Govt. M H College of Home Science & Science for Women, Jabalpur,M.P.

Department of Physics

PG Syllabus 2023-24

Physics

Govt. M H College of Home Science & Science for Women, Jabalpur
Post Graduate Syllabus: Physics
2023-24

M.Sc. PHYSICS

SCHEME OF EXAMINATION

SEMESTER – I

Paper	Paper Title	Max. Marks	Min marks
I	Mathematical Methods	35+ 15 (CCE) = 50	
II	Classical Mechanics	35+ 15 (CCE) = 50	
III	Electronic Devices	35+ 15 (CCE) = 50	
IV	Computational Methods & Programming	35+ 15 (CCE) = 50	
Lab A	General Physics Practical	50	20
Lab B	Computer Programming	50	20

SEMESTER – II

Paper	Paper Title	Max. Marks	Min marks
I	Quantum Mechanics-I	35+ 15 (CCE) = 50	
II	Statistical Mechanics	35+ 15 (CCE) = 50	
III	Electrodynamics and Plasma Physics	35+ 15 (CCE) = 50	
IV	Condensed Matter Physics	35+ 15 (CCE) = 50	
Lab A	Electronics Practical	50	20
Lab B	Computer Programming	50	20

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SEMESTER III

Paper	Paper Title	Max. Marks	Min Marks
I	Quantum Mechanics - II	35 + 15 (CCE) = 50	
II	Nuclear and Particle Physics	35 + 15 (CCE) = 50	
III	Special paper (a) Condensed Matter Physics - I	35 + 15 (CCE) = 50	
IV	Special paper (b) Electronics - I	35 + 15 (CCE) = 50	
Lab A	Based on papers III	50	20
Lab B	Based on papers IV	50	20

SEMESTER IV

Paper	Paper Title	Max. Marks	Min Marks
I	Atomic and Molecular Physics	35+15 (CCE) = 50	
II	**Elective Paper** (a) Physics of Lasers & Applications (b) Physics of Electronic Devices and Fabrication of Integrated Circuits and Systems (c) Non-linear Dynamics (d) Physics of Nano-materials	35+15 (CCE) = 50	
III	Special paper (a) Condensed Matter Physics - II	35+15 (CCE) = 50	
IV	Special paper (b) Electronics - II	35+15 (CCE) = 50	
Lab A	Based on papers III	50	20
Lab B	Based on papers IV	50	20
	Internship	100	40

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SEMESTER I : PAPER - I

MATHEMATICAL METHODS

Max Marks: 35, Minimum Pass Marks:12

UNIT – I

Tensor Analysis

Elements of cartesian tensors in three dimensions, Definition of transformation laws of scalars, vector, tensors of second, third and fourth rank, , covariant contravariant and mixed tensors, Isotropic tensor Kronecker δ^i_j ,Levi-Civita symbol ε_{ijk} , Tensor algebra (Null Tensor, addition, subtraction, inner product ,outer product).

Green's Function

Elements of Green's function, Green's function for the Sturm-Liouville operator, Series expansions for $G(x/\xi)$, Green's functions in two dimensions, Green's functions for initial conditions, Green's functions for boundary conditions, the Green's function method, A case of continuous spectrum.

UNIT II

Differential Equation

Recursion relation, generating function and orthogonality of Bessel and Legendre functions. Elementary ideas of Associated Legendre, Hermite and Laguerre's polynomials.

Integral Transforms

Fourier and Laplace transforms. Inverse Fourier and Laplace Transforms. Fourier and Laplace transforms of derivatives. Convolution theorem. Application to simple problems.

UNIT - III

Complex Variables

Analyticity of complex functions; Cauchy- Riemann equations; Cauchy's Theorem; Integral Formula; Taylor's and Laurent's series; Theorem of residues; Jordan's Lemma, simple cases of contour integration.

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UNIT - IV

Group Theory

Introduction to Groups, Reducible and irreducible representation of groups, Concept of reducibility in terms of invariant subgroups, Schur's Lemma, orthogonality relations for irreducible representation, the characters of representations, reduction of a reducible representation, multiplication of conjugate classes. The number of irreducible representations of a finite group.

Crystal symmetry operators, Translation groups, Crystal systems and point groups: applications of group theory in the electronic structure of crystals, in the translation group and in reciprocal lattice. A brief introduction to continuous groups and their representations: O(2), O(3), SU (2), SU (3); generators of U(N) and SU(N).

UNIT – V

This unit will be based on tutorial problems covering all the four units. Some sample problems are:-

(1) Geometrical representation of a second rank Cartesian tensor, principal axes system, application to electrical conductivity, quotient Rule.

(2) Green's function for a linear oscillator, Green's function and the Dirac δ-function, finding Green's function for Linear operators in 1-D.

(3) Potential due to discrete or continuous charge distribution; vibration of a circular membrane, solving the 1-D harmonic oscillator Schrodinger equation; Relation of the hydrogen atom, Schrodinger equation with Laguerre equation and solution.

(4) Solution of initial value problems by using Laplace transform; LT and inverse LT of various functions,

(5) Solution of limit dependent problems by Fourier transform; FT of Gaussian function, Application of FT of Dirac delta function.

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(6) Verification of analyticity of simple function, Evaluation of some definite integral using residues.

(7) Evaluation of integrals in complex variables

(8) Construction of the character table for the group D_3

In addition to above, tutorial will also consist of solving problems given in the Text and Reference books.

Text and Reference Books :

- Mathematical Methods for Physicists : G. Arfken
- Matrices and Tensors for Physicists : A.W. Joshi
- Advanced Engineering Mathematics : E. Kreyszig
- Special functions : E.D. Rainville
- Special functions : W.W. Bell
- Mathematical Methods for Physicists Engineers : K.F. Reily, M.P.Hob Son and and S.J. Bence
- Mathematics for Physicist : Mary L Boas
- Mathematical Physics : E Butkov

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SEMESTER I : PAPER - II

CLASSICAL MECHANICS

Max Marks: 35, Minimum Pass Marks:12

UNIT - I

Newtonian mechanics of one and many particle systems; Conservation theorems for linear momentum, angular momentum and energy; Constraints; their classification; Principle of virtual work; D'Alember's principle in generalized coordinates; The Lagrangian, Lagrange's equations; velocity dependent potential and dissipative function. Configuration space, Hamilton's principle; Generalized momenta and Lagrangian formulation of the conservation theorems and Jacobi's integral. Reduction to the equivalent one body problem; The equation of motion and first integrals; The differential equation for the orbit and integration power-law potentials.

UNIT - II

The Kepler problem: inverse square law of force; Artificial satellites; Scattering in a central force field, Rutherford scattering; Legendre transformations and the Hamilton's equations of motion; Conservation theorems and the physical significance of the Hamiltonian. Derivation of Hamilton's equations from a variational principle. The principle of least action.

The equations of canonical transformations and generating functions; Poisson's Brackets: their canonical invariance; Simple algebraic properties of Poisson Brackets. The equations of motion in Poisson Bracket notation; Poisson's theorem; Angular momentum Poisson Brackets, Hamilton's principal and characteristic functions; The Hamilton-Jacobi equation; Action Angle variables.

UNIT - III

Theory of small oscillations Equations of motion, Eigen frequencies and general motion. Normal modes and coordinates. Applications to coupled pendulum and linear triatomic molecule.

Rotating co-ordinate systems. Acceleration in rotating frames. Coriolis force and its terrestrial and astronomical applications. Elementary treatment of Eulerian co-ordinates and transformation matrices. Angular momentum inertia tensor. Euler equations of motion for a rigid body. Torque free motion for a rigid body. Symmetrical top and gyroscopic forces.

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UNIT - IV

Symmetries of space and time. Invariance under Galilean transformation, Covariant four- dimensional formulation. 4-Vectors and 4-Scalars. Relativistic generalization of Newton's laws, 4-momentum and 4-force. Invariance under Lorentz transformation, relativistic energy. Lagrangian and Gauge invariance Hamiltonian formulation in relativistic mechanics. Covariant Lagrangian, covariant Hamiltonian, Examples.

