# M. Sc. (Physics) Semester I: Core Paper CT-1

**Title of Course: Mathematical Physics and Classical Mechanics**

| | |
|---|---|
| No. of credits: | **03** |
| Teaching Hours: | 40 |
| Internal Examination, Preparation and Evaluation: | 05 |
| Total contact hours: | **45** |
| Total Marks: | **100** |
| External marks: | 70 |
| Internal Marks: | 30 |

**Structure of Semester End Examination**

Maximum Marks: **70** Time: **3 HRS**

Q. 1 Objective type answers covering all the five units. EIGHT questions will be asked, out of which, students have to answer any FIVE Marks: 5 × 2 = **10**

Q. 2 Three numerical problems (wherever possible) or conceptual questions will be asked. Students have to solve any TWO out of THREE Marks: 2 × 5 = **10**

Q. 3-7 Descriptive questions, each having internal option (3 or 3, 4 or 4 etc…). One from each unit, carrying 10 Marks each. Marks: 5 × 10 = **50**

**Detailed Syllabus**

**Unit 1** **07 HRS**

**Ordinary Differential Equations:**

Introduction, Solution of second order differential with variable coefficients (1) Homogenous equations (2) Inhomogeneous equations

Series integration method of the solution of linear differential equations (Frobenius' method)

**Unit 2** **11 HRS**

**Laplace and Fourier transforms:**

Integral transform, Laplace transform, Some simple properties of Laplace transforms (a) linearity property (b) shifting properties, first & second shifting (c) change of scale property

Laplace transform of derivatives & integral, inverse Laplace transform by partial functions

Fourier series and applications .The Fourier transform, Fourier sine & cosine transform simple application of Fourier transform

**Unit 3** **08 HRS**

**The Equation of Motion and First Integrals:**

The differential equation for the orbit, Condition for closed orbits, Bertrand's theorem, Kepler's problem, Inverse square law of force, classification of orbit's, Rutherford scattering

**Unit 4** **06 HRS**

**Canonical Transformations:**

The equation of canonical transformation, Example of Harmonic oscillator, Poisson brackets properties of Poisson brackets, The angular momentum Poisson bracket relation. The Virial theorem

**Unit 5** **08 HRS**

**Hamilton – Jacobi Theory:**

Hamilton – Jacobi theory, Hamilton – Jacobi equation for Hamilton's principal function, Harmonic oscillator example, Hamilton's characteristic and principle functions.

Moving coordinate system, Coordinate system with relative translational motions, Rotating coordinate systems, The Coriolis force, Motion on the earth

**Text Books:**

Classical Mechanics – H. Goldstein
Classical Mechanics – N.C. Rana and P.S. Joag

**Reference Books:**

Introduction to Classical Mechanics – R.G. Takwale & Puranik
Classical Mechanics of particles and rigid bodies – Kiran C. Gupta
Classical Mechanics – Y.R. Waghmare
Classical Mechanics – Bhatia
Classical Mechanics – Leech
Mathematical Physics – Rajput
Mathematics for Physics – M.L. Boas
Mathematical methods for physics – G. Arfkan

# M. Sc. (Physics) Semester I: Core Paper CT-2

**Title of Course: Electronic Devices and Circuits**

| | |
|---|---|
| No. of credits: | **03** |
| Teaching Hours: | 40 |
| Internal Examination, Preparation and Evaluation: | 05 |
| Total contact hours: | **45** |
| Total Marks: | **100** |
| External marks: | 70 |
| Internal Marks: | 30 |

**Structure of Semester End Examination**

Maximum Marks: **70** Time: **3 HRS**

Q. 1 Objective type answers covering all the five units. EIGHT questions will be asked, out of which, students have to answer any FIVE Marks: 5 × 2 = **10**

Q. 2 Three numerical problems (wherever possible) or conceptual questions will be asked. Students have to solve any TWO out of THREE Marks: 2 × 5 = **10**

Q. 3-7 Descriptive questions, each having internal option (3 or 3, 4 or 4 etc…). One from each unit, carrying 10 Marks each. Marks: 5 × 10 = **50**

**Detailed Syllabus**

**Unit 1** **08 HRS**

Junction Field Effect Transistors, Comparison with BJT, basic Construction, polarity conventions, Characteristics, JFET parameters, JFET-biasing, Common source amplifier, Source-follower, MOSFETS, DE-MOSFETS: Construction and Characteristics, E-MOSFETS: Construction and Characteristics, Complementary MOS (CMOS)

