3. To design a RC coupled two stage amplifier of a given gain and the cut off frequencies.
4. To study Hartley oscillator.
5. To Study Transistor bias Stability.
6. To design a Multivibrator of given frequency and study its wave shape
7. To study the characteristics of FET and use it o design an relaxation oscillator and measure its frequency.
8. To study 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 regulated 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, with load 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 perot Interferometer.
26. Determination of velocity of Ultrasonic waves.
27. Study of Eliptically polarised light by Babinet Compensator.
28. Verification of Cauchey's Dispersion relation

M. Sc PHYSICS FINAL

Paper-V	:	Advanced Quantum Mechanics and Introductory Quantum Field	Max Marks 100 Time 3 hrs
Paper-VI		Nuclear Physics	Max Marks 100 Time 3 hrs.
Paper-VII	:	Statistical and Solid State Physics	Max Marks 100 Time 3 hrs.
Paper-VIII	:	(A) Microwave Electronics	Max Marks 100 Time 3 hrs.
		OR	
Paper-VIII	:	(B) Plasma Physics	Max Marks 100 Time 3 hrs.

PAPER - V : ADVANCED QUANTUM MECHANICS AND INTRODUCTORY QUANTUM FIELD THEORY

Max. Marks 100 Duration 3 hrs.

Note : In all Ten questions are to be set. Five from each section. Candidates are required to attempt five questions in all, taking at least two questions from each section.

Section A

1. **Scattering (non-relativistic) :** Differential and 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 dependence 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, Coulomb scattering problem under first Born approximation in elastic scattering.

2. **Relativistic Formulation and Dirac Equation : Attempt for relativistic formulation of quantum theory, The Klein-Gordon equation, Probability density and probability current density, solution of free particle K.G. equation in momentum representation, interpretation of negative probability density and negative energy solutions.**

Dirac equation, orthogonality and completeness relations for Dirac spinors, interpretation of negative energy solution and hole theory.

3. **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 behaviour under Lorentz transformation. P.C.T. and CPT, expectation values of co-ordinate and velocity involving only positive energy solutions and the associated problems, inclusion of negative energy solution, Zitter bewegung, Klain paradox.

4. **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.

Section B

5. **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 feld, the meson propagator.

6. 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.

7. 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.

8. **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. Sakurai : 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).

PEPER - VI : NUCLEAR PHYSICS

Max. Marks 100 Duration 3 hrs.

Note : *In all Ten questions are to be set. Five from each section. Candidates are required to attempt five questions in all, taking at least two questions from each section.*

Section A

1. **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, noncentral and velocity dependent potentials, Analysis of the ground state ($3S_1$) of deuteron using a square well potential, range-depth relationship, excited states of deuteron. Discussion of the ground state of deutron under noncentral force, calculation of the electric quadrupole and magnetic dipole moments and the D-state admixture.

2. **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.

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

4. **Experimental Techniques : Gas filled counters; Scintillation**

[illegible] Cerenkov counters; Solid state detectors; Surface barrier detectors; [illegible] 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.

Section B

5. *Nuclear shell* **model** : Single particle and collective motions in [illegible] Assumptions and justification of the shell model, average shell potential, [illegible] coupling; single particle wave functions and level sequence; magic numbers; shell model predictions for ground state parity; angular momentum, [illegible] and electric-quadrupole moments; and their comparison with [illegible] configuration mixing; single particle transition probability [illegible] the shell model; selection rules; approximate estimates for the [illegible] and Weisskopf units; Nuclear isomerism.

6. **Collective nuclear models** : Collective variable to describe the [illegible] 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 [illegible] deformed even-even nucleus and moments of inertia; Collective spectra [illegible] electromagnetic transition in even nuclei and comparison with experimental data. Nilsson model for the single particle states in deformed nuclei.

7. **Nuclear gamma and beta decay** : Electric and magnetic multipole [illegible] gamma decay probabilities in nuclear system (no derivations) [illegible] probability. Selection rules; Internal conversion and zero- [illegible]

[illegible] characteristics of weak interaction, nuclear beta decay and [illegible] energy spectrum and Fermi-Kurie plot; Fermi th[illegible] [illegible] beta decay; parity conserved selection rules Fermi and Gammow-Teller) 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

8. 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; [illegible] cross section; statistical theory of nuclear reactions. [illegible] probability and cross section for specific reactions; The optical model. [illegible] reactions and their simple theoretical description (Butler [illegible]

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 Structure, Affiliated East-West Press,1982).
6. R.R. Roy and B.P. Nigam, Nuclear Physics, Willey-Easter, 1979
7. M.A. Preston & R.K Bhaduri-Structure of the Nucleus, Addision Wesley, 1975
8. R.M. Singru : Introductory Experimental Nuclear Physics
9. England - Techniques on Nuclear Structure (Vol. I)
10. R.D. Evans - The Atomic Nucleus (McGraw - Hills, 1955)
11. H. Enge - Introduction to Nuclear Physics, Addition-Wesley, 1970
12. W.E. Burcham - Elements of Nuclear Physics, 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

PEPER-VII : STATISTICAL AND SOLID STATE PHYSICS

Max. Marks 100 Duration 3 hrs.