UNIT-V

This unit will be based on tutorial problems covering all the four units. Some sample problems are-

(1) Simple pendulum with rigid support. Two connected masses with string passing over a pulley, virtual work.

(2) Various Poisson's brackets, their relation with PBs in quantum mechanics, stability of orbits under central force' orbital elements of planetary orbits.

(3) Rotating frames, Foucault's pendulum, small oscillations in Linear triatomic molecule and coupled pendulum.

(4) Relativistic Kinetic energy, mass variation, 4-momentum and 4-force.

In addition to above the tutorial will also consists of solving problems given in the Text and references books.

Text and References Books

- Classical Mechanics : N. C. Rana and P.S. Jog (Tata Mc Graw Hill, 1991)
- Classical Mechanics : H. Goldstein (Addision Wesley, 1980)
- Mechanics : A Sommerfiels (Academi Press 1952)
- Introduction to Dynamics : I. Perceival and Richards (Cambridge Univ. Press, 1982)

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SEMESTER I : PAPER - III
ELECTRONIC DEVICES

Max Marks: 35, Minimum Pass Marks:12

UNIT-I

Number System: Binary, Octal, Hexadecimal numbers and their Arithmetic and inter - conversions.

Transistors: JFET, BJT, MOSFET and MESFET, Construction, Structure, working Derivations of the equations for I-V characteristics under different conditions. High frequency limits.

Bistable circuits: Flip-flops – R-S, J-K, J-K master slave.

Microwave Devices: Tunnel diode, electron transfer devices (Gunn diode), Avalanche transit time devices, IMPATT diodes and parametric devices.

UNIT-II

Photonic Devices

Radiative and non-radiative transitions. Optical absorption, Bulk and their film photoconductive devices (LDR), diode photo detectors, solar cell (open circuit voltage and short circuit current, fill factor). LED (high frequency limit, effect of surface and indirect recombination current, operation of LED).

Diode lasers (condition for population inversion, in active region, Light confinement factor. Optical gain and threshold current for lasing. Fabry-Perrot cavity length for lasing and the separation.

UNIT - III

Digital Integrated Circuits

Characteristics of logic families, saturated logic families. RTL, DCTL, DTL,TTL, IIL, HTL Non saturated bipolar logic families, TTC, ECL, Unipolar logic families, Digital integrated circuits-SSI, MSI, LSI and VLSI circuits.

Operational Amplifiers

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DC Amplifier, Difference amplifier, operational amplifier, OP-AMP Parameters, Inverting and Non-Inverting modes, Use of OPAMP as adder, subtractor, inverter, differentiator, integrator, function generator.

UNIT - IV

Memory Devices : PMOS, NMOS and CMOS, SRAM and DRAM, non-volatile memory, magnetic, optical and ferroelectric memories, charge coupled devices (CCD). Electro optic, magneto optic and Acousto-optic effects. Example of some active devices in integrated optics based on these effects, liquid crystal display devices.

Piezoelectric, effect, Important materials exhibiting this property piezoelectric filters and resonators High frequency piezoelectric devices – Surface Acoustic Devices, Capacitor, Electrets and Piezoelectric electro mechanical transducer devices.

UNIT – V

This unit will be based on tutorial problems covering all the four units. Some sample problems are-

Design of MOSFET amplification in different configurations.

1. Microwave oscillators: Klystron and Magnetron.
2. Deviation of the condition of lasing action in a two level system, optical pumping
3. Derivation of rate equation for three – Laval Devices system.
4. Design of gates using DL, DTL etc. logics OPAMP
5. Derivation of expressions for OPAMP adder, substrates differentiator, integrator current voltage.
6. Derivation of expansions negated to pier element effect.

The problems given in this Text and preference books will form tutorial course.

Text and reference books

- Semi Conductor Devices – Physics and Technology : SM Sze (Wiley, 1985)
- Introduction to Semiconductor devices : M.S. Tyagi (John Wiley and Sons)
- Measurement, Instrumentation and Experimental Design in Physics and Engineering : M. Sayer and A. Mansingh
- Optical Electronics : Ajoy Ghatak and K. Thygarajan (Cambridge Univ. Press.).

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SEMESTER I : PAPER - IV

COMPUTATIONAL METHODS AND PROGRAMMING

Max Marks: 35, Minimum Pass Marks : 12

UNIT - I

Elementary information about digital computer principles, compilers, interpreters and operating system. BASIC programming, Flow charts, integer and floating point arithmetic expressions, built in functions, executable and non-executable statements, assignments, control and input-output elements, subroutines and functions, operations with files, Graphics, statements.

UNIT - II

Methods for determination of zeros of linear and nonlinear algebraic equation and transcendental equations, convergence of solutions. Solutions of simultaneous linear equation, Gaussian elimination, pivoting, iterative method, matrix inversion.

UNIT-III

Eigen values and eigen vectors of matrices, power and Jacobi method, finite differences, interpolation with equally spaced and unevenly spaced points. Curve fitting, polynomial least squares and cubic spline fitting.

Numerical differentiation and integration, Newton-Cotes formulae, Error estimates, Gauss method.

UNIT - IV

Random variables, Monte Carlo evaluation of integrals, Methods of importance sampling, Random walk and metropolis method, Numerical solution of ordinary differential equation, Euler and Runge-Kutta Methods, Predictor and corrector method, Elementary ideas of solution of partial differential equation.

UNIT - V

This unit will be based on tutorial problems covering all the four units. Some sample problems are:-

(1) Explain the use of sequential formatted data files. What are Random data files.

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(2) How is a sequential data file created in Basic.

(3) Write a program to obtain the roots of a quadratic equation with the provision that if the roots are complex, the execution should stop.

(4) Invert and diagonalize 3×3 and 4×4 symmetric matrices for example.

$$\begin{bmatrix} 2 & 0.5 & 0.1 \\ 0.5 & 3 & 0.1 \\ 0.1 & 0.1 & 4 \end{bmatrix} \qquad \begin{bmatrix} 3 & 1 & 1 & 0.5 \\ 1 & 4 & 1 & 1 \\ 1 & 1 & 5 & 1 \\ 0.5 & 1 & 1 & 6 \end{bmatrix}$$

(5) Find equations for the coefficients a and b of the curve $y = ae^{bx}$ by the least squares method.

(6) Use the Lagrange from to find the quadratic interpolation polynomial to the function f(x) having values.

X	:	1	2	3
F(x)	:	2	3	7

(7) Find out C_0, C_1, X_0 and X_1 such that the Gaussian quadrature rule

$$f(x)\,dx = c_0\, f(x_0) + c_1\, f(x_1)$$

is exact for polynomials of degree up to three. Hence evaluate the integral of exp(x) over x from x = 0 to x = 2.

(8) What are the methods to solve partial differential equations? Write down the difference analogue of the Laplace equations.

$$U_{xx} + U_{yy} = 0$$

(9) Write a program to solve the Laplace equations using Lattice method.

(10) Give In addition to above, the tutorial will also consist of Solving problems given in the Text and Reference books.

Text and reference books

- Introductory Methods of Numerical Analysis : Sastry
- Numerical Analysis : Rajaraman
- Numerical Reciter : Utter mind Teukolsky, Press and Flattery
- Programming with Basic : Gottfried (Schema Series)
- Programming with Basic : Balaguruswamy
- Numerical Analyses : Balagurswamy

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SEMESTER II : PAPER – I

QUANTUM MECHANICS – I

Max Marks: 35, Minimum Pass Marks:12

UNIT – I

Why QM? Brief prevision. Basic postulates of quantum mechanics, equation of continuity, Normality, orthogonlity and closure properties of eigen functions, Expectation values and Ehrenfest theorem. Free particle solution of Schrodinger equation, Box normalization, Dirac delta-function and its properties, solution of Schrodinger equation for one dimensional (a) potential well (b) potential step and (c) potential barrier.