**Unit 2** **08 HRS**

**Optoelectronic Devices:**

Classification, Radiative and non-radiative transitions, Light dependent resistors, photoconductive cells, Photo-diode, PIN Photodiode, Photo-transistor, Light emitting diodes, Liquid crystal displays, seven-segment displays, Opto-couplers

**Unit 3** **10 HRS**

**Solid State Devices for Special Applications:**

Two terminal devices, Zener diode, Varactor diode, step-recovery diode, Schottky diode, Voltage dependent resistors, Silicon controlled rectifier, TRIAC, DIAC, SCS, GCS, Uni-Junction transistor, UJT-relaxation oscillator, Programmable UJT (PUT), Thermistors, Solar-cells, semiconductor Laser, population inversion at junction optical gain and thereshold current for lasing

**Unit 4** **08 HRS**

**Integrated Logic Families:**

Digital IC terminology, The TTL logic family, Loading and fan-out, other TTL series, The ECL logic family, MOS digital ICs, CMOS series characteristics

**Unit 5** **06 HRS**

**Combinational logic Circuits Designing Using SSI:**

Review of Boolean algebra, Axioms and theorems, Canonical and standard Boolean functions, Designing of combinational logic circuits using gates, Various implementations, Design examples

**References Books:**

Electronic Circuits: Discrete and Integrated, Donald Schilling & Charles
Belove, MaGraw Hill International
Electronic devices and circuit theory, Robert Boylestad & Louis Nahselsky, PHI
Solid State Devices and integrated circuits, W.D. Cooper Weisbecker, Reston Pub (USA)
Solid state Devices & applications, Frederick Driscoll & Robert Coughlin, Prantice Hall
Digital Systems: Principles and Applications, Ronald J. Tocci, PHI

# M. Sc. (Physics) Semester I: Core Paper CT-3

**Title of Course: Quantum Mechanics - I**

No. of credits: **03**

Teaching Hours: 40
Internal Examination,
Preparation and Evaluation: 05

Total contact hours: **45**

Total Marks: **100**
External marks: 70
Internal Marks: 30

**Structure of Semester End Examination**

Maximum Marks: **70** Time: **3 HRS**

Q. 1 Objective type answers covering all the five units. EIGHT questions will be asked, out of which, students have to answer any FIVE Marks: 5 × 2 = **10**

Q. 2 Three numerical problems (wherever possible) or conceptual questions will be asked. Students have to solve any TWO out of THREE Marks: 2 × 5 = **10**

Q. 3-7 Descriptive questions, each having internal option (3 or 3, 4 or 4 etc…). One from each unit, carrying 10 Marks each. Marks: 5 × 10 = **50**

**Detailed Syllabus**

**Unit 1** **08 HRS**

One – dimensional harmonic oscillator by Schrodinger equation – power series solution, Plotting of Harmonic oscillator wave functions – classical correspondence – operator methods. Bra and Ket notations, Matrix representation of an operator, The Unitary transformation

**Unit 2** **08 HRS**

Angular momentum commutation relation, coordinate transformation, Angular momentum operators and its eigen value problems in position representation, Spherical harmonics

**Unit 3** **08 HRS**

Solution of Schrodinger equation in three dimension separable variable method, Applications to (I) Square well (II) Attractive coulomb potential (III) Hydrogen Atom

**Unit 4** **08 HRS**

Time independent perturbation theory: Stationary perturbation, Degenerate and no degenerate case, Application such as stark effect. Time dependent perturbation, General formulation and the first order theory, Periodic perturbation and Fermi Golden Rule, Interaction of electromagnetic field with atom,

**Unit 5** **08 HRS**

Approximation methods: Variational method and its application. WKB approximation – solution of one – dimensional Schrodinger equation, Conditions at turning points. Application of WKB approximation.

**Text Books:**

Quantum Mechanics – Schiff (McGraw Hill)
A text book of Quantum Mechanics – Mathews and Venkatesan
Quantum Mechanics – Amit Gowsami

**Reference Books:**

Fundamental of Quantum Mechanics – Vaghmare
Modern Quantum Mechanics – J. J. Sakurai
Quantum Mechanics – J. P. E. Peebles
Quantum Mechanics – K. K. Chopra, G. C. Agarwal

# M. SC. (Physics) Semester I: Core Paper CT- 4

**Title of Course: Electrodynamics and Plasma Physics**

| | |
|---|---|
| No. of credits: | **03** |
| Teaching Hours: | 40 |
| Internal Examination, Preparation and Evaluation: | 05 |
| Total contact hours: | **45** |
| Total Marks: | **100** |
| External marks: | 70 |
| Internal Marks: | 30 |