Note : In all Ten questions are to be set. Five from each section. Candidates are required to attempt five questions in all, taking at least two questions from each section.

Section A

1. **Basic Principles, Canonical** and Grand Canonical ensembles: Concept of statistical distribution, phase space, density of states, Liouville's theorem, systems and ensemble, entropy in statistical mechanics Connection between thermodyanic and statistical quantities micro canonical ensemble, equation of state, specific heat and entropy of a perfect gas, using micro canonical ensemble.

Canonical ensemble, thermodynamic functions for the canonical ensemble, calculation of mean values, energy fluctuation in a gas, grand canonical ensemble, thermodynamic functions for the grand canonical ensemble, density fluctuation[illegible] of translational, rotational and vibrational contributions to the partition function of an ideal diatomic gas. Specific heat of a diatomic gas, ortho and para hydrogen.

Identical particles and symmetry requirement. difficulties with Maxwell-Boltzmann statistics, quantum distribution functions. Bose-Einstein and Fermi-Dirac statistics, Boson statistics and Planck's formula, Bose Einstein condensation, liquid He^4 as a Boson system, quantization of harmonic oscillator and creation and annihilation of Phonon operators, quantization of fermion operators

3. **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 thermal conductivity and electrical conductivity, Widemann - Franz ratio, susceptibility, width of conduction band, Drude theory of light absorption in metals.

4. **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.

Section B

5. **Lattice Vibratuibs and Thermal Properties** : Interrelations between elastic constants C_{11}, C_{12} and C_{44} wave propagation and exparimental determination of elastic constant of cubic crystal, vibrations of linearmono and diatomic lattices. Determination of phonon dispersion by inelastic scattering of neutrons.

6. **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 centres in alkali halides.

7. **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.

Giver and AC and DC. Josephson tunnelings.

(b) Cooper pairs and derivation of BCS Hamiltonian. results of BCS theory (no derivation).

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. Palierson : Solid State Physics
7. Levy : Solid State Physics
8. Mckelvy : Solid State and Semi-conductor Physics.

PEPER - VIII : (A) MICROWAVE ELECTRONICS

Max. Marks : 100 — Duration 3 hrs

Note : *In all Ten questions are to be set. Five from each section. Candidates are required to attempt five questions in all, taking at least two questions from each section.*

Section A

1. Introduction to microwaves and its frequency spectrum. Application of microwaves.

   Wave guides : (a) Rectangular wave guides: Wave Equation & its solutions, TE&TM modes. Dominant mode 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. (a) **Resonators :** Resonant Modes of rectangular and cylindrical cavity resonators, Q of the cavity resonators, Excitation techniques, Introduction to Microstrip and Dielectric resonators, Frequency meter.

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

3. **Microwave tubes: Space charge ...**

Electric & Magnetic field of oscillations. Modes of oscillation & operating characteristics.

Traveling wave tubes : O & M type travelling wave tubes.

Gyrotrons: Constructions of different Gyrotrons. Field - Particle Interaction in Gyrotron.

4. **Microwave Measurement :**

a. Microwave Detectors: Power, Frequency, Attenuation, Impedance using smith chart, VSWR, Reflectometer, Directivity, coupling using direction coupler.

b. Complex permittivity of material & its measurement: definition of complex of Solids, liquids and powders using shift of minima method.

Section B

1. (a) Avalanche Transit Time Device: Read Diode, Negative resistance of an avalanching p-n Junction diode IMPATT and TRAPATT Oscillator.

(b) Transferred Electron Device: Gunn effect, two velley model, High field Domains, Different Modes for Microwave generation.

(c) Passive Devices: Termination (Short circuit and matched terminations) Attenuator, phase changers. E&H plane Tees, Hybrid Junctions. Directional coupler.

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

3. Microwave Antennas: Introduction to antenna parameters, Magnetic Currents, Electric and magnetic 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, Microstip wave guide, Microstrip antenna calculations, Microstrip design formulas.

4. Microwave Communication: (a) LOS microwave systems, Derivation of LOS communication range, OTH microwave systems. Derivation of field strength of tropospheric waves. Transmission interference and signal damping. Duct propagation.

5. Satellite Communication : Satellite frequencies allocation, Synchronous satellites. Satellite orbits. Satellite location with

Reference Books:

1. Electromagnetic waves & Radiating Systems : Jorden & Balmain.
2. Theory and application of microwaves by A.B. Brownwell & R.E. 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 R.E. 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-1 by R.E. Collin & F.J. 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. Wolf (J. Willey & Sons)
13. Antenna Theory & Design by RS Elliott (LPHI Ltd. New Delhi)
14. Microwave electronics by R.F. Sooboo (Addisen Westey public company.).
15. Microwave Active Devices, Vacuums by M.L. Sisodia new Age International New Delhi.
16. Semiconductors & Electronics device by A. Barle 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-427-431, 1992.

