recommended Books:

1. Quantum Mechanics - L.I. Schiff
2. Introduction to Quantum Mechanics - R. H. Dicke & J.P. Witke
3. Quantum Physics - S. Gassiorowick
4. Quantum Mechanics - B. Craseman & J.D. Powell
5. Quantum Mechanics - E. Merzbacker
6. Quantum Mechanics - Mathews & Venkateswar

Phy-406 **STATISTICAL MECHANICS** 100 (**80+20) MARKS**

Course Objective: This course is aimed to provide the basic concepts on foundations of classical and quantum statistics to make use of this theory in various branches of physics.

Contents:

UNIT – I

Idea about various kinds of statistics, Concept of macrostate & microstate with examples, Contact between statistics & thermodynamics, Postulate of classical statistical mechanics, Liouville's theorem, Microcanonical ensemble, Derivation of thermodynamics, equipartition theorem, classical ideal gas, Gibb's paradox.

UNIT – II

Canonical ensemble and energy fluctuation, grand canonical ensemble and density fluctuation, equivalence of canonical and grand canonical ensemble.

UNIT – III

The density matrix, ensemblies in quantum statistical mechanics, ideal gas in micro canonical and grand canonical ensemble, equation of state for ideal Fermi gas, Theory of white dwarf stars, ising model, Definition of Ising model, ID-Ising model,Ising model, Definition of Ising model, 1D-Ising model

UNIT – IV

Ideal Bose Gas, Photons and Planck's law Phonons, Bose- Einstein condensation. Thermodynamics description of phase transitions, phase transitions of first order and second order with examples, Discontinuity of specific heat.

Course Outcomes: A student after completion of this course will be able to determine the statistical and thus, thermodynamic behavior of separate macroscopic systems consisting of large number of microscopic particles satisfying various statistics like Maxwell-Boltzmann statistics, Bose-Einstein statistics and Fermi-Dirac statistics.

Recommended Books:

1. Statistical Mechanics - K. Hung
2. Elementary Statistical Physics - C. Kittel
3. Statistical Mechanics - F. Mohling
4. Statistical Mechanics - Landau and Lif shitz
5. Thermal Physics - C. Kittel
6. Statistical Mechanics - H. Patheria
7. Fundamentals of Statistical & Thermal Physics - F. Reif

Phy-408 CLASSICAL ELECTRODYNAMICS 100 (80+20) MARKS

Course Objective: The objective of this course is to familiarize with the concepts of classical electrodynamics related to Maxwell's equation, wave guides, field and radiation of localized oscillating sources and Maxwell field tensors

Contents:

UNIT – I

Maxwell's displacement current; Maxwell's equation, vector and scalar potentials, Gauge transformation, Lorentz and coulomb gauge, Green's function for the wave equation, Poynting's theorem, Plane waves in a non conducting medium, linear and circular polarizations, Stoke's parameters

UNIT-II

Reflection, Refraction of electromagnetic waves at a plane interface between dielectrics, frequency dispersion characteristics of dielectrics, conductors and plasma, Causality in the connection between D and E, Kramer-Kroning relations.

Wave guides, cylindrical wave guides, mode in a rectangular waveguide, rectangular resonate cavities

UNIT – III

Fields and radiation of a localized oscillating source, electric dipole, magnetic dipole and electric quadrupole fields, center-fed linear antenna with sinusoidal current, scattering by a small dielectric sphere in long wavelength limit, Rayleigh scattering

UNIT – IV

Radiation by moving charges; Lienard-Wiechert bPotentials and fields for a point charge, Total power radiated by an accelerated charge-Larmor's formula

Four vector notation, Relativistic particle kinematics and dynamics, covariant form of Maxwell equations, Maxwell field tensor, and transformation of electromagnetic field components

Course Outcomes: Student will understand the key features of electrodynamics since all the forces of ordinary experience are ultimately electromagnetic in nature except the force of gravity.