**Structure of Semester End Examination**

Maximum Marks: **70** Time: **3 HRS**

Q. 1 Objective type answers covering all the five units. EIGHT questions will be asked, out of which, students have to answer any FIVE Marks: 5 × 2 = **10**

Q. 2 Three numerical problems (wherever possible) or conceptual questions will be asked. Students have to solve any TWO out of THREE Marks: 2 × 5 = **10**

Q. 3-7 Descriptive questions, each having internal option (3 or 3, 4 or 4 etc…). One from each unit, carrying 10 Marks each. Marks: 5 × 10 = **50**

**Detailed Syllabus**

**Unit 1** **08 HRS**

**Maxwell's Equations:**

Vector algebra, Introduction to electrodynamics, Electrodynamics before Maxwell, Ampere's law, Maxwell equations in matter and boundary conditions

**Unit 2** **10 HRS**

**Electromagnetic Waves, Potentials and Fields:**

The wave equation for E and B, propagation in linear media, reflection and transmission at normal and oblique incidence, electromagnetic waves in conductors, scalar and vector potentials, Gauge transformations, Retarded potentials, Lienard - Wiechert potentials, the field of a moving point charge

**Unit 3** **08 HRS**

Definition of Plasma, Plasma parameters, criteria for plasma, Applications of Plasma Motion of Charged particle in Uniform B and E fields, non uniform B and E fields, time varying E field, adiabatic invariants

**Unit 4** **07 HRS**

Dielectric constant of Plasma, Fluid equation of Plasma, convective derivative, fluid drifts perpendicular to B, plasma instabilities

**Unit 5** **07 HRS**

Concept of phase and group velocities, plasma oscillations, expression for $\omega_p$, Experimental consequences – Whistler modes, Faraday rotation, Hydro magnetic waves and Magneto sonic or Alfven waves

**Text Book:**

Introduction to Plasma Physics & controlled fusion ($II^{nd}$ edition): Vol. 1: Plasma Physics By F.F. Chen

**Reference Book:**

Introduction to electrodynamics, D.J. Griffith (PHI, Private limited, New Delhi)
Plasma Physics by Bittencourt
Plasma Physics by Chakraborty

# M. Sc. (Physics) Semester II: Core Paper CT-5

**Title of Course: Quantum Mechanics - II and Statistical Mechanics**

No. of credits: **03**

Teaching Hours: 40
Internal Examination,
Preparation and Evaluation: 05

Total contact hours: **45**

Total Marks: **100**
External marks: 70
Internal Marks: 30

**Structure of Semester End Examination**

Maximum Marks: **70** Time: **3 HRS**

Q. 1 Objective type answers covering all the five units. EIGHT questions will be asked, out of which, students have to answer any FIVE Marks: 5 × 2 = **10**

Q. 2 Three numerical problems (wherever possible) or conceptual questions will be asked. Students have to solve any TWO out of THREE Marks: 2 × 5 = **10**

Q. 3-7 Descriptive questions, each having internal option (3 or 3, 4 or 4 etc…). One from each unit, carrying 10 Marks each. Marks: 5 × 10 = **50**

**Detailed Syllabus**

**Unit 1** **08 HRS**

**Classical Statistical Mechanics:**

The postulate of classical statistical mechanics, Derivation of thermodynamics, Classical ideal gas, Gibbs Paradox

**Canonical Ensembles and Grand Canonical Ensembles:**

Canonical Ensemble, Energy fluctuations in canonical ensemble, Grand canonical ensemble, Density fluctuations in grand canonical ensemble

**Unit 2** **08 HRS**

**Quantum Statistical Mechanics:**

Postulate of Quantum Statistical mechanics, Density matrix, Macro – Canonical ensemble, canonical ensemble, The ideal gases, Micro – canonical ensemble

**Unit 3** **08 HRS**

**Super Fluids:**

Liquid Helium, Why helium does not solidify? Tisza's two – fluid model

**The Ising Model:**

Defination of the ising model, Lattice gas, Binary alloys

**Unit 4** **08 HRS**

**Scattering Theory:**

Kinematics of the scattering process, Diffrentyial and total cross – sections, Wave mechanical picture of scattering, The scattering amplitude, Green's functions, Formal expression for the scattering amplitude, Born approximation, The screened Coulomb potential, Validity of Born approximation, Born series, The eikonel approximation

**Unit 5** **08 HRS**

**Partial Wave Analysis:**

Defination of partial waves, Asymptotic behavior of partial waves: phase shifts (a) partial waves (b) asymptotic form of radial function (c) phase shifts, The scattering amplitude in terms of phase shifts, The differential and total cross – sections, Optical theorem, Phase shifts: Relation to the potential, Expression for the phase shift

