M.Sc. Physics

2016-17

	CORE COURSES				
	I SEMESTER				
SUBJECT CODE	SUBJECT	L	P	T	TOTAL
MPH 511	MATHEMATICAL METHODS IN PHYSICS	80	0	20	100
MPH 512	CLASSICAL MECHANICS	80	0	20	100
MPH 513	CLASSICAL ELECTRODYNAMICS	80	0	20	100
MPH 514	QUANTUM MECHANICS	80	0	20	100
MPH 515	PRACTICAL I (Based on MPH 511 & MPH 512)	0	50	0	50
MPH 516	PRACTICAL II (Based on MPH 513 & MPH 514)	0	50	0	50
	SEMESTER: II				
MPH 521	ATOMIC, MOLECULAR PHYSICS AND PLASMA PHYSICS	80	0	20	100
MPH 522	ELECTRONICS DIGITAL CIRCUITS-	80	0	20	100
MPH 523	NUCLEAR PHYSICS	80	0	20	100
MPH 524	SOLID STATE PHYSICS AND NUMERICAL METHOD & COMPUTER PROGRAMMING	80	0	20	100
MPH 525	PRACTICAL III (Based on MPH 521 & MPH 522)	0	50	0	50
MPH 526	PRACTICAL IV (Based on MPH 523 & MPH 524)	0	50	0	50
	SEMESTER III				
MPH 531	ADVANCED QUANTUM MECHANICS	80	0	20	100
MPH 532	STATISTICAL MECHANICS	80	0	20	100
MPH 533	LASER	80	0	20	100
MPH 534	MATERIALS SCIENCE	80	0	20	100
MPH 535	PRACTICAL V (Based on MPH 531 & MPH 532)	0	50	0	50
MPH 536	PRACTICAL VI (Based on MPH 533 & MPH 534)	0	50	0	50
	SEMESTER IV				
MPH 541	MICROWAVE ELECTRONICS	80	0	20	100
MPH 542	NANOTECHNOLOGY	80	0	20	100
MPH 543	DISSERTATION	200	0	0	200
MPH 544	PRACTICAL VII(Based on MPH 541 & MPH 542	0	50	0	50

(Figures in parenthesis stand for number of hours of lecture , followed by number of hours of laboratory work, field work & total credit to be earned in the course respectively)

Note:1 hour of lecture=1 credit hour; 2 hours of lab=1 credit;3 to 4 sessions of field visit=1 credit

****15 LECTURE PER UNIT FOR EACH RESPECTIVE UNIT.**

PAPER - I: MATHEMATICAL METHODS IN PHYSICS

MATHEMATICAL METHODS IN PHYSICS

Unit - I

Complex Analysis : Complex numbers, Complex functions (polynomials, Exponential, Trigonometric omplex functions, Logarithm). Limits and continuity, differentiation, Analytical functions, Cauchy-Riemann conditions, Rectifiable arcs, Line integrals, Cauchy's theorem, Cauchy integral formula, Derivatives of analytical functions, Liouville's theorem. Power series Taylor's theorem, Laurent's theorem. Calculus of residues, evaluation of real definite integrals, summation of series, elementary discussion of branch cuts, Applications : Principal value integrals and dispersion relations.

Unit - II

Fourier series, Fourier integrals, Fourier transform, Parseval Relations, Convolution, Applications, Laplace transform, Bromwich integral (without proof) simple applications. Power series and contour integral solutions of second order diff. equations (Legendre, Bessel, Hermite, Laguerre as special examples properties of these functions). Legendre polynomials, Spherical harmonics and associated Legendre polynomials. Hermite polynomials. Sturm-Liouville systems and orthogonal polynomials.

Unit - III

Linear spaces and operators : Vector spaces, Linear independence, Bases, dimensionality isomorphisms. Linear transformations, inverses, matrices, similarity transformations, Eigenvalues and Eigenvectors. Inner product, orthogonality and completeness, complete orthogonal set, Gramm Schmidt orthogonalization procedure, Self-adjoint and unitary transformations. Eigenvalues and Eigenvectors of Hermitian and Unitary transformations, diagonalization. Function space and Hilbert space. Complete orthonormal sets of functions. Weierstrass's theorem (without proof) approximation by polynomial.

Unit - IV

Coordinate transformation in N-dimesional space: Contravriant and covariant tensor, Jacobian. Relative tcnsor, pseudo tensors (Example: change density, angu1ar momentum) Algebra of tensors, Metric theorem, Associated tensors,Reimannian space (Example: Euclidian space and 4-D Mmkowski space), Christoffelas symbols, transformation of Christoffelas symbols,

Covariant differentiation. Ricci's theorem, Divergence, Curl and Laplacian in tensor form. Stress-and Strain tensors. Hook's law in tensor form. Lorentz Covariance of Maxwell equation.

Unit - V

Group of transformations. (Example: symmetry transformation of square), Generators of a finite group, Normal subgroup, Direct product of groups.. Isomorphism and Homomorphism. Representation theory of finite groups, Invariant subspace and reducible representations, irreducible representation, Crystallo-graphic point groups. Irreducible representation of C_{4v} Translation group and the reciprocal lattice.

Reference Books:

1. Mathematical Methods for Physicists: George Arkfen (AcademicPress). .
2. Applied Mathematics for Engineers and Physicists: L. A. Pipe (McGraw Hill)
3. MathematicalMethods-Potter and Goldberg (Prentice Hall of fudia).
4. Elements of Group Theory for Physicists: A. W. Joshi (Wiley Eastern Ltd.)
5. VectorAnalysis (Schaum Series) (Mc Graw Hill).

PAPER - II: CLASSICAL MECHANICS

UNIT-1

Holonomic and nonholonomic constraints: D-Alembert's Principle, Generalized.coordinates,Lagrangian, lagrange's equation and its applications, Velocity dependant:potential in Lagaragian formulation.Generalized momentum, Legendre transfomation, Hamiltonian, Hamilton's Canonical equation. Calculus of variations and its ilpplication to simple problems, Hamilton's variational principle, Derivation of Lagrange's and Hamilton. Canonical equation from Hamiltons variational principle. Extension of Hamilton's Principle for nonconservative and nonholonomic systems. Method of Lagrange's multipliers,

Unit - II

Conservation principle and Noether's theorem. Conservation of energy, linear momentum and angular momentum as a consequence of homogencity of time and scope and isotropy of space respectively.