UNIT – II

Linear vector space, concept of Hilbert space, Bra and Ket notation for state vector, Representation of state vectors and dynamical variables by matrices, change of basis and Unitary transformation (Translation and rotation), Schrodinger, Heisenberg and Interaction pictures, Matrix theory of linear harmonic Oscillator, Creation and annihilation operators, Matrices for x, p, H. Heisenberg uncertainty relation through operators (Schwartz inequality).

UNIT – III

Solution of Schrodinger equation for (a) linear harmonic oscillator (b) hydrogen-like atom (c) three-dimensional harmonic oscillator (d) square well potential, and their respective applications to atomic spectra, molecular spectra and low energy nuclear states (deuteron).

UNIT – IV

Angular momentum is quantum mechanics, Eigen values and eigen functions of L^2 and L_Z in terms of spherical harmonics, Relation of angular momentum with rotation operator, commutation relations, Matrix representation of angular momentum, Pauli spin matrices and their algebra, Coupling of two angular moments and Clebsch-Gorden coefficients for $j_1=j_2=1/2$ and $j_1=1/2$ and $j_2=1$.

UNIT –V

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(1) Black body radiation and Planck's hypothesis, Insignificance of de Broglie hypothesis in macrophysics.

(2) Plotting of Harmonic oscillator wave functions in 1-d.

(3) Energy levels of a particle of mass m moving in one-dimensional potential.

$$V(x)= \begin{cases} +\infty & x<0 \\ +1/2\, m\,\omega^2 x^2 & : x>0 \end{cases}$$

(4) Admissible wave functions, stationary states.

(5) Wave function corresponding to minimum uncertainty product. Gaussian wave packet. Spread of wave packet in time.

(6) Continuous basis corresponding to position eigen values and wave functions corresponding to state vectors using position and momentum representation.

(7) Rotational spectra of diatomic molecules.

(8) Vibrational and rotational spectra of diatomic molecules.

(9) Obtaining the matrices for L+, L-, Lx, Ly, L^2,Lz, $[L_+,L_-]$.

(10) Problems related to pauli spin matrices, eq

$$e^{i\sigma y\theta/2} = \cos\theta/2 + i\sigma y \sin\theta/2$$

In additions to above the tutorial will also consist of soloing problems given in the Text and Reference Books.

Text and Reference Books

- Quantum Mechanics : L I. Schiff (Mc Graw-Hill)
- Quantum Physics : S. Gasiorowiz (Wiley)
- Quantum Mechanics : B. Craseman and J.D. Powel (Addison Wesley)
- Quantum Mechanics : AP Messiah
- Modern Quantum Mechanics : J.J. Sakurai
- Quantum Mechanics : Mathews and Venkatesan

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SEMESTER II :PAPER - II

STATISTICAL MECHANICS

Max Marks: 35, Minimum Pass Marks:12

UNIT-I

Foundations of statistical mechanics, specification of states of a system, contact between statistics and thermodynamics, classical ideal gas, entropy of mixing and Gibb's paradox.

Microcanonical ensemble, Phase space, trajectories and density of states, Liouville's theorem, canonical and grand canonical ensembles; partition function calculation of statistical quantities, Energy and density fluctuations.

UNIT - II

Statistics of ensembles, statistics of indistinguishable particles, Density matrix, Maxwell- Boltzmann, Fermi-Dirac and Bose- Einstein statistics, properties of ideal Bose gases, Bose-Einstein condensation. Properties of ideal Fermi gas, electron gas in metals. Boltzmann's transport equation

UNIT - III

Cluster expansion for a classical gas, Virial equation of state, Dynamical model of phase transition, Ising model in zeroth approximation, Ising model in first approximation. Exact solution in one-dimension.

Landau theory of phase transition, Scaling hypothesis for thermodynamic functions.

UNIT - IV

Thermodynamic fluctuation, spatial correlation. Brownian motion, Langevin theory, fluctuation dissipation theorem. The Fokker-Planck equation. Onsager reciprocity relations.

UNIT - V

This unit will be based on tutorial problems covering all the four units. Some sample problems are:

(1) Calculation of number of states and density of states.

(2) Relative population of particles in two energy levels.

(3) Liquid helium II

(4) Electrical and thermal conductivities.

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(5) Evaluation of virial coefficient

(6) Critical indices.

(7) Applications of Onsager relation

(8) Diffusion co-efficient

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Text and Reference Books

- Fundamentals of Statistical and Thermal Physics : F. Reif
- Statistical Mechanics : K. Huang
- Statistical Mechanics : R.K. Pathria
- Statistical Mechanics : R. Kubo
- Statistical Mechanics : Landau and Lifshitz

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SEMESTER II :PAPER - III

ELECTRODYNAMICS AND PLASMA PHYSICS

Max Marks: 35, Minimum Pass Marks:12

UNIT – I

Review of basics of electrostatics and magneto-statics (Electric field, Gauss law, Laplace's and Poisson's equations, method of images. Biot-Sawart law, Ampere's law). Maxwell's equations, scalar and vector potentials, Gauge transformation Lorentz Gauge, Coulomb gauge, Solution of Maxwell's equation in conducting media.

UNIT – II

Radiations by moving charges, Retarded potentials, Lienard-Wiechert potentials, Fields of charged particle in uniform motion, Fields of arbitrarily moving charged particle, Fields of an accelerated charged particle at low velocity and high velocity. Angular distributions of power radiated, Bremsstrahlung, Reaction force of radiation, Abrahm-Lorentz method of self-force, Difficulty with the Abrahm-Lorentz model, line-breadth and level-shift of an oscillator.

UNIT - III

Review of Four-vectors and Lorentz transformation is 4-dimensional spaces Invariance of electric charge, relativistic transformation properties of E and H fields, electromagnetic field tensor in 4-dimensional Maxwell equation, 4-vector current and potential and their invariance under Lorentz transformation, covariance of electrodynamics, Lagrangian and Hamiltonian for a relativistic charged particle in External EM field; motion of charged particles in electromagnetic fields, uniform and non-uniform E and B fields, Particle Drifts in Non-uniform field, static magnetic fields, Adiabatic invariant.

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UNIT – IV

Magneto-hydrodynamic equations, Magnetic diffusion, viscosity and Pressure, Magneto-hydrodynamic flow between Boundaries with crossed Electric and magnetic fields, Pinch Effect, Instability in a Pinched Plasma column, magneto-hydrodynamic waves, magneto sonic and Alfven waves, Plasma oscillations, short wave length limit for plasma oscillations and Debye Screening Distance.

UNIT – V

This unit will be based on tutorial problems covering all the four units. Some sample problems are :

(1) Obtain the formal solution for electromagnetic boundary value problem with Green function.

(2) Discuss the problem of conducting sphere is a uniform electric field by method of images and Green's functions.

(3) For a solenoid wound with N turns per unit length and carrying a current I, show that the magnetic flux density on a point on the axis is given (for $N \rightarrow \infty$) by

$$B_z = \frac{2\pi NI}{C}(\cos\theta_1 + \cos\theta_2)$$

Where θ_1, θ_2 are the angles between the axis and the lines joining the point on the axis to the first and last turns of the solenoid.

(4) A linear accelerator accelerates protons to almost relativistic speeds. Determine fraction of power radiated by the protons to the power supplied in terms of the gradients of the linear electric field.

(5) A charged particle oscillated according to the harmonic law Determine the total average intensity of the emitted radiation.

(6) Discuss the Lagrangian and Hamiltonian for a relativistic charged particle in External electromagnetic field.

(7) Obtain the expression for energy radiated as Cherenkov radiation per unit distance along the path of the particle.

(8) Consider a magnetic field configuration that is cylindrically symmetric and a charged particle is injected into it. Use the adiabatic invariant of motion to

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describe conditions in which the injected particle would bounce back from the direction of increasing field gradient.

(9) Consider the problem of waves in an electronic plasma when an external magnetic field B_0 is present. Use the fluid model, neglecting the pressure term as well as collisions.

(a) Write down the linearized equations of motion and Maxwell equations, assuming all variables vary as exp (ik.x-iωt).