Recommended Books:

1. Classical Electrodynamics: - J.D. Jacksons
2. Introduction to Electrodynamics: - D.J. Griffiths
3. Electrodynamics - B. B. Laud
4. Foundation of Electrodynamics Theory - Reitz, Milford and Christy
5. Classical Electrodynamics - S. P. Puri
6. Principles of Optics - M. Born and E. Wolf
7. Classical Electricity and Magnetism - Panotsky and Phillips

Phy-410 PRACTICALS 100 MARKS

COMPUTATIONAL METHODS IN PHYSICS

Course Objectives: It aims to practice students how to solve physics problems through different numerical techniques

Contents:

(A) Exercises for acquaintance:

1. To find the largest or smallest of a given set of numbers
2. To generate and print first hundred prime numbers
3. Sum of an AP series, GP series, Sine series, Cosine series
4. Factorial of a number
5. Transpose a square matrix
6. Matrix multiplication, addition
7. Trace of a matrix
8. Evaluation of log and exponentials
9. Solution of quadratic equation
10. Division of two complex numbers
11. To find the sum of the digits of a number

(B) Numerical Analysis:

1. Interpolation by Lagrange method
2. Numerical solution of simple algebraic equation by Newton- Raphson method, Bisection method
3. Solution of linear homogeneous equations
4. Matrix inversion
5. Numerical integration : Trapezoidal method, Simpons method, Gauss quadrature method
6. Solution of ordinary differential equation by Runge-Kutta Method
7. Least Square fit using rational functions
8. Eigenvalues and eigenvectors of a matrix
9. Solution of Radioactive decay, Simple harmonic oscillator

Course Outcomes: A student having taken the course would be expected t to write programs for solving various problems in Physics using techniques like summing up of infinite series, interpolating data, solving differential equations and numerical integration. The skill of developing programme and practice for computational work and analysis helps students getting employability in different branches of physics and engineering.

Recommended Books:

1. V. Rajaraman, Fundamentals of Computers (Prentice Hall, India).
2. C. Xavier, Fortran 77 and Numerical methods.
3. P.S. Grover, Programming and Computing with FORTRAN 77/90, (Allied publishers)
4. Byron S. Gottfried. Schaum's outline of Theory and Problems of Programming with C, New Delhi: Tata McGraw-Hill.
5. An Introduction to Computational Physics, T. Pang, Cambridge University Press.

OE-Phy-412 ELECTRONICS & INSTRUMENTATION 80 MARKS

(Open Elective)

Course Objectives: This course is aimed to familiarize the students with fundamental of electronic passive and active components and their use in simple electronic instruments.

Contents:

Unit – I (20)

Fundamental ideas of PN junction: construction and working principle, properties of pn junction. Zener diode: working principle and properties, zener diode as voltage stabilizer. Fundamental ideas of Transistor: structure, principle of operation and static characteristics of bipolar junction transistor (common base and common emitter connection only),

Unit – II (20)

Operational amplifier: Introduction to Op amplifier, the 741OP amplifier. Inverting and Non-inverting amplifier: voltage gain, input and output impedance.

Applications of Operational amplifier: Summing amplifier, differential amplifier, Integrating amplifier, differentiator amplifier, Barkhausen criterion of oscillation, Hartley oscillator, Colpitts oscillator (working principle & diagram).

Unit – III (20)

Basic digital concepts: Binary logic states, Binary Arithmetic.

Logic gates and Combinational logics: Gate types and truth table of AND, OR, NOT, NAND, NOR, XOR, XNOR. Converter: Analog to digital and digital to analog. Boolean algebra and Demorgan's theorems. Boolean theorems: Algebraically, Venn diagram and induction table. Half and Full adder, Half and Full subtractor, flip flop (RS and JK).

Unit – IV (20)

Modulation: Amplitude modulation, frequency modulation, phase modulation and demodulation.