Unit-III

Canonical transformation, integral in variants of poincare: Lagrange's and Poisson brackets as canonical invariants. cyclic coordinates, Equation of motion in Poisson bracket formulation, Infinitesimal contact transformation and generators of symmetry, Liouville's theorem, Hamilton Jacobi equation and its applications.

Unit - IV

Action angle, variable adiabatic invariance of action variable : The Kepler problem in action angle variables,theory of small oscillation in Lagrangian formulation,normal coordinates and its applications,Orthgonal transfonnation,Eulerian angles,Euler theorem, Eigen values of the inertia tensor, Euler equations. Force free motion of a rigid body.

Unit - V

Laplace transforms, and their properties, Laplac transform of derivatives and integrals of laplac transform, Laplace, Convolution theorem,Impulsive function Application of laplace transform in solving liner differential equations with constant coefficient with variable coefficient and liner partial differential equation.

Reference Books:

1 Goldstein Classical Mechanics.
2. Landau.and Lifshitz - Classical Mechanics.
3. A. Raychoudhary - Classical Mechanics.

PAPER -III : CLASSICAL ELECTRODYNAMICS

Unit - I

1. **Electrostatics: Electric field;** Gauss law, Differential form of Gauss law. Another equation of electrostatics and the scalar potential, surface distribution of charges and dipoles and discontinuties in the electric field and potential, Poisson and-Laplace equations, Green's Theorem, Uniqueness of the solution with Dirichlet or Neumann Boundary conditions, Fomal so1ution of Electrostatic Boundary value problem with Green's Function, Electrostatic potential energy and energy density, capacitance.
Boundary- Value'Problems in Electrostatics: Methods of Images, Point charge in the presence of a grounded conducting sphere point charge in the preseqce of a charge insulated conducting sphere, Point charge near a conducting sphere at fixed potential, conducting sphere in a unifonn electric field by method of images, Green function for the sphere, General solution for the potential, Conducting sphere with Hemispheres at different potential, orthogonal functions and expansion.

Unit - II

2. Magnetostatics: Introduction and defmition, Biot, and Savart law, the differential equation of magnetostatics and Ampere's law, Vector potential and Magnetic induction for a circular current loop, Magnetic fields of a localized current distribution, Magnetic moment, Force and torque on and energy of a localized current distribution in an external magnetic induction, Macroscopic equations. Boundary conditions_on B and H. Methods of solving Boundary-value problems in magnetostatics, Unifonnly magnetized sphere, Magnetized sphere in an external field, Permanent magnets, Magnetic shielding, spherical shell of permeable material in an unifonn field.

Unit - III

Multipoles, Electrostatics of Macroscopic Media Dielectrics: Multiple expansion, multipole expansion of the energy of a charge distribution in an external field, Elementary treatment of electrostatics with permeable media, Boundary value problems with dielectrics. Molar polarizability, and electric susceptibility. Models for molecular polarizability, Electro-static energy in dielectric media. .
Time varying fields, Maxwell's eqllations Conservation Laws: Energy in a magnetic field, Vector and Scalar potentials. Gauge transformations, Lorentz gauge, Coulomb gauge, Green functions for the wave equation, Derivation of the equations of Macroscopic Electromagnetism, Poyntings theorem and conservations of energy and momentum for asystem ofcharged particles. and EM fields. Conservation laws for macroscopic media. Electromagnetic field tensor. Transformation of .four ,potentials.and four currents. Tensor description of Maxwell's equation.

Unit - IV

Plane Electromagnetic Waves and Wave Equation : Plane wave in a nonconducting medium. Frequency dispersion characteristics of dielecttics, conductors and plasmas, waves in a conducting or dissipative medium, superposition of waves in one dimension,group velocity,casualty connection between D and E. Kramers-Kroning relation. . **Covariant Form of Electrodynamic Equations :** Mathematical properties of the space-time special relativity, Invariance of electric charge covariance of electrodynamics, Transformation of electromagnetic fields.

Unit - V

Radiation by moving.charges : Lienard-wiechert Potentials for a point charge, Total power radiated by an accelerated charge ,Larmour's formula and its relativistic generalization, Angular distribution of radiation emitted by an accelerated charge, Radiation emitted by a charge in arbitrary extremely relativistic motion. Distribution in frequency and angle of energy radiated by accelerated charges, Thomson scattering and radiation, Scattering by quasi free charges, coherent and incoherent scattering, Cherenkov radiation.

Reference Books :

1. J.D. Jackson-.-Classical Electrodynamics
2. Panofsky andPhilips Classical Electricity and Magnetism'
3. Introduction to Electrodynamics-Gritfiths
4. Landau and Lifshitz--Classical Theory of Field
5. Landau and Lifshitz.:.Electrodynamics of Continuous Media

PAPER -IV : QUANTUM MECHANICS,

UNIT - I

States, Amplitudes and Operators: States of a quantum mechanical system, representation of quantum,- mechanical states, properties. of quantum mechanical amplitude; operators and change of state, a complete set of basis states, Products of linear operators, language of quantum mechanics, postulates, essential definitions and commulation relations.

Observable and deseription of system: Process of measurement, expectation values, time dependence of quantum mechanical amplitude, observables with no classical analogue, spin. dependence of quantum-mechanical amplitude on position. the wave fimction, super-position of amplitudes, identical particles.

UNIT - II

The Co-ordinate Representation: Compatible observables, quantum conditions and uncertainty relation, Co-ordinate representation, of operator&; position, momentum and angular momentum, time dependence of expectation values, the Ehrenfest's theorem; the time evolution of wave function, the Schrodinger equation, energy quantization, ,periodic potential as an example.

Symmetries and Angular momentum: (a) Compatible observables and constants of motion, symmetry' transformation and conservation laws, invariance, under space and time translations and space rotation and conservations of momentum, energy and angular momentum.

UNIT - III

Angular momentum operators and, their eigen values, matrix representations of the angular momentum operators and their eigen states, co-ordinate representations of the orbital angular momentum operators and their eigen state (spherical harmonics), composition of angular momentum, Clebsch- Gordon coefficients tensor operators anq Winger Expart theorem, commutation relations, of Jx, Jy, Jz with reduced spherical tensor operator, matrix elements of vector operators, time reversal invariance and vanishing of static electric dipole moment of a stationary state.

