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 of 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. Verification of Cauchey's Dispersion relation.
29. Study of DC gate control characteristics and Anode current characteristics of SCR.

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.

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Paper – V

ADVANCED QUANTUM MECHANICS & INTRODUCTORY QUANTUM FILED THEORY

Max. Marks 100 **Duration : 3hrs.**

Note: In all ten questions are to be set, five from each section. Candidates are required to attempt five questions in all taking atleast 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- Wigger formula, quasi stationary states.

   The Lippman-Schwinger equation and the Green's function approach for scattering problem, Bein 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 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 and hole theory.

3. **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

4. **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.

5. **The occupation number representation for fermions:** second quantization of the Dirac field, the femion propagator, the e.m. interaction and gauge invariance, covariant quantization of the free electromagnetic field the photon propagator.
6. **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.

Reference Books:

1. Ashok Das and A.C. Millissiones : Quantum Mechanics - A Modern Approach.(Garden and Breach Science Publishers)
2. E. Meržbaker : Quantum Mechanics, Second Edition (John Wiley and sons)
3. Bjorken and Drell : Relativistic Quantum Mechanics (MGraw Hill)
4. J.I. 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 – VI
NUCLEAR PHYSICS

Max. Marks 100 **Duration : 3hrs.**

Note: In all ten questions are to be set, five from each section. Candidates are required to attempt five questions in all taking atleast 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,)of deuteron using a square well potential, range-depth relationship, excited states of deuteron, Discussion of the ground state of deuteron 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 qualitalive discussion of proton-proton scattering at low energy: General features of two-body seattering af high energy Effect of exchange forces: Phenomemonological Hamada- Johniston 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 section for polarized and unpolarized radiation, angular distribution of scattered ploton and electrons, Energy loss of charged particles due to ionization, Bremstrahlung; energy target and projectile dependence of all three processes, Range-energy curves; Straggling.

Section - B

4. **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; agic 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.

5. **Nuclear gamma and beta decay:** Electric and magnetic multipole moments and gamma decay probabilities in nuclear system (no derivations), Reduced transition probability, Selection rules; Internal conversion and zero-zero transition.

   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 Gammow-Teller) for allowed transitions, l-values; General interaction Hamiltonian for beta decay with parity conserving and son conserving terms; Forbidden transitions Experimental verification of parity violation, The V-A interaction and experimental evidence.

6. **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 ($\ell = 0$), continuum cross section; statistical theory of nuclear reactions, evaporation probability and cross section for specific reactions; The optical model, Stripping and pick-up readtions, 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.

Reference Books:

1. J. M Blatt and V.E. Weisskipf: Theoretical Nuclear Physics
2. Statistical theory of nuclear reactions, Exaparation probability and cross section 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 Bop Nigam, Nuclear Physics, 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-The Atomic Nucleus(McGraw-Hills, 1955)
11. H. Edge - 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.

Paper – VII

STATISTICAL AND SOLID STATE PHYSICS

Max. Marks 100 **Duration : 3hrs.**

Note: In all ten questions are to be set, five from each section. Candidates are required to attempt five questions in all taking atleast 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 thermodynamics 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 f gas, grand Canonical ensemble, thermodynamic functions for the grand canonical ensemble.

2. **Partition functions and Statistics:** Partition functions and Properties, partition function for an ideal gas and calculation of thermodynamic

quantities, Gibbs Paradox, validity of classical approximation, determination of translational, rotational and vibrational contributions to the partition function of ideal diatomic gas. Specific heat of a diatomic gas,

Identical particles and symlaetry requirement, difficulties with Maxwell-Boltzmann statistics, quantum distribution functions, Bose-Einstein and Fermi-Dirac statistics, Boson statistics and Planck's formula, Bose Einstein condensation.

3. **Theory of Metals :** Pernmi- 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 conduétion band, Drude theory of light, absorption in metals.
4. **Band Theory:** Bloch theorem, Kronig Penny model, effective mass of electrons, NFE model, tight binding method and calculation of density for a band in simple cubic lattice.