Radio wave propagation: Surface wave, space wave, troposphere wave and sky wave. AM/FM radio transmitters and receivers (Block diagram only). Elementary principles of TV.

Introduction to microprocessor, Basic idea of Oscilloscope, Signal measurement, signal to Noise enhancement, signal generator.

Course Outcomes: On completion of this course the student of other department will learn about PN junction Diodes, Transistors, Field Effect Transistors, their principles and applications, Basic operational amplifier characteristics, OPAMP parameters, applications as adder, subtractor inverter, integrator, differentiator, Oscillators etc. They also learn basics of major digital devices. The student will acquire fundamental knowledge on AM/FM transmitter and receiver, TV, oscilloscope, signal measurement, signals to Noise enhancement, signal generator etc and how to use it.

Recommended Books:

1. Fundamental Principle of Electronics - B. Ghosh
2. Electronic Fundamental and application - J. D. Ryder
3. Integrated Electronics - Milliman and Halkias
4. Foundation of Electronics - Chattopadhyay, Rakshit Saha and Purkait
5. Electronic: Principle & Application - A. P. Malvinoz

SEMESTER-III

Phy-501 Quantum Principle, Atomic& Molecular Spectra 100(80+20) MARKS

Course Objectives: This course is aimed to familiarize the students with fundamental of atoms and molecules associated with electric and magnetic field effects.

Contents:

UNIT-I

Atomic spectra and Bohr model of hydrogen atom with infinite and finite nuclear mass, Quantum mechanical treatment of one electron atom, Energy levels using spherical polar coordinate, bound state Eigen functions, Spectra of alkali elements.

UNIT-II

Fine structure of hydrogen atom (relativistic correction to the kinetic energy, spin-orbit term and Darwin term), fine structure splitting, fine structure of spectral lines, hyperfine structure (magnetic dipole and electric quadruple), Laser: spontaneous and stimulated emission, Einstein coefficients.

UNIT-III

Linear stark effect, normal and anomalous Zeeman effect, Schrodinger equation for two electron atom, spin wave function and Pauli exclusion principle, level scheme of two electron atoms. Central field approximation, electron states in a central field (configuration, shell and sub-shells) equivalent and non-equivalent electrons, correlation to the central field approximation (correlation effect, L-S coupling and J-J coupling) L-S coupling in equivalent and non-equivalent electrons, fine structure in L-S and J-J coupling.

UNIT-IV

General nature of molecular structure, Born-Oppenheimer approximation for diatomic molecules, rotational energy of diatomic molecule (diatomic linear symmetric top and spherical top), vibrational energy of diatomic molecule (diatomic molecule as simple harmonic oscillator, Morse potential energy curve) and centrifugal distortion of diatomic molecules, Rotational and rotational-vibrational spectra of diatomic molecules, electronic spectra of diatomic molecules (vibrational and rotational structure of electronic spectra).

Course Outcomes: Upon successful completion of this course, student will be able to distinguish the radius of electron orbit and its energy expression with respect to finite and infinite nuclear mass of hydrogen atom. They can obtain the energy for electron orbitals and multiplets of fine structure and hyperfine structure of one-electron atom. They will learn to calculate the effects of electric and magnetic field on the energy levels of hydrogen atom (Stark effect and Zeeman effect) and lande-g factor. They can apply simple harmonic oscillator to determine the vibrational spectrum of diatomic molecule.

Recommended Books

1. Introduction to atomic spectra — H.E.White
2. Atomic and molecular spectra: Laser — Raj Kumar
3. Fundamentals of molecular spectroscopy — C.B.Banwell

Phy-503 **CONDENSED MATTER PHYSICS** **100(80+20) MARKS**

Course Objectives: This course is aimed to familiarize the students with fundamental of crystals formation along with their basic electrical, thermal and electronic properties using classical and quantum mechanical theories.