UNIT - IV

Hamiltonian matrix and the time evolution of Quantum mechanical States: Hemriticity of the Hamiltonian matrix, Time independent perturbation of an arbitrary system, simple matrix examples of time-, independent perturbation, energy given states of a two state system, diagonalizing of energy matrix, time independent perturbation of two state system the perturbative solution: Weak field and strong field cases, general description of two state system. Pauli matrices. Ammonia molecule as an example of two state system.

UNIT - V

Interaction with External Fields: Non degenerate first order stationary perturbation method, atom in a weak uniform external electric field and first and second order Stark effect, calculation of the polarizability of the ground state of H-atom and of an isotropic harmonic oscillator, Degenerate stationary perturbation theory. Linear Stark effect for H-atom levels, inclusion of spin-orbit and weak magnetic, field, Zeeman effect, strong magnetic field and calculation of interaction energy.

SEMESTER -II

PAPER -I : ATOMIC, MOLECULAR PHYSICS AND PLASMA PHYSICS

UNIT - I

Transition Between Stationary States: Transitions in a two state system, Time independent perturbations-The Golden rule, phase space, emission and absorption of radiation, induced dipole transition and Spontaneous emission. of radiation. energy width of a quasi stationary state.

UNIT - II

Systems with Identical Particles: Indistinguish ability and , exchange symmetry, many particle wave functions and Pauli's exclusion principle, spectroscopic terms for atoms. The Helimn atom, Variational method and its use in the calculation of ground state and excited state energy, Helimn atom. The Hydrogen molecule, Heitler-London method for molecule, WKB method for one dimensional problem, application to bound states (Bohr-Sommerfield quantization) and the barrier penetration (alpha decay, problems.

UNIT - III

HydrogenAtom : Gross structure energy spectnuil, probability distribution of radial and angular (l=1,2) wave ,functions (no derivation), effect of spin, relativistic correction to energy levels and fine structure, magnetic dipole interaction and hyperfine structure, the Lamb shift

UNIT - IV

Spectroscopy(qualitative) : General features of the spectra of one and two electron system-sin.glet,doublet and triplet characters of emission spectra, general features of Alkali spectra,rotation and vibration band spectrum of a molecule, PQ and R branches, Raman spectra for rotational and vibrational transitions, comparison with infra red spectra. general features of electronic spectra. Frank and Condon's principle.

Unit-V

Plasma Physics : Introduction and definitions, MHD equations Magnetic diffusion viscosity and pressure; Pinch effect. instabilities in a pinched plasma column. Magneto hydrodynamic waves; Plasma oscillations, short wave length limit of plasma oscillations and Debye shielding distance. Radiation damping, self fields. of a particle, scattering and absorption of radiation by a bound system: Introductory considerations, Radiative reaction force from conservation of energy, APHaham Lorentz evaluation of the self force, difficulties with abraham Lorentz model;Integro-differential equation of motion including radiation damping,. Line Breadth and level shift of an oscillator, Scattering and absorption of radiation. by an oscillator, Energy transfer to a harmonically bound charge.

ReferenceBooks:

1. Ashok Das and A.C. Melissionos. Quantum Mechanics-A modern Approach (Gordon and Breach Science Publishers).
2. P.A.M.Dirac, Quantum Mechanics.
3. E. Merzbaker, Quantum Mechanics, Second Edition (John Willey and Sons).
4. L.P.Landau aridH.M. Lifshitz, Quantum Mechanics-Non relativistic theory (pergamon Press)
5. A..Ghatak and S. Lobnathan.- Quantum Mechanics: Theory and , Applications,Third Edition(Mac Millan India Ltd.) ,
6. G. K. Woodgate,ElementaryAtomic Structure, Second Edition Clarendon Press, Oxford.
7. T.A. Littlefield- Atomic and Molecular Physics.
8. Eistanberg and Rasmik-QuantumPhysicsof Atoms. Molecules, Solids and Nuclear Particles.
9. White - Atomic Spectra.
10.Herzberg- Molecular Spectra.

PAPER -II ELECTRONICS DIGITAL CIRCUITS-

UNIT- I

Operational Amplifiers: .Differential amplifier - circuit configurations-dual input, balanced output differential amplifier. DC analysis - AC analysis, inverting and nonninverting inputs, CMRR - constant current bias level translator. Block diagram of a typical Op-Amp-analysis.Open loop configuration,inverting and non-inverting amplifiers

UNIT- II

Op-amp with negative feedback - voltage series feed back -effect of feed back on closed loop gain, input rersistence, output resistance, bandwidth and output offset voltage - voltage follower. Practical op-amp-input offset voltage -input bias current -input offset current, total output offset voltage, CMRR frequetency response. DC and AC amplifier, summing, scaling and averaging amplifiers, instrumentation amplifier, integrator and differentiator.

UNIT - III

Oscillators and Wave Shaping Circuits: Oscillator Principle- Oscillator types, Frequency stability, response, The Phase shift oscillator, Wein bridge OScillator,LC tunable oscillators, Multivibrators-Monostable and Astable, Comparators, Square wave and Triangle wave generation, Clamping and Clipping. Voltage regulators- fixed regulators, Adjustable voltage regulators, Switching regulators.

UNIT - IV

Digital Electronics: Combinational Logic :The transistor as a switch;circuit Realisation of OR,AND,NOT, NOR and NAND gates, Exclusive OR gate, Boolean algebra - Demorgan's theorems Adder, SuPHractor, Comperator, Decoder / Demultiplexer ,Data selector/ multiplexer - Encoder.

UNIT-V Sequential Logic: Flip -Flops: one-bit memory; The RS Flipflop, JK Flip- Flop, JK master slave Flip -Flops, T Flip -Flop, D Flip- Flop, Shift resisters - syncronous and asynchronous counters- cascade counters,Binary counter, Decade counter. Basic concepts about fabrication and characteristics of integrated circuits.Fortran 77: Variable, Expression, jumping. Bracching an looping statement ,Input / Output statement Statement for handling Input / Output Files, Subroutine, External, Function ,Special statements ,COMMON,ENTRY FORMAT,PAUSE,Equvalence . Programming of simple problems involving use of interpolation differentiation, Integration, matrix inversion and least square analysis.