Section-B

5. **Lattice Vibrations and Thermal Properties:** Interrelations between elastic constants C11, C12 and C44 wave propagation and experimental determination of elastic constant of cubic crystal, vibrations of linearmono and diatomic lattices, Determination of phonon dispersion by inelastic scattering of neutrons.
6. **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 inclastic neutrons scattering, heat capacity. Nuclear Magnetic resonance: Conditions of resonance, Block equations: NMR –experiment and characteristics of an absorption line.
7. **Superconductivity:** (a) Experimental results: Meissner effect, beat capacity, isotope effect, flux quantization ultrasonic attenuation. Giver and AC and DC. Josephson tunnelings.

   (b) Cooper pair: Cooper pairs and derivation of BCS Hamiltonian, results 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 la Solid State Physics.

6. Patterson: Solid State Physics.
8. Mckelvy: Solid State and Semi-conductor Physics.

Paper – VIII

STATISTICAL AND SOLID STATE PHYSICS

Max. Marks 100 **Duration : 3hrs.**

Note: In all ten questions are to be set, five from each section. Candidates are required to attempt five questions in all taking atleast two questions from each section.

Section-A

1. **Wave guides:** Introduction to microwaves and its frequency spectrum, microwaves.

   (a) Rectangular wave guides: Wave Equation & its solutions, TE & TM modes, Dominant mode and choice of wave guide Dimensions Methods of excitation of waye: guide.

   (b) Circular wave guide- wave equation & its solutions, TE, TM & TEM modes.

   (c) Attenuation Cause of attenuation in wave guides, wall church & 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 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 spreading of an electron beam, Beam focusing. Klystrons: Velocity Modulation, Two Cavity Klystron, Reflex Klystron, Efficiency of Klystrons.

   Electric & Magnetic Field of oscillations, Modes of oscillation & operating characteristics.

   Travelling wave tubes: O & M type travelling wave tube.

4. **Microwave Measurement:**

   (a) Power, Frequency, Attenuation, Impedance Using smith chart, VSWR.

Section B

1. **(a) Avalanche Transit Time Device:** Read Diode, Negative resistance of an avalanching P-n Junction diode IMPATT.

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

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(c) Passive Devices: 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. **(a) 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, Duct propagation.

   (b) 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 & Balpriiy.
2. Theory and application of microwaves by A.B. Brownwell 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 I. Sisodia yd G.S. Raghuvanshi (New Age International, New Delhi)
6. Foundations of microwave engineering by RECollih. (McGraw Hill).
7. Microwave Semiconductor Devices and their Circuit applications by H.A Watson.
8. Microwave by M.L. Sisodia and Vijay Laxml Gupta. New Age, New Delhi,
9. Antenna Theory, Part-1 by A. CollaterAL. Zucker (McGraw Hill, New York)
10. Microstrip Antennas by Bahl & Bhartiya (Artech House, Messachausetts)
11. Antenna Theory Analysis by Tuklanis Harper & Row. Pub. & Inc. New York.
12. Antenna Theory Analysis by EA W01"(J. Willey & Sons).
13. Antenna Theory & Design By RS Elliott (LPHI Ltd. New Delhi).
14. Microwave clectronics by RE Soohoo (Addisen Westey public company.).
15. Microwave Active Devices, Vacuoums 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. Vinderziel, (PHII. Indin).
18. Hand book of microwave measurement Vol-Il by M. Sucher & J.Fox (polytechnic Press, New York).
19. Microwave devices & circuits by S.Y Liao(PHI, India).

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20. Microwave Principles by H.J. Reich (CBS).
21. Simple microwave techniques for measuring the dielectric paranieters of solids & their powder by J.M. Gandhi, J.S. Yadav, J. of pure & applied physics Vol 30. pp-427431, 1992

Paper – VII
PLASMA PHYSICS

Max. Marks 100 **Duration : 3hrs.**

Note: In all ten questions are to be set, five from each section. Candidates are required to attempt five questions in all taking atleast two questions from each section.