Contents:

UNIT – I

Vibrations of mono atomic and diatomic lattices, dispersion relation, optic and acoustic modes, Quantum of lattice vibration and phonon, phonon momentum, inelastic scattering of neutrons and photons by phonons.

Lattice heat capacity, Debye & Einstein model, Anharmonic crystal interactions, Thermal conductivity and thermal expansion.

UNIT – II

Density of states in one dimension, effect of temperature on Fermi-Dirac distribution, Free electron gas in three dimensions, Heat capacity of electron gas, Electrical and thermal conductivity of metals, hall effect, Crystal of inert gases, ionic crystals, covalent crystals, metallic bonding, hydrogen bonded crystals.

UNIT –III

Electrons in periodic potential, Bloch's theorem, Cronig-Penny model, origin of band gap.Intrinsic and impurity semiconductors, band gap, law of mass action, intrinsic carrier concentration, mobility in the intrinsic region, extrinsic carrier concentration, mobility in the extrinsic region, P-N junction, rectification.

UNIT –IV

Experimental survey, Meissner effect,Type-I and Type-II superconductors, Thermodynamics of superconductors, London theory, Josephson effect, Basic concepts of copper pairing in BCS theory.

Course Outcomes: This paper helps one understand microscopic origin of structures and various phenomena observed in different kinds of solid like insulator, semiconductor, and metal with special treatment on superconductor.

Recommended Books:

1. Introduction to Solid State Physics - C. Kittel
2. Solid State Physics - A. Omar
3. Solid State Physics - Asscchroff Mermin
4. Solid State Physics - A. J. Dekker
5. Solid State Physics - O.E. Animalau

Phy-505 ADVANCED QUATUM MECHANICS 100(80+20) MARKS

Course Objectives: This course is aimed to familiarize the students with fundamental of the preliminary aspects of non-relativistic quantum mechanics and advanced quantum mechanics for solving different relevant physical problems.

Contents:

UNIT – I

Klein-Gordon equation and its drawbacks, The Nonrelativistic limit, Lorentz invariance of KG equation, KG equation in Schrodinger form, The solution of KG equation for a square well potential, Dirac equation, Properties of Dirac Matrices, Probability density and continuity equation.

UNIT-II

Non-relativistic reduction of Dirac equation Covariant form of Dirac equation, Algebraic properties of gamma matrices, magnetic moment and Darwin's term, bilinear covariant, Lorentz Covariance of Dirac equation, Free particle solution of Dirac equation

UNIT – III

Projection operators for energy and spin, Physical interpretation of free particle solution, Zitterbewegung, Hole theory, Charge conjugation, Space reflection and Time reversal symmetries of Dirac equation. Dirac equation with central potential

Continuous systems and fields, Transition of discrete to continuous systems, Lagrangian and Hamiltonian formulations, Noether's theorem

UNIT – IV

Second quantization, Quantization of neutral scalar field, and charge scalar field, Dirac field, and electromagnetic field (Expansion of fields in terms of creation, annihilation operator and number operator, unequal space time commutators, anti-commutators, propagator functions and their integral representations, Vacuum expectation value, Time ordered product, Feynman propagator)

Course Outcomes: Students will have achieved the ability to explain the relativistic quantum mechanical equations, namely, Klein-Gordon equation and Dirac equation, describe second quantization and related concepts, explain the formalism of relativistic quantum field theory. Creation and annihilation operators, space-time commutators, Feynman propagator etc

Recommended Books:

1. Relativistic quantum mechanics - J.D. Bjorken and S.D. Drell
2. Relativistic quantum mechanics - W. Greiner
3. Advanced Quantum Mechanics - J. J. Sakurai
4. Advanced Quantum Mechanics – F Schwabl
5. Quantum Field theory – F. Mandle and G. Shaw
6. Quantum Field Theory - C. Itzykson and J.Zuber
7. Quantum Mechanics (Vol. III) - A. Mesiah