Reference Book

1. Ryder-Electronic Fundamentals and applications.
2. Millman and Thub-Pulse, Digital and Switching waveforms.
3. Millman and Helkias-Integrated Electronics.
4. Ryder-network Lines and Fields.
5 Bapat-Electronics Devices and Circuitrs.
6. A Ralston and P. Rabinowitz, A First Course in Numberical analysis Mc Graw Hill (1985)
7. S.S. Sastry, Introductory Methods of Numerical Analysis. Prentice hall of India (1979).
8. Ram Kumar, Programming with Fortran 77, McGraw-Hill (1986).
9. "Electronic'Devicesand circuit theory by Robert Boylested and Louis Nashdsky PHI, New Delhi. 1100001, 1991 .
10."OPAmps& Linear integratedcircuits, by Ramakanth A. Gayakwad PHI, Second Edition, 1991.
11. Digital principles and Applications by A.P. Malvino and Donald P.Leach, Tata Megraw - Hill company, New Delhi, 1993.
12. Microprocessor Architecture, Programming and applications with 8085/8086 by Ramesh S. Gaonkar,Wiley - Eastern Ltd., 1987.

PAPER -III NUCLEAR PHYSICS-

UNIT - I

Nucleon-Nucleon Scattering and Potentials : Partial wave analysis of the neutron-proton scattering at low energy assuming central potential with square well shape, concept of the-scattering length, coherent scattering of neutrons by protons in (ortho and para) hydrogen molecule; conclusions of these analyses regarding scattering lengths, range and depth of the potential; the effective range theory (in neutron-proton scattering) and the shape independence of nuclear potential; A qualitative discussion of proton proton scattering at low energy: General features of two-body scattering at high energy Effect of exchange forces: Phenomemonological Hamada- Johnston hard core potential and Reid hard core and soft core potentials; Main features of the One boson Exchange Potentials (OBEP) no derivation.

UNIT - II

Two Nucleon system and Nuclear Forces: General nature of the force between nucleons, saturation of nuclear forces, charge independence and spin dependence, General forms of two nucleon interaction, central, non central and velocity dependent potentials, Analysis of the ground state (3S1)of deuteron using a square well potential, range-depth relationship, excited states of deuteron, Discussion of the ground state of deutron under non central force, calculation of the electric quadrupole and magnetic dipole moments and the D-state admixture.

Experimental Techniques: Gas filled counters; Scintillator counter, Cerenkov counters; Solid state detectors; Surface barrier detectors; Electronic circuits used with typical nuclear detectors; Multiwire proportion chambers; Nuclear emulsions, techniques of measurement and analysis of tracks; Proton synchrotron; Linear accelerations; Acceleration of heavy ions.

UNIT - III

Nuclear shell model: Single particle and collective motions in nuclei: Assumptions and justification of the shell model, average shell potential, spin orbit coupling; single particle wave functions and level sequence; magic numbers; shell model predictions for ground state parity; angular momentum, magnetic dipole and electric-quadrupole moments; and their comparison with experimental data; configuration mixing; single particle transition probability according to the shell model; selection rules; approximate estimates for the transition probability and Weisskopf units: Nuclear isomerism.

Collective nuclear models: Collective variable to describe the the cooperative modes of nuclear motion; Parametrization of nuclear surface; A brief description of the collective model Hamiltonian (in the quadratic approximation); Vibrational modes of a spherical nucleus, Collective modes of a deformed even-even nucleus and moments of, inertia; Collective spectra and electromagnetic transition in even nuclei and comparison with experimental data; Nilsson model for the single particle states in deformed nuclei.

UNIT - IV

Interaction of radiation and charged particle with matter (No derivation): Law of absorption and attenuation coefficient; Photoelectric effect, Compton scattering, pair production; Klem-Nishima cross sections for polarized and unpolarized radiation, angular distribution of scattered photon and electrons, Energy loss of charged particles due to ionization, Bremstrahlung; energy target and projectile dependence of all three processes, Range-energy curves; Straggling.

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Nuclear Reactions: Theories of Nuclear Reactions; Partial wave analysis of reaction Cross section; Compound nucleus formation and breakup, Resonance scattering and reaction- Breit-Wigner dispersion formula for S-waves (l= 0), continuum cross section; statistical theory of nuclear reactions, evaporation probability and cross section for specific reactions; The optical model, Stripping and pick-up reactions and their simple theoretical description (Butler theory) using plane wave Born approximation (PWBA) Short comings of PWBA nuclear structure studies with deutron stripping (d,p) reactions.

UNIT - V

Nuclear gamma and beta decay: Electric and magnetic multipole moments and gamma decay probabilities in nuclear system (no derivations), Reduced transition probability, General characteristics of weak interaction; nuclear beta decay and lepton capture; electron energy spectrum and Fermi- Kurie plot; Fermi theory of beta decay (parity conserved selection rules Fermi and Gammaw-Teler) for allowed transitions; ft-values; General interaction Hamiltonian for beta decay with parity conserving and non conserving terms; Forbidden transitions ,Experimental verification of parity violation; The V-A interaction and experimental evidence.

Reference Books :

1.J. M Blatt and V.E. Weisskipf: Theoretical Nuclear Physics
2. Statistical theory of nuclear reactions, Exaparation probability and cross section for specific reaction.
3. L.R.B Elton: Introductory Nuclear Theory, ELBS Pub. London, 1959
4. B.K. Agrawl : Nuclear Physics, Lokbharti Pub, Allahabad. 1989
5. M.K. Pal: Nuclear Structlire, Affiliated East-West Press, 1982).
6. RR Roy and B.P.Nigam, Nuclear Pbysics, Willey-Easter, 1979
7. M.A. Preston & RK Bhaduri-Structure of the Nucleus, Addision Wesley, 1975
8. RM. Singru : Introductory Experimental Nuclear Physics
9. England - Techniques on Nuclear Structure (Vol.D
10. RD. Evans-TheAtomicNucleus(McGraw-Hills, 1955)
11. H. Enge -Introduction to Nuclear PeYsic~,Addition-Wesley, 1970

12. W.E.Burcham- Elementsof NuclearPhysics,ELBS, Longman, 1988
13. B.L. Cohen - Concpt of Nuclear Physics Tata Mc-Graw Hills, 1988
14. E. Segre - Nuclei, Particles Benjamin, 1977
15. I. Kaplan - Nuclear Physics, Addison Wesley, 1963
16. D. Hallidy - Introductory Nuclear Physics, Wiley, 1955.
17. Harvey - Introduction of Nuclear Physics and Chemistry

PAPER -IV SOLID STATE PHYSICS AND NUMERICAL METHOD & COMPUTER PROGRAMMING

UNIT - I

Band Theory: Block theorem, Kronig Penny model, effective mass of electrons, Wigner-Seitz approximation, NFE model, tight binding method and calculation of density for a band in simple cubic lattice, pseudo potential method.