(b) Show that the dispersion relation for the frequencies of the different modes in terms of the wave number can be written.

$$\omega^2(\omega^2-\omega_p^2)(\omega^2-\omega^{p2}-k^2c^2) = \omega^2_B(\omega^2-k^2c^2)[\omega^2(\omega^2-\omega p^2-k^2c^2)+\omega p^2c^2(k.b)^2]$$

where b is the unit vector in the direction of B, ω_p and ω_B are the plasma and precession frequencies, respectively.

(c) Show that for propagation parallel to B_0 the dielectric constant is recovered.

(d) Assuming $\omega_B \ll \omega_p$, solve approximately for the various roots for the cases

(i) K parallel to b

(ii) K perpendicular to b. Sketch your result for w^2 versus k^2 in the two cases.

Text and Reference Books

- Classical Electrodynamics : J D Jackson
- Electromagnetic Theory : B.B. Laud
- Classical Electricity and Magnetism : Pan of sky and Philips
- Plasma Physics : Chen
- Plasma Physics : Bittencourt

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SEMESTER II :PAPER - IV

(CONDENSED MATTER PHYSICS)

Max Marks: 35, Minimum Pass Marks:12

UNIT - I

Interaction of X-rays with matter, absorption of x-rays, Elastic scattering from a perfect lattice. The reciprocal lattice and its applications to diffraction techniques, the Laue powder and rotating crystal methods. Crystal structure factor and intensity of diffraction maxima.

Point defects, line defects and planar (stacking) faults. The role of dislocation in plastic deformation and crystal growth. The observation of imperfections in crystals, x-ray and electron microscopic techniques.

UNIT - II

Free electron Fermi gas, Energy levels of orbital in one and three dimensions. Electrons in a periodic lattice, Bloch theorem band theory of solids. Classification of solids, Effective mass, Tight-binding, cellular and pseudo-potential methods, Fermi surface, de Hass von Alfen effect

UNIT - III

Atomic and molecular polarizability, Claussius-Mossotti relation, types of polarizability, Dipolar polarizability, and frequency dependence of dipolar polarizability. Ionic and electronic polarizability Hall effect in low fields, quantum Hall effect, Magneto-resistance. Super conductivity, critical temperature persistent current, Meissner effect. General idea about high temperature superconductors.

UNIT - IV

Weiss theory of ferromagnetism, Heisenberg model and molecular field theory, spin waves and magnons, Curie-Weiss law for susceptibility, Ferri and antiferro-magnetic order, Domains and Bloch-wall energy.

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Optical reflectance, Kramer-Kronig relations, Light absorption spectrum of semiconductors, cyclotron resonance, Photo-electromagnetic effect, Faraday effect, Elements of Raman effect in solids.

UNIT - V

This unit will be based on tutorial problems covering all four units. Some sample problems are:

(1) Given that the primitive basis vectors of a lattice a = (a/2) (i + j), b = a/2 (j + k) and c = a/2 (k + j) where i, j and k are usual three unit vectors along Cartesian coordinates. What is the Bravais lattice?

(2) Determine planes in a f c c structure having highest density of atoms.

Or

Evaluate density of atoms for Cu. in atoms/cm^2.

(3) For the delta function potential and with $p > 1$ find at $k = 0$ the energy of the lowest energy band. Also find the band gap at $k = \pi /a$.

(4) Consider a square, lattice in two dimensions with the crystal potential.

$$U(x,y) = 4U \cos(\pi x/a) \cos(\pi y/a)$$

Apply the central equation to find approximately the energy gap at the corner point $(\pi/a, \pi/a)$ of the Brillouin Zone.

(5) Explain why the Hall constant is inversely proportional to the electron concentration M.

Text and Reference Books

- Solid State Physics : C. Kittel
- Introduction to Solid : Azaroff
- Crystallography for Solid State Physics : Verma and Shrivastava
- Solid State Physics : A.J. Dekker
- Elementary Solid State Physics : Omar
- Solid State Physics : Aschroft and Mermin
- Principles of Condensed Matter Physics : Chaikin and Lubensky

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SEMESTER I : LIST OF PRACTICALS

LAB A

Section 1 (General Physics)

(Preferably six experiments to be performed by the students)

(1) Determination of separation of two plates of Fabry Perot Etalon.

(2) (a) Measurement of Wavelength of He-Ne Laser.

(b) Measurement of thickness of thin wire with laser.

(3) Determination of Poisson's Ratio of glass plate by Cornu's method.

(4) Optical Fibre

(a) Determination of numerical aperture.

(b) Attenuation loses.

(c) Bending loss.

(5) Production and study of elliptically and circularly polarized light by Fresnel's Rhomb.

(6) Verification of Hartman's formula by constant deviation spectrometer.

(7) Verification of Fresnel's law of reflection for polarized light.

(8) Study of the fluorescence spectrum of DCM dye and to determine the quantum yield of fluorescence maxima and full width at half maxima for this dye using mono-chromator.

(9) To study Faraday effect using He-Ne Laser.

(10) Determination of e/m eluting by normal Zeeman effect.

(11) Measurement of resistively of a semiconductor by four prove method at different temperature and determination of band gap.

(12) Measurement of Hall coefficient of given semiconductor identification of type of semiconductor and sign of charge carrier concentration.

(13) Determination of Lande's factor of DPPH using ESR.

TUTORIAL

(1) Coherence and its relevance in diffraction.

(2) Effect of magnetic field on the plane of polarization.

(3) Normal Zeeman effect by Fabry Perot Etalon.

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(4) Longitudinal and transverse bending of glass plate.

(5) Variation of refractive index with wave length of light.

(6) Propagation of light wave through optical fiber.

(7) Identification of charge type by Hall voltage measurement.

(8) Four probe method and the contact resistance problem.

SECTION -1 ELECTRONICS

(Preferably six experiments to be performed by the students)

(1) Design of a regulated power supply.

(2) Design of a common Emitter Transistor Amplifier.

(3) Experiment on Bias stability.

(4) Negative Feedback (Voltage Series/ Shunt and Current Series/Shunt).

(5) Astable, Monostable and bistable Multivibrator.

(6) Characterization and application of Silicon controlled Rectifier.

(7) Experiment on FET and MOSFET characterization and application as an amplifier.

(8) Experiment an UJT and its applications.

(9) Digital I : Basic Logic Gates, TTL, NAND and NOR.

(10) Digital II : Combinational Logic.

(11) Flip-Flops.

(12) Operational Amplifier (741).

(13) Differential Amplifier.

TUTORIAL

(1) Network Analysis- Thevenin and Norton's equivalent circuits.

(2) Basics of p-n junction-Diffusion current, Drift current, junction width, forward and reverse biasing, significance of Fermi level in stabilizing the junction.

(3) Zener Diode- characteristics and Voltage regulation.

(4) Transistor biasing and stability.

(5) Wein bridge and phase shift oscillators.

(6) Solving Boolean expressions.

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(7) Atomic scattering power and geometrical structure factor.
(8) Effect of capacitance and load resistance on output of an amplifier.
(9) Integrated circuit timer familiarization.
(10) Op-amp differentiator.
(11) Multiplexor and De-multiplexor.
(12) Registers and counters.
(13) Coincidence circuits, counters, timers.

LAB B (COMPUTER PROGRAMMING)

(Preferably six experiments to be performed by the students)

(1) Preparation of result of an examination.

(2) Mean standard deviation, coefficient of correlation and the equation of regression line for two variables.

(3) Least squares fit for a straight line.

(4) Least squares fit for a parabola.

(5) Solution of simultaneous equations.

(6) Solution of differential equations.

(7) Graphical depiction of expanding cube.

(8) Integration by Simpson's Rule.

(9) Integration by Gaussian Quadrature.

(10) Solution of partial differential equation.

TUTORIAL

(1) Different BASIC statements.
(a) If (b) GOTO (c) GOSUB statement.

(2) Graphic statements in BASIC.

(3) GET-PUT and LOCATE statements.

(4) Newton Raphson iterative method for the solution of non-linear equations.