Section-A

1. **Basic properties and occurrence:** Definition of plasma, Criteria for plasma Behaviour. Plasma oscillation. Quasi neutrality and Debye Shielding. The plasma parameter, natural occurrence of plasma. Astrophysical plasmas. Plasma in Magnetosphere and ionosphere. Introduction to various theoretical approaches: Kinetic, Multi-Elude and single fluid.
2. **Charged particle motion and drifts:** Guiding centre motion of a charges particle. Motion in (i) uniform electric and magnetic field (ii) gravitational and magnetic fields. Motion in non-uniform magnetic field (1) grad B perpendicular to B, grad B drift and curvature drift (ii) grade B parallel to B and principle of magnetic mirror, Motion in non-uniform electric field for small Larmour radius, Time varying electrio field and polarization drift, Time varying magnetic field adiabatic invariance romantic moment.
3. **Diffusion and Resistivity:** Collision and diffusion parameters. Decay of a plasma by diffusion, ambipolar diffusion. Diffusion across magnetic field. Collision in fully ionized plasma. Plasma resistivity: Diffusion in fully ionized plasmas. Solution of Diffusion equation, plasma production and diagnostics, Thermal ionization. Saha equation. Brief discussion of methods of laboratory plasma production; Steady stage glow discharge, microwave breakdown and induction discharge, Double Plasma machine, elementary ideas about plasma diagnostics Electrostatic and magnetic probes.
4. **MHD power generation:** basic principle and working of MID power generator, Conductivity of gascousty working lluid, Basic fluid equations, Generalized Ohm's law, Faraday and Hall generators performance characteristics and electrical efficiency of Faraday and hall generators.

Section-B

5. **Waves in plasma:** Electron plasma waves. long Waves, Electrostatic electron oscillations perpendicular to B, upper hybrid oscillations. Electrostatic ion waves perpendicular to B. 10h cyclotron waves, Lower hybrid oscillations,

Electromagnetic waves in field free plasma. Electromagnetic waves perpendicular to B. Cut olls and resonances Electromagnetic waves parallel to magnetic field, hydro magnetic waves. Magnetosonic waves.

6. **Equilibrium and stability:** Hydromagnetic equilibrium. Diffusion of magnetic field into plasma, Classification instabilities. The gravitational instability. Kinetic treatment of plasma oscillations and landau damping, physical explanation.

7. **Non-linear effects:** The Sagdcov potential, Derivation of KdV equation for ion acoustic waves. Soliton solution in onc dimension. Elementary ideas about the ponderinotive force and parametric instability. Oscillating two stream instability.

8. **Controlled thermonuclear fusion:** Potentials and problems of controlled thermonuclcar fusion, Ignition temperature and Lawson criteria, Magnetic confinement. Simple discussion of Tokrmak, stellarators, multipoles and z pinch, Idea about inertial 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 Consmic.
3. W.B. Kunkel: Plasma Physics in Theory and Application
4. J.A. Bittencoms: Fundamentals of Plasma Physics (Pergamnons Press 1986.
5 Huddlestone & leonord : Plasma Diagnostic Technique.
6 R.C. Davidson: Methods in Non-linear Plasma Theory (Academy Press) 1972
7. Holt and Haskel. Foundations of plasma.

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LIST OF EXPERIMENTS FOR M.Sc PREVIOUS

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 eight for the session 20-21)

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 andao statistical nature of radioactive decay.
4. To study spectrum of-B (Beta) particles using Gamma ray spectrometer.
5. To calibrate a scintillation spectrometer determine energy of y-rays from an 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 souttering of Gamma-rays and verily the energy shift formula
8. To study temperature variation of resistivity or a semi-conductor and to obtain band gap using four probe method.
9. To study Hall Effect 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 beam width and calculate its gain.

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17. Find the dielectric contact of a given solid (Teflon) for three slotted section. 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 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.

Only For Session
2020-21

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