Phy-507 (A) ELECTIVE –I (SOLID STATE PHYSICS) 100 (80+20) MARKS

Course Objectives: This course is aimed to familiarize the students with fundamental of lattice vibration problem, Fermi surface, perturbation formalism, transport properties in metals

Contents:

UNIT – I

Born-oppenheimer approximation, Hamitonian for lattice vibrations in the harmonic approximation, normal modes of the system and quantization of lattice vibrations, Phonons. Wave equation for an electron in a periodic potential, Bloch functions,

UNIT- II

Brillouin Zones, electrons and holes, effective mass of electrons in crystals, methods of tight binding and plane wave. Construction of Fermi surface, Experimental method for study of Fermi Surface: Cyclotron resonance in metals and De-Hass Van Alphen effect.

UNIT – III

Perturbation formulation, Dielectric function (Lindhard's expression) of an interacting electron gas, Static screening, Screened impurity, Kohn effect, Friedel oscillation and Friedel sum rule, Dielectric constant of a semiconductor, Plasma Oscillations.

UNIT – IV

The Boltzmann equation, Electric conductivity, General transport coefficients, Thermal conductivity, Thermoelectric effect, The Hall effect, Magnetoresistance, Wannier functions, Equation of motion in Wannier representation, Equivalent Hamiltonian and impurity levels, The mass tensor, Zener break down and tunneling

Course Outcomes: Students will learn: the basics about the electron-phonon interaction, lattice vibration and its quantization as well as Bloch's theorem, the band structure and its implication in understanding various properties of solids, various methods to detect the Fermi surface of material, electron-electron interaction in solid leading to different features of solid and transport property of solid under influence of perturbation.

Recommended Books:

1. Introduction to Solid State Physics: - C. Kittel
2. Quantum Theory of Solid - C. Kittel
3. Principles of the Theory of Solids - J.M. Ziman
4. Introduction of the Theory of Solid State Physics - James D. Patterson
5. Solid State Physics - Asscchroff Mermin

Phy-507 (B) ELECTIVE –I (PARTICLE PHYSICS) 100(80+20) MARKS

Course Objectives: This course is aimed to familiarize the students with fundamental of colliders, detectors and concepts of classification of particles, fundamental interaction, etc. It also provide the information on scattering and symmetries associated with high energy particles

Contents:

UNIT- I

Broad preview and overview, a bit of discussion of history and current status, colliders and detectors, LHC and main detectors, Units in Particle Physics.

Classification of Matter: lepton and quark, colour, Isospin, Strangeness and Hypercharge, Gellmann-Nishijima Formula, Lepton and Baryon number conservation, Fundamental interaction and conservation laws.

UNIT-II

Symmetry transformation and conservation laws: Symmetries, Group and Conservational laws, Angular Momentum-classification of elementary particles, Angular momentum of a composite system, The group SU(2), System of identical particles, Isospin: an example of the SU(2) group, Relation between decay rates and isospin conservation, Descrete symmetries, Parity, pion spin and parity, Charge conjugation, CP-violation, time reversal, CPT theorem, G-parity,

UNIT-III

The SU (3) Symmetry: The generator of SU (3), Lie- Algebra of SU (3), Lie algebra and shift operators, Coupling of T-U- and V- multipletes.

Quarks and SU(3): Constructions of SU (3) multipletes, The product representation, Meson in the quark model, Baryon in the quark model, Gell-Mann-Okubo mass formula for Baryons and Mesons, Baryon wave function, Magnetic moments of Baryon,

UNIT-IV

Quantum Electrodynamics (QED):

The S-matrix expansion, Time ordered product, Normal ordered product, Wick's theorem, Feynman diagrams in configuration and momentum space, First order terms in S-matrix, 2^{nd} order terms: Compton scattering, Electron-electron scattering, closed loop, Feynman rules for QED

Course Outcomes: The students will learn about the elementary particles, its interactions and role played by symmetries. The understanding of the basic theory of groups particularly SU(2) and SU(3) to know the more about the symmetry in nature will achieved. Besides they will also learn how to calculate amplitude for QED.