(5) What is meant by numerical integration? Derive Trapezoidal rule for numerical integration.

(6) Reading from a data file and writing on a data file in BASIC.

NOTE: Appropriate other experiments can be added based on prescribed syllabus in both the labs A & B.

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SEMESTER – III
PAPER - I
QUANTUM MECHANICS – II
Max Marks : 35, Minimum Pass Marks : 12

UNIT – I

Approximation method for bound states: Rayleigh-Schrodinger perturbation theory of non-degenerate and degenerate levels and their application to perturbation of an oscillator, normal Helium atom, and First order Stark effect in Hydrogen. Variation method and its application to ground state of helium, W.K.B. approximation method, connection formula, Ideas on potential barrier with applications to the theory of alpha decay.

UNIT-II

Time dependent perturbation theory: Method of variation of constants, constant and harmonic perturbation, transition probability, adiabatic and sudden approximation. Hamiltonian for a charged particle under the influence of external electromagnetic field, Absorption and induced emission, Transition probability in Electric dipole approximation, Einstein's A and B coefficients.

UNIT – III

Theory of scattering, Physical concepts, scattering amplitude, scattering cross section. Born approximation and partial waves. Scattering by a perfectly rigid sphere, complex potential and absorption, scattering by spherically symmetric potential. Identical particles with spin, symmetric and anti-symmetric wave functions, Pauli's exclusion principle, Pauli's spin matrices.

UNIT – IV

Schrodinger's relativistic equation (Klein-Gordon equation), Probability and current density, Klein-Gordon equation in presence of electromagnetic field, Hydrogen atom, short comings of Klein-Gordon equation. Dirac's relativistic equation for a free electron, Dirac's matrices, Equation of motion for operators, position momentum and angular momentum; spin of an electron, Zitterbewegung, Dirac's relativistic equation in electromagnetic field, negative energy states and their interpretation, Hydrogen atom, Hyperfine splitting.

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UNIT – V

This unit will be based on tutorial problems covering all the four units. Some sample problems are:-

1. Normal Zeeman Effect.
2. Anomalous Zeeman Effect.
3. Van der Waals interactions.
4. Ionization of a hydrogen atom
5. Selection rules for single and many particle systems.
6. Optical theorem and Ramasuer- Townsend effect.
7. Scattering from standard simple potentials using partial wave analysis and Born Approximation.
8. Slater determinant.
9. Spin and statistics
10. Difference in collision process between classical and quantum identical particles.
11. Magnetic moment and spin of a Dirac's electron.
12. Covariance of a Dirac's equation.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books :-

- Quantum Mechanics : L. I. Schiff
- Quantum Mechanics : S. Gasiorowicz
- Quantum Physics : B. Craseman and J.D. Powell
- Quantum Mechanics : A.P. Messiah
- Modern Quantum Mechanics : J.J. Sakurai
- Quantum Mechanics : Mathews and Venkatesan
- Quantum Mechanics : A.K. Ghatak and Loknathan

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SEMESTER – III
PAPER II
NUCLEAR AND PARTICLE PHYSICS
Max Marks : 35, Minimum Pass Marks : 12

UNIT – I

Nuclear Interactions and Nuclear Reactions

Nucleon- nucleon interaction, exchange forces and tensor forces, meson theory of nuclear forces, nucleon-nucleon scattering, Effective range theory, spin dependence of nuclear forces, charge independence and charge symmetry of nuclear forces, Isospin formalism, Yukawa interaction.

Direct and compound nuclear reaction mechanisms, cross sections in terms of partial wave amplitudes, compound nucleus, scattering matrix, Reciprocity theorem, Breit- Wigner one–level formula, Resonance scattering.

UNIT – II

Nuclear Models

Liquid drop model, Bohr–Wheeler theory of fission, Experimental evidence for shell effects, shell model, spin, orbit coupling, magic numbers, Angular momenta and parities of nuclear ground states, Qualitative discussion and estimates of transition rates, magnetic moment and Schmidt lines, Collective model of Bohr and Mottelson .

UNIT – III

Nuclear Decay

Beta decay, Fermi theory of beta decay, Comparative half, lives, Parity violation, Two component theory of neutrino decay, Detection and properties of neutrino, Gamma decay, Multipole transition in nuclei Angular momentum and parity selection rules Internal conversion, Nuclear isomerism.

General ideas of nuclear radiation detectors, Linear accelerator, Betatron, Proton-synchrotron, Electron synchrotron.

UNIT – IV

Elementary Particle Physics

Types of interaction between elementary particles, Hadrons and leptons, Symmetry and conservation laws, Elementary ideas of : CP and CPT invariance, Classification of hadrons, Lie algebra, SU(2) – SU (3) multiplets, Quark model, Gell-Mann-Okubo mass formula for octet and decuplet hadrons, Charm, bottom and top quarks.

Cosmic Rays

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Nature, composition, charge and energy spectrum of primary cosmic rays, production and propagation of secondary cosmic rays. Soft, penetrating and nucleonic components, Origin of cosmic rays, Rossi curve, Bhabha – Heitler theory of cascade showers.

UNIT – V

This unit will be based on tutorial problems covering all the four units. Some sample problems are.

1. Scattering Matrix.
2. Nucleon- Nucleon phase Shifts.
3. Double Scattering Experiment to measure polarization.
4. Ground state spectroscopic configuration of nuclei on the basis of single particle shell model.
5. The Q – Equation.
6. Calculation of Absorption Cross Section.
7. Nuclear Quadrapole moment.
8. Curie Plot
9. Selection Rules for βand γdecay.
10. Parity Violation Experiment.
11. Neutrino Helicity.
12. Isospin Symmetry.
13. Lie Algebra.
14. Origin of cosmic rays.
15. Bhabha-Heitler theory.

In addition to above the tutorial will also consist of solving problems given in Text and Reference books.

Text and Reference Books:-

- Kenneth S. Kiane. Introductory Nuclear Physics, Wiley New York 1988..
- H.A. Enge, Introduction to Nuclear Physics, Addison - Wesley ,,1975.
- G.E. Brown and A.D. Jackson, Introduction to Nucleon nucleon Interaction, North Holland, Amsterdam, 1976.
- Y.R. Waghmare, Introductory Nuclear Physics, Oxford-IBH Bombay,1981
- I. Kaplan, Nuclear Physics, 2" Ed. Narosa, Madras, 1989
- R.D.Evans, Atomic Nucleus, McGraw Hill, New York, 1955.
- B.L. Cohen, Concepts of Nuclear Physics, TMGH, Bombay, 1971.
- R.R. Roy and B.P. Nigam Nuclear Physics, Wiley- Eastem Ltd, 1983.
- Bruno Rossi, Cosmic Rays
- B.N. Shrivastava, Basic Nuclear Physics and Cosmic Rays
- M.P. Khanna, Particle Physics, Prentice Hall
- Burcham, Nuclear Physics

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2023-24

SEMESTER – III
PAPER III
SPECIAL PAPER (a) CONDENSED MATTER PHYSICS – I
Max Marks : 35, Minimum Pass Marks : 12

UNIT – I

Imperfection In Crystals

Mechanism of plastic deformation in solids, stress and strain field of screw and edge dislocations. Elastic energy of dislocations. Forces between dislocations. Stress needed to operate Frank-Read source, dislocations in fcc, hcp and bcc lattices.

UNIT – II

Partial dislocations and stacking faults in closed packed structures. Experimental methods of observing dislocations and stacking faults. Electron microscopy, kinematical theory of diffraction contrast and lattice imaging.

Elementary concepts of surface crystallography. Scanning tunneling and atomic force microscopy.

UNIT - III

Films and Surface

Study of surface topography by multiple-beam interferometry, conditions for accurate determination of step height and film thickness (Fizeau Fringes). Electrical conductivity of thin films, difference of behaviour of thin films from bulk, Boltzmann transport equation for a thin film (for diffused scattering), expression for temperature coefficient of resistivity of thin films.