PEPER - VIII (B) : PLASMA PHYSICS

Max. Marks 100

Section A

1. **Basic properties and occurence.** Definition of plasma. Criteria [illegible] plasma behaviour. Plasma oscillation. Quasineutrality and Debye shielding. The plasma parameter. natural occurence of plasmas. Astrophysical plasmas. Plasma in Magnetospbere and ionosphere. introduction to various theoretical approaches : Kinetic, Multi-Fluid and single fluid.

2. **Charged particle motion and drifts :** Guiding centre motion of a charges particle. Motion in (i) uniform electric and magnetic fields (i) gravitational and magnetic fields. Motion in non-uniform magnetic field (i) Grad B perpendicular to B, Grad B drift and curvature drift (ii) Grad B parallel to B and principle of magnetic mirror. Motion in non-uniform electric field for small larmour radius. Time varying electic field and polarization drift. Time varying magnetic field adiabatic invariance of magentic moment.

3. **Diffusion and resistivity:** Collision and diffusion parameters. Decay of a plasma by diffusion. ambipolar diffusion. Diffusion across a [illegible] field. Collision in fully ionized plasma.. Plasma resistivity. Diffusion [illegible] plasmas. Solution of Diffusion equation. plasma production [illegible]. Thermal ionization. saha equation. Brief discussion of methods [illegible] plasma production . Steady state glow discharge. microwave [illegible] and induction discharge. Double plasma machine. elementary [illegible] plasma diagnostics. electrostatic and magnetic probes.

4. **MHD power generation.** basic principle and working of MHD [illegible]. Conductivity of gaseous working fluid. Basic fluid equations. [illegible] Ohm's law. Faraday and Hall generators. performance [illegible] and electrical efficiency of Faraday and Hall Generators.

Section B

1. **Waves in plasma:** electron plasma waves. Ion Waves. [illegible] electron oscillations perpendicular to B, upper hybrid oscillations. [illegible] waves perpendicular to B. ion cyclotron waves. Lower hybrid [illegible]. Electromagnetic waves in field free plasma. Electromagnetic waves [illegible] B. Cut offs and resonances. Electromagnetic waves parallel [illegible] field. Hydromagnetic waves. Magnetosonic waves.

2. **Equilibrium and Stability :** Hydromagnetic equilibrium. [illegible] of magnetic field into a plasma. Classification of instabilities. The [illegible] instability. Kinetic treatment of plasma oscillations and landau damping physical explanation.

3. **Non-linear effects :** The Sagdeev potential. Derivation of KdV [illegible] ion acoustic waves. Soliton solution in one dimension. Elementary [illegible] the ponderomotive force and parametric instability. Oscillating [illegible]

4. **Controlled thermonuclear fusion :** Potentials and problems of controlled thermonuclear fusion. Ignition temperature and Lawson criteria Magnetic confinement. Simple discussion of Tokmak, stellarators, multipoles and Z-pinch. Idea about intertial confinement and laser fusion. Methods of plasma heating and problems of fusion.

References :

1. F.F. Chen: An Introduction to Plasma Physics (Plenum Press) 1974.
2. Boley : Plasmas : Laboratory and Cosmic.
3. W.B. Kunkel : Plasma Physics in theory and Application.
3. J.A. Bittencourt: Fundamentals of Plasma Physics (Pergamon Press) 1986
4. Huddlestone & Leonord : Plasma Diagnostic Techniques.
5. R.C. Davidson : Methods in Non-linear Plasma theory. 1972.
6. Holt and Haskel : Foundations of Plasma.

LIST OF EXPERIMENTS FOR M.Sc FINAL

Scheme :

The examination will be conducted for two days. 6 hrs. each day. The distribution of the marks will be as Follows :

	Marks
Two experiments	120
Viva	40
Record	40
Total	200
Minimum Pass Marks	72

LIST OF EXPERIMENTS (any eighteen)

1. To determine 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 GM counter 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.

formula.

8. To study temperature variation of resistivity for a semi-conductor and to obtain band gap using four probe method.
9. To study hall effect and to determine hall 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. To determine ultrasonic velocity and to obtain compressibility for a given liquid.
14. Study the characteristics of a given Klystron and calculate the mode number, E.T.S. and transit time.
15. Study the simulated L.C.R. transmission 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 beamwidth and calculate its gain.
17. Find the dielectric constant of a given solid (Teflon) for three different lengths by using slotted section.
18. Find the dielectric constant of a given liquid (organic) using slotted section of K-band.
19. Verification of Bragg's law using microwaves..
20. Determination of Dielectric Constant of a liqcid by lecher wire.
21. Study of a Heat Capacity of Solids.
22. Study of lattice dispersion.

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Dy. Registrar
(Academic)
University of Raja[sthan]
JAIPUR