Semiconductors: law of mass action, calculation of impurity conductivity,ellipsoidal energy surfaces in Si and Ge, Hall effect, recombination mechanism, optical transitions and Schockely-Read theory excitons, photoconductivity, photo-Luminescence.Points line, planar and bulk defects, colour centres, F-centre and aggregate centresin alkali halides.

UNIT - II

Theory of Metals: Fermi- Dirac distribution function, density of states, temperature dependence of Fermi energy, specific heat, use of Fermi. Dirac statistics in the calculation of thennal conductivity and electrical conductivity, Widemann -Franz ratio, susceptibility, width of conduction band, Drude theory of light, absorption in metals.

Lattice Vibratuibs and Thermal Properties: Interrelations between elastic constants C11, C12 and C44 wave propagation and exparimental determination of elastic constant of cubic crystal, vibrations of linearmono and diatomic lattices, Detennipation of phonon dispersion by inelastic scattering of neutrons.

UNIT - III

Magnetism: Larmor diamagnetism.Paramagnetism,Curie Langevin and Quantum theories. Susceptibility of rare earth and transition metals. Ferromagnetism: Domain theory, Veiss molecular field and exchange,spin waves: dispersion relation and its experimental determination by inelastic neutrons scattering, heat capacity. Nuclear Magnetic resonance: Conditions of resonance, Black equations. NMR-experiment and characteristics of an absorption line. **Superconductivity:** (a) Experimental results: Meissner effect, heat capacity, microwave and infrared properties, isotope effect, flux quantization, ultrasonic attenuation, density of states,

nuclear spin relaxation, Giver and AC and DC, Josephson tunnelings.
(b) Cooper pairs and derivation of BCS Hamiltonian, results of BCS theory (no derivation).

UNIT - IV

Errors in numerical analysis: Source of error, Round off error, Computer Arithmetic, Error Analysis, Condition and stability,Approximation, Functional and Error analysis, the method of,Undetermined Coefficients. Use of interpolation formula, Iterated interpolation. Inverse interpolation,Hannite interpolation and Spline interpolation, Solution of Linear equations , Direct and Iterative methods, Calculation of eigen value and eigen vectors for sysmmetric matrices. **Solution of Nonliner equation:** Bisection method, Newton's method,.modified Newton's method, method of Iteration, Newton's method and method of iteration for a system of cosuation Newton's method for the case of complex roots.

UNIT - V

Integration of a function: Trapezoidal and Simpson's rules. Gaussian quadrature formula, Singular integrals, Double integration.

Integration of Ordinary differential equation: Predictor - corrector methods, Runga-Kuttamethod, Simultaneous and Higher order equations Numerical Integration and Differentiation of Data, Least-Squares Approximations, Fast FourierTransform. .

Some elementary information about Computer: CPU, Memory, Input/ Output devices, Super, Mini and Micro systems, MS-DOS operating system, High Level Languages, Interpreter and Compiler. Programming: Algorithm and Flowchart.

Reference Books:

1. Huag : Statistical Mechanics
2. Reif : Fundamentals of Statistical and Thermodynamical Physics
3. Rice : Statistical mechanics and Thermal Physics
4. Kittle: Elementary statistical Mechanics
5. Kittle : Introduction to Solid State Physics
6. Patterson:Solid State Physics
7. Levy : Solid State Physics
8. Mckelvy: Solid State and Semi-conductor Physics.

SEMESTER-3

PAPER -I ADVANCED QUANTUM MECHANICS

UNIT - I

Scattering (non-relativistic): Differentialand total scattering cross section,- transformation from CM frame to Lab frame, solution of scattering problem by the method of partial wave analysis, expansion of a plane wave into a spherical wave and scattering amplitude, the optical theorem, Applications.- scattering from a delta potential, square well potential and the hard sphere scattering of identical particles, energy dependance and resonance scattering. Breit-Wigner formula, quasi stationary states. The Lippman-Schwinger equation and the Green's function approach for scattering problem, Born approximation and its validity for scattering problem, Coulombscatteringproblem under first Born approximation in elastic scattering.
Relativistic Formulation and Dirac Equation: Attempt for relativistic formulation of quantum theory, The Klein-Gordon equation, Probability densityand probabilitycurrentdensity,solutionof free particle KG equation in momentum representation, interpretation of negative probability density and negative energy solutions.

UNIT - II

Dirac equation for a free particle, properties of Dirac matrices and algebra of gamma matrices, non-relativistic correspondence of the Pauli equation (inclusive of electromagnetic interaction). Solution of the free particle. Dirac equation, orthogonality and completeness relations for Dirac spinors, interpretation of negative energy solution.

Symmetries of Dirac Equation : Lorentz covariance of Dirac equation, proof of covariance and derivation of Lorentz boost and rotation matrices for Dirac spinors, Projection operators involving four momentum and spin, Parity (P), Charge. conjugation(C), time reversal (T) and CPT operators for Dirac spinors, Billinear covariants, and their transformations behavior under Lorentz transformation, P,C,T and CPT, expectation values of coordinate and velocity, involving only, positive energy solutions and the associated problems, inclusion of negative energy solution, Zitter bewegung, Klain paradox.

UNIT - III

The Quantum Theory of Radiation : Classical radiation field, transversality condition, Fourier decomposition and radiation oscillators, Quantization of radiation oscillator, creation, annihilation and number operators; photon states, photon as a quantum mechanical excitations of the radiation field, fluctuations and the Uncertainty relation, validity of the classical description, matrix element for emission and absorption, spontaneous emission in the-dipole approximation, Rayleigh scattering. Thomson scattering and the -Raman effect, Radiation damping and Resonance fluorescence.

UNIT - IV

Scalar and vector fields: Classical Lagrangian field theory, 'Euler-Lagrange's equation, Lagrangian density for electromagnetic field. Occupation number representation for simple harmonic oscillator,linear array of coupled oscillators, second quantization ,of identical bosons, second quantization of the real Klein Gordan field and complex ,Klein-Gordan field, the meson propagator.

The occupation number representation for fermions, second quantization of the Dirac filed, the femion propagator, the e.m. interaction and gauge invariance, covariant quantization of the free electromagnetic field, the photon propagator.

UNIT - V

S-matrix, the S-matrix expansion, Wick's theorem, Diagrammatic representation in configuration space, the momentum representation, Feynman diagrams of basic processes, Feynman rules of QED. Applications of S .matrix formalism: the Coulomb scattering, Bhabha scattering, Moller scattering, Compton scattering and pair production.