UNIT – IV

Lattice Dynamics

Lattice Dynamics of monatomic and Diatomic lattice, Optical phonons and dielectric constants. Mossbauer effect, Debye – Waller factor, Anharmonicity. Thermal expansion and thermal conductivity. Umklapp process, Interaction of electrons and phonons with photons.

Optical Properties of Solids

Direct and indirect transitions. Absorption in insulators, polaritons, one phonon absorption, optical properties of metals, skin effect and anomalous skin effect.

UNIT – V

This unit will be based on tutorial problems covering all the four units.
Some sample problems are.

1. Consider two parallel dislocation lying on the same slip plane. Their Burgers

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vectors lie parallel to the slip plane but are not parallel to each other. Their magnitudes are equal. Find all possible orientations of the Burgers vectors for which the component of the force between the dislocations that acts parallel to the slip plane is zero.

2. Prove that the stress σ_{zz} never exerts a force on a dislocation in which burgers vector lies parallel to the x direction regardless of the orientation of the dislocation line.
3. Derive Taylor's relation between dislocation density and applied stress.
4. Discuss the working of atomic force microscope
5. Bring out the essential differences between diffuse and specular electron scattering from the conventional solid : bulk and films by taking the specific property of electrical conductivity.
6. What are thin and thick film? With reference to electronic conduction which films can be referred to as thin and which as thick taking into account the mean free path as a reference parameter.
7. Estimate for 300 K the root mean square thermal dilation AV/V for a primitive cell of sodium. Take the bulk modulus as 7×10^{10} erg cm^{-3} Note that the Debye temperature 158 K is less than 300 K so that the thermal energy is of the order of K_BT. Use this result to estimate the root mean square thermal fluctuation Δ a/a of the lattice parameter.
8. Consider a classical harmonic oscillator with small anharmonic terms so that the potential energy is $V(x) = ax^2 + bx^3 + cx^4$. Using the partition function approach show that the mean energy (ξ) and mean thermal displacement from equilibrium (x) are :
   $(\xi) = K_BT\,[15b^2/16a^2 - 3c/4a^2]\,(K_BT)^2$
   $(x) = -(3b/4a^2)\,K_BT$
   The former leads to a high temperature contribution to the specific heat that is linear in temperature. The latter is an indication of the origin of thermal expansion (and the proper sign of the coefficient)

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books:-

- X-ray crystallography : Azaroff
- Elementary Dislocation Theory : Weertman & Weertman
- Crystallography for Solid State Physics : Verma & Srivastava
- Solid State Physics : Kittel
- The Powder Method : Azaroff & Buerger
- Crystal Structure Analysis : Buerger
- Transmission Electron Microscopy : Thomas
- Multiple Beam Interferometry : Tolansky
- Thin films : Heavens
- Physics of thin film : Chopra
- Introduction to Solid State Theory : Medelung
- Quantum Theory of Solid State : Callaway

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SEMESTER – III
PAPER IV
SPECIAL PAPER (b) ELECTRONICS - I
Max Marks : 35, Minimum Pass Marks : 12

UNIT – I

Communication Electronics
Amplitude modulation- Generation of AM waves- Demodulation of AM waves DSBSC modulation. Generation of DSBSC waves, Coherent detection of DSBSC waves, SSB modulation, Generation and detection of SSB waves. Vestigial sideband modulation. Frequency division multiplexing (FDM).

Microwave
Advantages and disadvantages of microwave transmission, loss in free space, propagation of microwaves, atmospheric effects on propagation, Fresnel zone problem, ground reflection, fading sources, detectors, components, antennas used in MW communication systems.
Introduction to satellite communication, Geo-stationary satellite, orbital patterns, and satellite systems link modules.

UNIT-II

Microwave and Radar
Klystrons, Magnetrons and Travelling Wave Tubes, Velocity modulation, Basic principles of two cavity Klystrons and Reflex Klystrons, principles of operation of magnetrons, Helix Travelling Wave Tubes, Wave Modes.
Radar block diagram and operation, radar frequencies, pulse considerations. Radar range equation, minimum detectable signal, derivation of radar range equation, Antenna parameters, system losses, propagation losses, Radar transmitters- receivers, display.

UNIT-III

Microprocessor
Introduction to Intel 8085 microprocessor, instruction for 8085, and addressing modes, Data Transfer, Arithmetic, Logical and branch group of instructions. Stack, I/O and machine control group. (Examples related to each group of instructions). Timing and operation status, Memory read write, I/O read, I/O write, register move, and move immediate, Timing diagrams.
Interrupts : Various interrupts handling facilities of inlet 8085 vector and non vectored interrupt Maskable and non maskable interrupts.

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UNIT-IV

Programmable Interface Devices:

Internal Architecture and pin out diagrams of 8155 and 8255 programmable interface. Programmable interrupt controller Intel 8259, Direct memory access and 8257 DMA controller 8279 display/ key board controller.

Interfacing with D/A and A/D converters

Elementary method of digital to analog conversion. Working of DAC 0808 and programme for interfacing with 8255 in 8085 based system.

Basic technique for analog to digital conversion. Internal block diagram of ADC 809 and working. Interfacing of IC 809 with 8085 based system.

UNIT – V

This unit will be based on tutorial problems covering all the four units. Some sample problems are:

1. Effect of frequency and phase error in detection of DSBSC and SSBC signals.
2. Frequency considerations in satellite communication.
3. Make a clear distinction between velocity modulation and current modulation. Show how each occurs in Klystron amplifier, and explain how current modulation is necessary if the tube is to have significant power gain.
4. Different type of Radar system.
5. Timing diagrams for 8085 microprocessor instruction for fetch and execute machine cycles and calculation of T states used.
6. Program with flow chart to take in ten data samples of one microsecond interval and store them in memory.
7. Interfacing of 8255 with 8085 in MOD 0 and MOD 1.
8. Program for a interrupt driven clock using 50 Hz mains as an interrupting source.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books:-

- Radio Engineering : G.K.Mittal
- Electronic Communication : Roddy & John Coolen
- Communication Electronics : John Kennedy
- Microprocessor Architecture : Ramesh S. Gaonkar
- Programming &Application with
- 8085 Microprocessors : B. Ram
- Microcomputer : Malvino
- Microwaves : K.L. Gupta
- Advance Electronics : Wayne Tamasi Communication System

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SEMESTER – IV
PAPER - I
ATOMIC AND MOLECULAR PHYSICS
Max Marks : 35, Minimum Pass Marks : 12

UNIT –I

Quantum states of one electron atoms, Atomic orbitals, Hydrogen spectrum , Pauli's principle. Spectra of alkali elements, spin orbit interaction and line structure of alkali spectra, Methods of molecular Quantum Mechanics, Thomas Fermi Statistical Model, Hartree and Hartree Fock Method. Two electron system, interaction energy in LS and JJ coupling, Hyperfine structure (qualitative), line broadening mechanisms (general ideas).

UNIT – II

Types of molecules, Diatomic linear, symmetric top, asymmetric top and spherical top molecules, Rotational spectra of diatomic molecules as a rigid rotator, Energy level and spectra of non-rigid rotator, intensity of rotational lines.

UNIT – III

Vibrational energy of diatomic molecule, diatomic molecule as a simple harmonic oscillator, Energy levels and spectrum, Morse potential energy curve, Molecules as vibrating rotator, vibration spectrum of diatomic molecule PQR branches IR spectrometer (qualitative).

UNIT – IV

Introduction to ultraviolet, visible and infra-red spectroscopy, Raman spectroscopy: Introduction, Pure rotational and vibrational spectra, Techniques and instrumentation, Stimulated Raman spectroscopy, Experimental techniques: Photo electron spectroscopy, Elementary idea about photo-acoustic spectroscopy and Mossbauer spectroscopy and NMR Spectroscopy.

UNIT –V

This unit will be based on tutorial problems covering all the four units.
Some sample problems are:

1. Write all possible term symbols for the following electron configurations
   (a) [Be]2p3p (b) [He]2s2p (c) [Be]2p3d
2. Normal and anomalous Zeeman effect
3. Paschen Back effect, Stark effect.