Recommended Books:

1. Introduction of High Energy Physiccs- D.H. Perkins
2. Elementary Particle Physics- D.J. Griffiths
3. Nuclear and Particle Physics- W. E. Burcham and M. Jobes
4. The Physics of Elementary Particles- H. Murihead
5. Quantum Field Theory – F. Mandl and G.Shaw
6. Concept of Particle Physics - V. Weisskopf G.K. Gottfried

7. Quarks & Leptons - F. Halzen & A.D. Martin
8. Quantum Field Theory - Itzyksen and Zuber
9. Quantum Mechanics (Symmetries)- W. Greiner, B. Muller

Phy-410 **PRACTICALS** **100 MARKS**

Experiments on Electronics

Course Objectives: This course is aimed to familiarize the students hands on training on designing and studying the characteristics of various electronic components.

Contents:

1. To study the operation of R-S Flip Flop.
2. To determine impedance and power factor of an A.C. Circuit.
3. To study the FET. Characteristics.
4. To study the MOSFET Characteristics.
5. To study the Pentode Characteristics.
6. To study the rectification with various filter circuit.
7. To study the regulated power supply.
8. To study the zener Diode Characteristics.
9. To study the Characteristics of tetrode valve.
10. Characteristics of Hartly oscillator.
11. Characteristics of multivibrator.
12. To study the operational amplifier
13. Two stage RC coupled amplifier.
14. Verification of logic gates using NAND gates

Course Outcomes: At the end of this practical course, student is expected to understand the basic concepts of electronics through experiments, which would immensely help them to tackle various electronic devices.

SEMESTER – IV

Phy—502 BASIC NUCLEAR & PARTICLE PHYSICS 100(80+20) MARKS

Course Objectives: This course is aimed to familiarize the students with different standard nuclear models, nucleon-nucleon scattering and nuclear reactions. It also provides the fundamental forces along with the dynamics of elementary particles.

Contents:

UNIT – I

Ground state of Deuteron, Schrödinger wave equation for Deuteron and its solution, Shape of the ground state wave function, Normalization of Deuteron wave function, size or radius of the Deuteron, Magnetic moment of Deuteron, Quadrapole moment of Deuteron.

UNIT- II

Nucleon-Nucleon scattering: Scattering cross-section, Neutron-proton scattering below 10 MeV (Scattering of Neutrons by free proton), Effective range theory for n-p scattering (Shape independence of nuclear potential), Mesons and nuclear force field (Field theory of Nuclear forces), Generalized Pauli's exclusion principle

UNIT – III

Liquid drop model and Weissacker's mass formula, Shell model of the nucleus, Fermi gas model Single particle shell model, Explanation of nuclear data by shell model, Collective model of nucleus, rotational motion of the nucleus, vibration of spherical Nuclei, Description of nuclear Reactions, Q-value, derivation of elastic and reaction cross section, description by partial wave analysis, Resonances, Breit-winger one level formula.

UNIT – IV

Basic forces, Classification of elementary particles, spin and parity, determination of isospin, strangeness, lepton and baryon number, conservation laws, Gell-Mann-Nishijima Scheme, Meson and baryon octet, Elementary ideas of SU (3) symmetry and quark model.

Course Outcomes: Students will learn: various properties of simplest nucleus as well as nuclear models, to study the n-p scattering using partial wave method and effective range theory, the concept of meson and nuclear forces, various aspects of nuclear reactions and about the fundamental interactions of nature along with the building block of matter

Recommended Books:

1. Fundamental of Nuclear Physics – J. Verma, R.C. Bhandari and D.R.S. Somayajulu
2. Introductory Nuclear Theory - L.R.S. Elton
3. Nuclear Physics - R.R.Roy and B.P.Nigam
4. Elementary Particle Physics - M.J. Longo
5. Subatomic Physics - Fraucnfelder & Henley
6. Concepts of Particle Physics - Gortfried & Weissokopf
7. Introduction to Nuclear Physics – H.Enge

Phy-504 (A) ELECTIVE –II (SOLID STATE PHYSICS) 100(80+20) MARKS

Course Objectives: This course is aimed to familiarize the students with different models on magnetism, dielectrics, Defects along with data analysis on material research.