Reference Books :

1. Ashok Das and A.C. Millissiones : Quantum Mechanics -A Modern Approach.(Garden and Breach Science Publishers)
2. E. Merzbaker : Quantum Mechanics, Second Edition (John Wiley and sons)
3. Bjorken and Drell : Relativistic Quantum Mechanics (MGraw Hill)
4. J.J. Sakuri : Advanced Quantum Mechanics (John Wiley)
5. F. Mandal & G. Shaw, Quantum Field Theory (John Wiley)
6. J,M. Ziman, Elements of Advance Quantum Theory, (Cambridge University Press).

PAPER –II STATISTICAL MECHANICS

UNIT - I

Specification of the state of the system, Macroscopic and Microscopic states, Phase space, Statistical ensemble, Postulate of equal a priori probability, Probability calculations, Behaviour of density of states, Liouville's theorem(Classical), Quasi-static processes.

Equilibrium conditions and constraints, Distribution of energy between systems in equilibrium, Approach to thermal equilibrium, Temperature, Heat reservoir, Sharpness of the probability distribution, Dependence of the density of states on the external parameters, Equilibrium between interacting systems.

UNIT - II

Micro-canonical ensemble, System in contact with heat reservoir, Canonical ensemble, Applications of canonical ensembles (Paramagnetism, Molecule in an ideal gas, Law of atmosphere), System with specified mean energy, Calculation of mean values and fluctuations in a canonical ensemble, Connection with thermodynamics, Grand-canonical ensemble, Physical interpretation of α, Chemical potential in the equilibrium state, Mean values and fluctuations in grand canonical ensemble, Thermodynamic functions in terms of the Grand partition function.

UNIT - III

Classical partition functions and their properties, Calculations of thermodynamic quantities, Ideal monoatomic gas, Gibbs paradox, Equipartition theorem and its Simple applications. i) Mean kinetic energy of a molecule in a gas ii) Brownian motion iii) Harmonic Oscillator iv) Specific heat of solid. Maxwell velocity distribution , Related distributions and mean values.

UNIT -IV

Symmetry of wave functions, Quantum distribution functions, Boltzmann limit of Boson and Fermion gases, Evaluation of the partition function, Partition function for diatomic molecules, Equation of state for an ideal gas, The quantum mechanical paramagnetic susceptibility.

UNIT - V

Photon gas – i) Radiation pressure ii) Radiation density iii) Emissivity iv) Equilibrium number of photons in the cavity. Einstein derivation of planck's law, Bose-Einstein Condensation, Specific heat, Photon gas – Einstein and Debye's model of solids.

Fermi energy, Mean energy of fermions at absolute zero, Fermi energy as a function of temperature , Electronic specific heat, White – Dwarfs, Compressibility of Fermi gas, Pouli's paramagnetism, A relativistic degenerate electron gas

Reference Books :

1. Fundamentals of Statistical and Thermal Physics, - F.Reif, McGraw – Hill, International Edition (1985)
2. Fundamentals of Statistical Mechanics, B.B.Laud, New Age International Publication (2003)
3. Statistical Mechanics, R.K.Pathria, Bufferworgh Heinemann(2nd Edition)
4. Statistical Mechanics,K.Huang, John Willey & Sons (2nd Edition)
5. Statistical Mechanics,Satya Prakash, Kedar Nath Ram Nath Publication (2008)

PAPER –III LASER

UNIT -I

Interaction of radiation with matter : Absorption, spontaneous and stimulated emission, Einstein's Coefficients, population inversion, metastable states, gain, absorption coefficient, stimulated cross section, threshold condition.

UNIT –II

Two level system (Ammonia maser-Physical separation of excited species from those in ground state). Three and Four level system, Rate equations for three and four level system, threshold pump power, relative merits and de-merits of three and four level system. Roby laser, Nd: YAG laser, Nd:glass, Amplifiers for these lasers, their characteristics, semiconductor
lasers, color center laser.

UNIT –III

Optical resonators : Resonator configurations, Stability of resonators, Characteristics of Gaussian beam, Transverse and longitudinal modes, mode selection techniques (at least two techniques in each case), losses in a resonator, Hardware design-laser support structure, mirror mounts, optical coating etc.

UNIT –IV

Gas and dye lasers : excitation in gas discharge, collisions of 1st and 2nd kind, electron impact excitation-its cross section, different types of gas lasers : He-Ne, N_2, CO_2, Metal vapour lasers, Excimer and chemical laser, dye laser.

UNIT –V

Laser applications: (i) Holography, (ii) Optical communications /optical fiber (iii) Laser spectroscopy, (iv) Material processing welding cutting etc. (v) Medical applications, (vi) Doppler free two photon absorption, (viii) Isotope separation.

Reference Books :

1. *Principles of lasers,* Fourth edition-by Orazio Svelto
2. (Plenum Publishing Corporation, New York, USAISBN 0-306-454748-2).
3. *Solid state laser engineering,* first and second edition,
4. walter Koechner *Springer series in Optical Sciences,* (Springer-Verlag, New York, USA ISBN).
5. *Principles of Laser and their applications,* Callen, O'shea, Rhodes
6. *Laser parameters*, Heard *Reference Books :*
7. *Masers,* A. G. Siegman.
8. *Gas lasers,* Garret.
9. *Maser Handbook,* vol. 1-4, F. T. Arecchi, E. O. Schul Dubois, (North Holland)

PAPER IV –MATERIALS SCIENCE

UNIT-I

Short review of basic structures, Tetrahedral and octahedral sites and their properties and importance,substitutional and interstitial solid solutions (only definitions), coordination number and Pauling rules,Crystal Structures of metallic alloys, Ceramics, polymers, silicates, composite materials etc. This include structures such as NaCl, CsCl, Rutile, flurite, corrundum, Hexagonal and cubic zink Blende, NiAS, Perovskine, spinel and inverse spinel, quartz, silicates (linkages of tetrahedral and octahedral units), glass, polymers etc.,

UNIT-II

Physical Thermodynamics including topics such as Laws of thermodynamics, internal energy, reversible and irreversible reactions (with reference to materials phase transitions), heat of formation, concept of entropy, derivation of expression for configurational entropy using concept of multiplicity, micro and macrostates etc., free energies, chemical potential, derivation of various thermodynamical expressions, concepts of eqillibrium and metastability, Phase diagrams of elements, applications of thermodynamics, Clapeyron and Clauses-Clapeyron equations for phase transitions, vapor pressures, effect of temperatures, its importance to vacuum systems and materials evaporation for thin films.