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4. The measured value of the first line ($J = 0$) in the rotational spectrum of carbon monoxide is 3.84235 cm^{-1}. Determine the moment of inertia and bond length of the molecule.
5. The data for the $^{1}H^{35}Cl$ molecule are :
Bond length = 127.5 pm
Bond force constant = 516.3 Nm^{-1}
Atomic masses : $^{1}H = 1.673 \times 10^{-27}$kg, $^{35}Cl = 58.066 \times 10^{-27}$ kg
Determine the following
(a) The energy of fundamental vibration $h\nu_0$
(b) The rotational constant B.
(c) The wave numbers of the line $P_{(1)}$, $P_{(2)}$, $R_{(0)}$, $R_{(1)}$ and $R_{(2)}$
(d) Sketch the expected vibration-rotation
6. How many normal modes of vibration are possible for the following molecules : HBr, 0_2, OCS (linear), SO_2 (bent), BCl_3, $HC \equiv CH$, CH_4, CH_3I, C_6H_6
7. With which type of spectroscopy would one observe the pure rotational spectrum of H_2? If the bond length of H_2 is 0.07417 nm. What would be the spacing of the lines in the spectrum ?
8. Raman Spectrum of Chloroform, $CHCl_3$, molecule shows that Raman lines appear at 262, 366, 668, 761, 1216 and 3019 cm^{-1} on low frequency side of exciting line. Comment on the spectrum.
9. The strongest lines in the Infra-red and Raman spectra of nitrous oxide are shown in the table

Vcm^{-1}	Infra-red	Raman
589	Strong; PQR contour -	
1285	Very strong; PR contour	Very strong; polarized
2224	Very strong; PR contour	Strong; depolarized

Comment on the spectra.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Books

- Introduction to Atomic Spectra : H.E. White
- Fundamentals of molecular spectroscopy : C.B. Banwell
- Spectroscopy vol.I, II & III : Walker and Stanghen
- Introduction to molecular spectroscopy : G.M. Barrow
- Spectra of diatomic molecules : Herzberg.
- Molecular spectroscopy : Jeanne L. Mc Hale
- Molecular spectroscopy : J.M.Brown
- Spectra of atoms and molecules : P.F.Bemath.
- Modem spectroscopy : J.M. Halia

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SEMESTER – IV
PAPER – II (ELECTIVE PAPER)
ELECTIVE PAPER (a) : PHYSICS OF LASERS & ITS APPLICATIONS
Max Marks : 35, Minimum Pass Marks : 12

UNIT –I

Working principle of laser, threshold condition characteristics of laser, Gaussian beam and its properties, optical Resonators, longitudinal and transverse modes of laser cavity, mode selection, gain in a Regenerative Laser cavity.

Rate equations and threshold for 3 and 4 level systems. Q switching, mode locking and obtaining ultra-short pulses. Spectral narrowing.

UNIT – II

Ruby laser, He-Ne laser, Nd based lasers, semiconductor lasers, Nitrogen laser, CO_2 laser, ion laser Dye laser, chemical laser, excimer laser, Higher power laser systems.

UNIT –III

Laser fluorescence and Raman scattering and their use in ranging and pollution studies; ultra high resolution spectroscopy with laser, and its application in isotope separation, single atom detection and rotational and vibrational level of molecules. Optical fibers, use of lasers in light waves communication. Qualitative treatment of medical and engineering applications of lasers.

UNIT – IV

Crystal optics, propagation of light in a medium with variable refractive index, Electro, optical effect. Non-linear interaction of light with matter, laser induced multi-photon processes, second harmonic generation phase matching, third harmonic generation optical mixing, Parametric generation of light, self-focusing of light, Frequency mixing in gases and vapours, Optical bistability and optical phase conjugation, Frequency up conversion.

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UNIT – V

This unit will be based on tutorial problems covering all the four units. Some sample problems are:-

1. Calculation of threshold population inversion for laser action in a cavity of given parameters.
2. Calculation of gain coefficient.
3. Determining line width of laser line.
4. Determining line pulse duration in case of Q switched or mode locked laser.
5. Calculation of power of the laser output in case of certain laser system.
6. Tuning of laser in order to obtain- a particular wave length
7. Finding distance of an object by laser range finder.
8. Determining vibrational levels of molecule by scattering of laser light.
9. Calculation of intensity of second harmonic and third harmonic generated by non-linear interaction of laser light with matter.
10. Calculate the wave length separation between the longitudinal modes of a 1530 nm semiconductor laser in which the active layer in 0-2 μ_m long and has a refractive index of 4.0.

    In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and Reference Book :-

Lasers	:	Svelte
Optical Electronics	:	Yariv
Laser spectroscopy	:	Demtroder
Non-Linear Laser spectroscopy	:	Letekhov
Lasers	:	A.L. Siegman
Optical Electronics	:	K.Tyagrajan & A.K. Ghatak.

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Govt. M H College of Home Science & Science for Women, Jabalpur
Post Graduate Syllabus: Physics
2023-24

SEMESTER – IV
PAPER III
SPECIAL PAPER (a) CONDENSED MATTER PHYSICS – II
Max Marks : 35, Minimum Pass Marks : 12

UNIT – I

Interaction of electrons with acoustic and optical phonons, polarons, Superconductivity : Manifestations of energy gap, Cooper pairing due to phonons, BCS theory of superconductivity, Ginzsburg –Landau theory and application to Josephson effect : d-c-Josephson effect, a-c Josephson effect, macroscopic quantum interference. Vortices and type II superconductors, high temperature superconductivity (elementary).

UNIT – II

Point defects : Shallow impurity states in semiconductors. Localized lattice vibrational states in solids, vacancies, interstitial and colour centers in ionic crystals. Structure and symmetries of liquids, liquid crystals and amorphous solids. Aperiodic solids and quasi-crystals; Fibonacci sequence, Penrose lattice and their extension to 3-dimensions.

UNIT – III

Special carbon solids; fullerenes and tubules, formation and characterization of fullerenes and tubules. Single wall and multi -wall carbon tubules. Electronic properties of tubules. Carbon nano-tubules based electronic devices. Definition and properties of nanostructured materials. Methods of synthesis of nanostructures materials. Special experimental techniques for characterization of nanostructured materials. Quantum size effect and its applications.

UNIT - IV

Disorder in condensed matter, substitutional, positional and topographical disorder, short and long range order, Atomic correlation function and structural descriptions of glasses and liquids.

Anderson model for random systems and electron localization, mobility edge, qualitative application of the idea to amorphous semiconductors and hopping conduction.

UNIT – V

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This unit will be based on tutorial problems covering all the four units.
Some sample problems are:

1. Draw diagrams showing some possible two-phonon processes in which a neutron enters with momentum P and leaves with momentum P'. In labeling the diagrams take due account of the conservation law.

2. The average rate of dissipation of energy for an electromagnetic wave is $W = \langle E.J. \rangle$ where the average is over a complete cycle. Show that $W = (\omega\varepsilon_2 /8\pi)E^2_o = \sigma E^2_o/2 = \sigma_1 E^2$

3. How do the (2l+1) fold degenerate energy levels of a free atom split up in a crystal field invariant to all proper rotations which transform a cube into itself ? The free atom is invariant to operations of the (infinite) rotation group. The characters of the irreducible representations of this group are
$\lambda^{(l)}(\phi) = \sin [(l + ½) \phi \ / \sin \phi/2$
The point group of the crystal field has 24 elements in five classes and hence also five irreducible representations. Set up character table for this group

4. (a) Show whether periodicity can exist together with a periodicity in a structure (b) What is golden mean ratio ? How it is relevant to quasi crystals.

5. Band structure formula for crystals is not quite valid for Nanostructure, why?

6. Distinguish between crystalline, amorphous solids and liquids.

7. What are onion carbon structure ? How are they related with fullerene.

8. Calculate the lifetime of electrons and holes in a semiconductor with recombination centers (acceptors with levels E_R in the energy gap) Treat explicitly the limits of large and small defect concentration nr. Discuss the recombination mechanism in both cases. Compare the two possible definitions : $\delta\eta(t) - \exp. (-t/\tau)$ (decay time) and $\delta\eta = G\ \tau$□(steady state).