Contents:

UNIT- I

Diamagnetic langevins theory of diamagnetism, Quantum theory of diamagnetism of core electrons, Landau, leels and Landau diamagnetism of conduction electrons.

Paramagnetism- Quantum theory of paramagnetism, conduction electron (pauli), Paramagnetism. Ferromagnetism-Exchange integral and origin of ferromagnetic order, Mean field approximation, curie-Weiss Law, spin waves and magnons, Block $T^{3/2}$ law, Anti ferromagnetic orders. Neel temperature.

UNIT- II

Simple ideas about magnetic resonance, Classical picture of resonance, The Block equation and interpretation of experiment by Block equation, Nuclear magnetic resonance, shape effect in ferromagnetic resonance anti ferromagnetic resonance, Lossely bound excitons, Tightly bound excitons. Excitonic waves. Point defects in solids, Lattice vacancies, colour (F) centers, Raman effect in crystals, Energy loss of fast particles in a solid.

UNIT – III

Macroscopic electric field, local electric field at an atom, dielectric constant and polarizability.

Ferroelctric crystals, Polarization catastrophe, Landau theory of Phase transition, second order transition, first order transition, soft optical phonons

UNIT – IV

Phenomenological Electron phonon interaction, Second quantized form of Hamiltonian for electrons and phonons in interaction, Electron-electron attractive interaction via virtual phonon exchange, Cooper pairs and BSC Hamiltonian, Superconducting ground state and the gap equation at $T=0^0K$.

Josephson effect- SQUIDS, Elementary ideas of high temperature, super conductivity

Course Outcomes: After successful completion of this course student will be able to: distinguish between diamagnetism, paramagnetism and collective magnetism. They will also learn how to calculate microscopic and macroscopic electric field and establish relation between dielectric constant and polarizability. They will able to obtain Josephson current with and without magnetic field and derive resonance frequency over different shape of the crystal. They will develop the knowledge to distinguish between schottky and frenkel defects and calculate the number of defects in a system.

Recommended Books:

1. Introduction to Solid State Physics - C. Kittel
2. Quantum Theory of Solids - C. Kittel
3. Principles of the Theory of Solid - J.M. Ziman
4. Introduction to the theory of Solid State Physics - James D. Patterson
5. Solid State Physics - Asscchroff Mermin

Phy-504 (B) ELECTIVE –II (PARTICLE PHYSICS) 100(80+20) MARKS

Course Objectives: This course is aimed to familiarize the students with fundamental of scattering process and decay associated with high energy physics. It also provides the information of quantum Chromodynamics and gauge symmetry

Contents:

UNIT- I

QED processes in lowest order

Relativistic Kinematics: Mandelstamm variables,
Cross section, spin sums, photon polarization sums, Lepton-pair production in electron-positron collisions, Bhabha scattering, Compton Scattering, Scattering by an external field and Mott Scattering Formula, Bremsstrahlung

UNIT-II

Weak interaction:

Classification of weak interactions, Charged leptonic weak interaction, Decay of Muon, Decay of neutron, decay of Pion, Charged weak interaction of quarks, Neutral weak interaction (The Cabibbo angle and Cabibbo hypothesis, Cabibbo-GIM Mechanism)

UNIT-III

Electrodynamics and Chromodynamics of Quarks

Hadron production in e+e- collision, Elastic electron-proton scattering, Feynman rules for Chromodynamics, Colour factors-colour factor for octet configuration, Pair annihination in QCD, Asymptotic freedom, Elementary knowledge of Neutrino Oscillation