UNIT-III

Defects in Materials : point defects, line defects (dislocations), surface defects (grain boundaries), volume defects (voids), defects formation energies, their impact on physical properties of materials, formation energies, defect creation and annihilation, thermodynamic aspects such as concentration and interactions, stress fields, Burger vector, slip and glide motions of dislocations, calculation of surface energies and its importance etc.

UNIT-IV

Phase Diagrams : Concepts of solid solubility, Hume-Rothery rules, concept of formation of phase diagrams on basis of entropy and free energy changes for compositions, Phase diagrams of various categories such as that of limited solubility, eutectic, peritectic etc. with examples, intermetallic alloys etc.

UNIT-V

Diffusion in solids : concentration gradients, steady state non steady state flow, Fick's laws, error functions, diffusivity (macroscopic and microscopic diffusion models), importance of diffusion for materials synthesis and processing, examples and applications such as oxidation, corrosion, carborization, decarborization, nitridation, Nernst-Einstein equation, concentration profiles, etc. Heat Treatment and Phase transformations in solids : Variation of free energies, nucleation and growth, surface and volume free-energies, Quenching, Nucleation rate, growth rates derivation of related expressions, T-T-T diagrams, applications of nucleation and growth and precipitation reactions.

Reference Books:

1. *Physical Metallurgy,* Vol. 1 and Vol. 2 by R. W. Chan and P. Hassen North Holland Publishing Company, New York, 1983.
2. *Materials Science and Engineering,* V. Raghvan, (Prentice-Hall Pvt. Ltd.), 1989.
3. *Introduction to Materials Science for Engineers,*
4. J. F. Shackelford, (Macmillan Publishing Company, New York), 1985.
5. *Physical Metallurgy,* Smallman.
6. *Thermodynamics,* Swalin.

SEMESTER-4

PAPER –I

1. MICROWAVE ELECTRONICS

UNIT - I

1. Introduction to microwaves and its frequency spectrum, Application of microwaves. **Wave guides:** (a) Rectangular wave guides: Wave Equation & its solutions,TE&TM modes.Dominan tmode and choice of wave guide Dimensions Methods of excitation of wave guide.

(b) Circular wave guide-wave equation & its solutions, TE, TM & TEM modes. (c) Attenuation - Cause of attenuation in wave guides, wall current & derivation of attenuation constant, Q of the wave guide.**2. Resonators:** Resonant Modes of rectangular and cylindrical cavity resonators, Q of the cavity resonators, Excitation techniques, Introduction to Microstrip and Dielectric resonators, Frequency meter.

UNIT - II

Farrites: Microwave propagation in ferrites, Faraday rotation, Devices employing Faraday rotation (isolator, Gyrator, Circulator). Introduction to single crystal ferromagnetic resonators, YIG tuned solid state resonators.

Microwave Measurement:

Microwave Detectors: Power, Frequency, Attenuation, Impedance Using smith chart, VSWR, Reflectometer, Directivity, coupling using direction coupler. Complex permittivity of material & its measurement: definition of complex of Solids, liquids and powders using shift of minima method.

UNIT - III

Microwave tubes: Spacecharge spreadingof an electronbeam, Beam focussings. **Klystrons:** Velocity Modulation, Two Cavity Klystron, Reflex Klystron Efficiency of Klystrons. **Magnetrons:** types & description, Theoretical relations between Electric & Magnetic field of oscillations. Modes of oscillation & operating characteristics. **Gyrotrons:** Constructions of different ,Gyrotrons, Field. -Particle Interaction in Gyrotron.

UNIT - IV

Avalanche Transit Time Device:Read Diode, Negative resistance of an avalanching p-n Junction diode IMPATT and TRAPATT Oscillator. Transferred Electron Device: Gunn effect, two velley, model, High field Dotrutins, Different Modes for Microwave generation. Passive Devices: Termination (Short circuit and matched terminations) Attenuator, phase changers, E&H plane Tees, Hybrid Junctions. Directional coupler.

Parametric Amplifier: Varactor, Equation of Capacitance in Linearly graded & abrupt p-njun.ction, Manely Rowe relations, parametric upconvertor and Negative resistance parametric amplifier,-use of circulator, Noise in parametric amplifiers.

UNIT - V

Microwave Antennas: Introduction to antenna parameters, Magnetic Currents, Electric and magne* current sheet, Field of Huygen's source, Radiation from a slot antenna, open end of a wave guide and Electromagnetic Horns. Prabolic reflectors, Lens antennas. Radiation fields of Microstrip wave guide, Microstrip wave guide, Microstrip antenna calculations, Microstrip design formulas.
Microwave Communication: LOS microwave systems, Derivation of LOS communication range, OTH microwave systems, Derivation of field strength of tropospheric waves. Transmission interference and signal damping, Ductpropagation.
(Satellite Communication: Satellite frequencies allocation, Synchronous satellites,Satellite orbits, Satellite location with respect to earth and look angle, earth coverage and slant range, Eclipse effect, Link calculation, Noise consideration, Factors affecting satellite communication.

Reference Books:

1. Electromagnetic waves & Radiating Systems: Jorden & Balmain.
2. Theory and application of microwaves by A.B. Brownwell & RE. Beam (McGraw Hill) .
3. Introduction to microwave theory by Atwater (McGraw Hill).
4. Principles of microwave circuit by G.C. Montgomery (Mc Graw Hill)
5. Microwave Circuits & Passive Devices by M.L. Sisodia and G.S. Raghuvanshi (New Age International, New Delhi)
6. Foundations of microwave engineering by RE. Collin. (McGraw Hill).
7. Microwave Semiconductor Devices and their Circuit applications by H.A. Watson
8. Microwave by M.L. Sisodia and Vijay Laxmi Gupta. New Age, New Delhi.
9. Antenna Theory, Part-I by RE. Collin & EJ. Zucker (McGraw Hill, New York)
10.Microstrip Antennas by Bahl & Bhartiya (Artech House, Messachausetts)
11. Antenna Theory Analysis by C.A. Balanis Harper & Row. Pub. & Inc. New York.
12. Antenna Theory Analysis by E.A. W01""(J. Willey & Sons)
13. Antenna Theory & Design by RS Elliott (LPHI Ltd. New Delhi)
14. Microwave electronics by RE Soohoo (Addisen Westey pubblic company,).
15.Microwave Active Devices, Vacuoums by M.L. Sisodia new Age International New Delhi.
16. Semiconductors & Electronics device by A. BarIe vs (PHI, India).
17. Solid State physical electronics by A.Vanderziel, (PHI, India).