9. The carbon nanotubes can be both semiconducting and metallic why?

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In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and References Books

- Crystal Structure Analysis : Burger
- The Physics of Quasi-crystals : Eds steinhardt and Ostulond
- Hand Book of Nanostructured Materials
- and Nanotechnology (Vol. 1 to 4) : Ed. Hari Singh Nalwa
- Quantum Theory of Solid State : Callaway
- Theoretical Solid State Physics : Huang
- Quantum Theory of Solids : Kittle
- Introduction to Solid State Theory : Madelung
- Solid State Physics : J.P. Shrivastava
- X-ray Crystallography : Azaroff
- Elementary Dislocation theory : Weertman and Weertman
- Crystallography for Solid State Physics : Verma and Shrivastava
- Solid State Physics : Kittel
- Elementary Solid State Physics : M. Ali Omar

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Post Graduate Syllabus: Physics
2023-24

SEMESTER – IV
PAPER IV
SPECIAL PAPER (b) ELECTROINCS – II
Max Marks : 35, Minimum Pass Marks : 12

UNIT-I

Digital Communication

Pulse-Modulation Systems: Sampling theorem- Low pass and Band pass Signals, PAM, Channel Bandwidth for a PAM signal, Natural sampling, Flat-Top sampling, Signal recovery through Holding, Quantization of signal, Quantization, Differential PCM, delta Modulation, Adaptive Delta Modulation, CVSD. Digital Modulation techniques: BPSK, DPSK, QPSK, PSK, QASK, BFSK, FSK, MSK.

UNIT-II

Noise in pulse code and Delta modulation systems: PCM transmission, calculation of Quantization noise, output-signal power, Effect of thermal noise, Output signal to noise ratio in PCM,DM, Quantization noise in DM, output signal power, DM output-signal –to Quantization-noise ratio. Effect of thermal noise in Delta modulation, output signal- noise ratio in DM.

Computer communication systems: Types of networks, Design of a communication network, examples TYMNET, ARPANET, ISDN, LAN.

Introduction to Mobile radio and satellites: Time division multiple Access (TDMA), Frequency Division Multiple Access (FDMA), ALOHA, Slotted ALOHA, Carrier Sense Multiple Access (CSMA) Poisson distribution, protocols.

UNIT-III

Introduction to 8086, Microprocessor chip, Internal Architecture, Introduction (Basics of) to Programming of 8086 and Assembly language. Programme development steps. Construction of machine code for 8086 Instructions, writing a programme for use with assembler, Assembly language program development tools.

Assembly Language Programming Technique: Simple sequence programmes. Basic idea of flags and jumps, While – Do, IF- THEN, IF –THEN-ELSE Structure based simple programs. Writing and using Assembler Macros.

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UNIT – IV

8086 System Connection Timings : 8086 Hardware Review, Addressing Memory and ports in microcomputer system, Basic Idea about Timing parameters, Minimum mode waveform and calculation for access time. Interrupts: 8086 Interrupts and Interrupts response with some hardware

Applications.

Digital and Analog Interfacing of 8086: Methods of parallel data transfer, single Handshake I/O , Double Handshake Data transfer. 8255 Handshake applications: Lathe control and speech synthesizer. Display and keyboard interfacing with 8279, D/A interfacing with micro-compiler, A/D interfacing (introduction).

Elementary Idea about 80816, 80286, 80386 to Pentium processors

UNIT - V

This unit will be based on tutorial problems covering all the four units.
Some sample problems are:

1. Explain the meaning of pulse code modulation. Draw one complete cycle diagram. Draw one complete cycle of some irregular waveform and show it is quantized using eight standard pulses.
2. Efficiency of PCM
3. Noise in PCM system
4. Signal to noise ratio in time division multiplexed PAM systems.
5. Program for creating a delay loop using 16 bit register pair.
6. Program for 8086 in Assembly Language using IF-THEN-ELSE structure.
7. Debugging Assembly Language Programs for 8086 μp with simple examples.
7. Assembly Language for interrupts procedure in 8086.

In addition to above the tutorial will also consist of solving problems given in the Text and References books.

Text and References Books

- Principles of communication system : Taub & Schilling (1994) II Edition
- Communication systems : Simon Haylein III Ed.
- Microprocessors and Interfacing : Douglas Hall 2nd Ed. (1992)
- Programming and Hardware
- The Intel Microprocessor 8086/8088/ : Brey & Brey
- Pentium Pro Processor Architecture Programming & Interfacing

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M.Sc. (Physics) III & IV Semester:
Laboratory/ Practical Course

Note: Appropriate other experiments can be added based on prescribed syllabus in both labs A and B

(a) CONDENSED MATTER PHYSICS

(Preferably six experiments to be performed by the students)

1. Measurements of lattice parameters and indexing of powder photographs.
2. Interpretation on transmission Laue photographs.
3. Determination of orientation of a crystal by back reflection Laue methods.
4. Rotation/Oscillation photographs and their interpretation.
5. To study the modulus of rigidity and internal friction in metals as a function of temperature.
6. To measure the cleavage step height of a crystal by Multiple Fizeau fringes.
7. To obtain Multiple beam Fringes of Equal Chromatic Order. To determine crystal step height and study birefringence.
8. To determine magneto-resistance of a Bismuth crystal as function of magnetic field.
9. To study hysteresis in the electrical polarization of a TGS crystal and Measure the Curie temperature.
10. To measure the dislocation density of a crystal by etching.
11. Solution of some problems in spherical geometry using stenographic Wulffnet.
12. Study of symmetry of crystal models.
13. Measurement of Hall coefficient.
14. Determination of Lande's 'g' factor using ESR.
15. Determination of Energy band gap
16. Study of Lattice dynamics.
17. Measure of resistivity using four probe.
18. Hysteresis Loop tracer.
19. Study of Luminescence.

Tutorial : Laboratory /Practical Course
CONDENSED MATTER PHYSICS

1. Study of X-ray diffraction from liquid, amorphous materials.
2. Determination of dislocation density by Reflection X-ray topography.
3. To take Buerger Precession photograph of a crystal and index the reflections.
4. To measure the superconductivity transition temperature and transition width of high-temperature superconductors.
5. To determine the optical constants of a metal by reflection of light.
6. Model evaluation of dispersion curves of one-dimensional lattice.
7. Creation of low pressure and measurement.
8. Thin film deposition and operation of vacuum coating unit.
9. Data analysis using computers.
10. Operation of Spectrophotometer.

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11. NMR Instrumentation.
12. Surface structural study of materials using Carl Zeiss microscope.

(b) ELECTRONICS

Preferably six experiments to be performed by the students

1. Amplitude Modulation and Demodulation.
2. TDM PULSE Amplitude Modulation and Demodulation.
3. Study of PCM Receiver and Transmitter.
4. Study of satellite – C Band Receiver.
5. Study of AM – FM Receiver set.
6. Pulse position/ Pulse width Modulation and Demodulation.
7. FSK Modulation.
8. Microwave characterization and measurement.
9. Study of Motor speed control Interface and programming.
10. Temperature control using 8086.
11. Programs for Addition, Division, Subtraction, & Multiplication with 8085 µp system.
12. Programs for (a) To find Largest Number.
    (b) To find Smellers Number
13. Programme for Addition, Subtraction, Multiplication and Division with 8086.
14. Dielectric measurement of Solid/Liquids using Microwave.
15. SWR Reflection Coefficient Measurement.
16. Study of E Plane , H Plane, Magic Tees Bends.
17. Frequency Guide wavelength measurement.

Tutorials: Laboratory/Practical course
ELECTRONICS

1. Digital Communication.
2. Cellular Communication
3. Mobile Communication via satellite
4. Trouble shooting in 8086 Microprocessor System.
5. 8086 Instruction Description
6. Microprocessor based process control system
7. Trouble shooting in 8085 based system
8. Trouble shooting AM based Radio Receiver

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