UNIT-IV

Gauge Symmetries:

The Lagrangian and single particle wave equations, U(1) local gauge invariance and QED, Spontaneous symmetry breaking-hidden symmetry, Spontaneous symmetry breaking of a global gauge symmetry, Spontaneous symmetry breaking of local SU (2) gauge symmetry and Higgs Mechanism, Choice of Higgs field, masses of the Gauge bosons, Masses of fermions, $SU(2) \times U(1)$ invariant Standard model (Salam- Weinberg) Lagrangian

Course Outcomes: The student will learn relativistic kinematics and how to calculate cross section for various interaction of QED. The student would be equipped with an in-depth knowledge of familiar interaction and symmetry of nature i.e., weak interaction, gauge symmetry etc. To know the world more they will learn beyond standard model which will encourage them to widen their research interests in these topics.

Recommended Books:

1. Quantum Field Theory - F. Mandl and G. Shaw
2. Introduction to High Energy Physics - D. H. Perkins (Cambridge U. Press)
3. Elementary Particle Physics - D.J. Griffiths
4. Quarks and Leptons – F.Halzen and A.D. Martin
5. Concept of Particle Physics - V.Weisskopf & K.Gottfried
6. Quantum Field Theory - Itzyksen and Zuber

Phy-506 (A) **PRACTICALS ELECTIVE** **100 MARKS**

Experiments on Solid State Physics

Course Objectives: This course is aimed to familiarize the students with hand on practice on various solid state properties associated with metal or semiconductors

Contents:

1. Study of energy gap of germinum by four-probe method.
2. Calibration of magnetic field using Hall apparatus.
3. Determination of Hall voltage and Hall coefficients.
4. Measurements of Hall angle and mobility
5. Determination of magneto resistance of Bismuth
6. Determination of Ferro-electric transition point (curie temperature) of given simple
7. Study of dispersion relation for the monoatomic and diatomic lattice using the given electrical transmission line
8. Find the Young's modulus for the given metal using composite Pizoelectric oscillator technique.
9. Velocity of ultrasonic waves in a given medium at different temperature.
10. Measurement of lande's factor of DPPH by ESR at Microwave frequency.

Course Outcomes: Students will perform some experiments to familiar with the properties of solids taught in the solid state physics elective course.

Phy-506 (B) **PRACTICALS ELECTIVE (B)** **100 MARKS**

Experiments on Particle Physics

Course Objectives: This course is aimed to familiarize the students with fundamental of various spectroscopic techniques related to high energy physics. It also provides hands on training on handling and studying different devices like GM counter, SCA, MCA, amplifier etc.

Contents:

1. Calibration of the x-ray spectrometer and determination of x-ray energy of unknown sources.
2. Determination of resolving poser of x-ray spectrometers.
3. Study of b spectrum.
4. Determination of absorption co-efficient of Aluminium using G.M Counter.
5. X-test and operating point determination using G-N tube.
6. Characteristics of G.M. counter.
7. Study of surface barrier detector.
8. Determination of value for DPPH using ESR.
9. Study of counter technique.
10. Study of single channel analyzer.
11. Study of photo detector and photo multiplier.
12. Study of wide-band amplifier.
13. Emulsion photograph studies.

Course outcomes: Student will gain practical knowledge of radiation sources and radiations using different detectors.

Phy-508 **PROJECTS** **100 MARKS**

Course Objectives: This course is aimed to familiarize the students with collecting literature and compiling as well as to provide the pathways to undertake study on different areas of physics research.

This course will be based on preliminary research oriented topics both in theory and experiment. At the completion of the project by the semester end, the student will submit project report in the form of dissertation which will be examined by the examiners. The examination shall consist of (a) Presentation and (b) Comprehensive Viva-Voce.

Course Outcomes: Students will develop their ability to search literature, compile the review work and also how to perform research through the project work. This develops practical skill for application of the research theme chosen for the Dissertation.