18. Hand book of microwave measurement Vol-II by M. Sucher & J.Fox (polytechnic Press, New York).

19. Microwave devices & circuits by S.Y.Liao(PHI, India).
20. Microwave Principles by H.J. Reich (CBS).
21. Simple microwave technique for measuring the dielectric parameters of solids & their powder by J.M. Gandhi, J.S. Yadav, J. of pure & applied physics Vol. 30, pp-427431, 1992.

Paper- II NANOTECHNOLOGY

UNIT -I

Low dimensional materials. Application in electronics, communication, medicine etc. Electron states in a potential well, spherically symmetric potential, Coulomb potential and periodic potential. Tunneling through a potential barrier. Excitons, biexcitons, dark excitons.

UNIT – II

Clusters. Fullerens, semiconductor and metal clusters, cluster stability. Nanotubes. Electron states in nanoparticles, effective mass approximation, weak confinement, strong confinement, size dependent oscillator strength.

UNIT – III

Synthesis of nanomaterials (bottom up approach) by physical techniques. Introduction to vacuum techniques (pumps, gauges, materials). Physical vapour deposition, electron beam evaporation, sputter deposition, laser ablation, ion beam mixing, plasma deposition.

UNIT - IV(Synthesis of nanomaterials by chemical, biological and hybrid routes). Concepts of colloids, LaMer diagram, L.B films, Miceller route, self assembly, biosynthesis, electrophoresis, immobilization in glass, zeolites, polymers.

UNIT – V

Analysis Techniques. UV-VIS-IR spectroscopy, Luminescence techniques, X-ray, electron and neutron Diffraction, Small Angle X-ray and Neutron Scattering, photon correlation spectroscopy, Extended X-ray , Absorption Fine Structure (EXAFS), X-ray Photoelectron Spectroscopy, Auger Electron Spectroscopy.

Reference Books:

1. *Physics of Low Dimensional Structures,* J. H. Davis, (Cambridge Press), 1998.
2. *Semiconductor Quantum Dots,* L. Banjaj and S. W. Koch.
3. *Low Dimensional Semiconductors,* M. J. Kelly, Clarendon,1955.
4. *Characterization of Materials,* J. B. Wachtman and Z.
5. H. Kalman, Butterworth-Heinmann, USA, 1993.
6. *Experimental Phyysics,* Modern Methods, R. A. Dunlop.

7. *Instrumental Methods of Analysis,* H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle, (CBS Pub.), 1986.

LIST OF EXPERIMENTS FOR M.Sc. PREVIOUS

List of Experiments (any eighteen) :

1. To design a single stage amplifier of a given voltage gain and lower cut of frequencies.
2. To determine Lo. Co. and Rf of a given coil and to study the variations of Rf with frequency.
3. To design a RC coupled two stage amplifier of a given gain and the cutoff frequencies.
4. To study Hartley oscillator.
5. To Study Transistor bias Stability.
6. To design a Multiv~bratorof given frequency and study its wave shape.
7. To study the characteristics ofFET and use it 0 design an relaxation oscillator and measure its frequency.
8. Tostudy the characteristics of an operational amplifier.
9. To study the characteristics of a UJT and use it to design a relaxation oscillator and measure its frequency.
10. To study the addition, integration and differentiation properties of an operational amplifier.
11. Determine Plack constant using solar Cell.
12. To determine Plack constant and work function by a photo-cell.
13. To study regqlated power supply using (A) Zener diode only (b) Zener diode with a series transistor (c) Zener diode with a shunt transistor.
14. To verify Fresnel's formula;
15. To study the percentage regulation and variation of Ripple factor, withload for a full wave rectifier. .
16. To study analog to digital and digital to analog conversion.
17. To study a driven mechanical oscillator.
18.To verify Hartmann's formula using constant deviation spectrograph.
19. To find e/m of electron using Zeeman effect.
20. To find Dissociation energy to I.
21. Study of CH Bands.
22. Salt Analysis / Raman effect (Atomic).
23. Design and study of pass filters.
24. Michelson Interferometer.
25. Fabry parot Interferometer.
26. Determination of velocity of Ultrasonic waves.
27. Study of Eliptically polarised light by Babinet Compensator.

28. Veafication of Cauchey's Dispersion relation.
29. Study of DC gatecontrol characteristics and Anode current characteristics of SCR.

LIST OF EXPERIMENTS FOR M.Sc. FINAL

LIST OF EXPERIMENTS (any eighteen) :

1. Todetermine half-life of a radio isotope using GM counter.
2. To study absorption of particles and determine range using at least two sources.
3. To study characteristics of a GMcounter and to study statistical nature of radioactive decay.
4. To study spectrum of -β particles using Gamma ray-spectrometer.
5. To calibrate a scintillation spectrometer and determine energy of γ-rays from an unknown source.
6. (a) To study variation of energy resolution for a Nai (T) detector.
   (b) To determine attenuation coefficient (u) for rays from a given source.
7. To study Compton scattering of γ-rays and verify the energy shift formula
8. To .stud y temperature variation of resistivity or a semi-conductor and to oPHain band gap using four probe method.
9. To study hall effect a:nd to det,erminehall coefficient.
10. To study the variation of rigidity of a given specimen as a function of the temperature.
11. To study the dynamics of a lattice using electrical analog.
12. To study ESR and determine g -factor for a given spectrum.
13. Todetermine ultrasonic velocity and to oPHain compressibility for agiven liquid.
14. Study, the characteristics of a gb len Klystron and calculate the mode number, E.T.S. and transit time.,
15. Study the simulated L.C.R. tran:5mission line (audio frequency) and to find out the value for and Zo experimentally from the graph.
16. Study the radiation pattern of a given Pyramidal horn by plotting it on a Polar graph paper. Find the Half power beam width and calculate its gain.
17. Find the dielectric constaD.tof a gi yen solid (Teflon) for three different lengths by using slotted section.
18. Find the dielectric const.ant of a given liquid (organic) using slotted section of K-band.
19. Verification of Braggs law using microwaves..
20. Determination of Dielectric Constant of a liquid by lecher wire.
21. Study of a Heat Capacity of Solids.
22. Study of lattice dispersion.