**Text Books:**

Statistical Mechanics – K. Huang (Wiley)

Quantum Mechanics – Mathews and Vankatesan

# M. Sc. (Physics) Semester II: Core Paper CT-6

**Title of Course: Atomic and Molecular Physics**

No. of credits: **03**

Teaching Hours: 40
Internal Examination,
Preparation and Evaluation: 05

Total contact hours: **45**

Total Marks: **100**
External marks: 70
Internal Marks: 30

**Structure of Semester End Examination**

Maximum Marks: **70** Time: **3 HRS**

Q. 1 Objective type answers covering all the five units. EIGHT questions will be asked, out of which, students have to answer any FIVE Marks: 5 × 2 = **10**

Q. 2 Three numerical problems (wherever possible) or conceptual questions will be asked. Students have to solve any TWO out of THREE Marks: 2 × 5 = **10**

Q. 3-7 Descriptive questions, each having internal option (3 or 3, 4 or 4 etc…). One from each unit, carrying 10 Marks each. Marks: 5 × 10 = **50**

**Detailed Syllabus**

**Section I: ATOMIC PHYSICS**

**Unit 1** **08 HRS**

Application of Schrodinger equation for hydrogen atom, interpretation of the results of Schrodinger equation, atomic energy levels, dependence of wave function on the angle θ and Φ, radial dependence of wave function.

**Unit 2** **08 HRS**

Pauli's exclusion principle, maximum number of electrons in a given group or subgroup, different series in alkali spectra, term values in alkali spectra and quantum defect, L-S coupling, JJ coupling, interaction energy in L-S coupling & JJ coupling, fine structure and hyperfine structure (qualitative), Line-broadening mechanisms (general ideas), normal and anomalous Zeeman effect, Paschen-back effect and Stark effect.

**Section II: MOLECULAR PHYSICS**

**Unit 3** **08 HRS**

Rotation of molecules, classification of molecules, interaction of radiation with rotating molecule, rotational spectra of rigid diatomic molecules, isotope effect in rotational spectra, intensity of rotation lines, non-rigid rotator, linear polyatomic molecules.

**Unit 4** **08 HRS**

Symmetric top molecules, asymmetric top molecules, Stark effect, microwave spectrometer, information derived from rotational spectra, vibrational energy of a diatomic molecule, infrared spectra (preliminaries), morse curve and the energy levels of a diatomic molecules.

**Unit 5** **08 HRS**

Vibrating diatomic molecule, diatomic vibrating rotator, vibration of polyatomic molecules, normal modes of vibration in crystal, interpretation of vibrational spectra, I-R spectrophotometer-instrumentation

**Text Books:**

Elements of Spectroscopy by Gupta Kumar Sharma
Molecular Structure & Spectroscopy by G. Aruldhas
Introduction to Atomic Spectra by H. E. White
Introduction to Molecular Spectroscopy by G. M. Barrow

## M. Sc. (Physics) Semester II: Core Paper CT-7

**Title of Course: Space Physics**

| | |
|---|---|
| No. of credits: | **03** |
| Teaching Hours: | 40 |
| Internal Examination, Preparation and Evaluation: | 05 |
| Total contact hours: | **45** |
| Total Marks: | **100** |
| External marks: | 70 |
| Internal Marks: | 30 |

**Structure of Semester End Examination**

Maximum Marks: **70** Time: **3 HRS**

Q. 1 Objective type answers covering all the five units. EIGHT questions will be asked, out of which, students have to answer any FIVE Marks: 5 × 2 = **10**

Q. 2 Three numerical problems (wherever possible) or conceptual questions will be asked. Students have to solve any TWO out of THREE Marks: 2 × 5 = **10**

Q. 3-7 Descriptive questions, each having internal option (3 or 3, 4 or 4 etc…). One from each unit, carrying 10 Marks each. Marks: 5 × 10 = **50**

**Detailed Syllabus**

**Unit 1** **10 HRS**

**Basic Concepts of Earth's Atmosphere**:

Atmosphere nomenclature, Hydrostatic equations scale height, Geopotential height, Chemical concepts of atmosphere, Thermodynamic considerations, elementary chemical kinetics composition and chemistry of middle atmosphere and thermosphere. Thermal balance in the atmosphere, models of neutral atmosphere (CIRA, US Standard atmosphere)

**Unit 2** **12 HRS**

**Solar Radiation and its Effects on the Atmosphere:**

Solar radiation at the top of the atmosphere, Attenuation of solar radiation in the atmosphere, radiative transfer, thermal effect of radiation, photochemical effects of radiation, Airglow

**Structure and Variability of Earth's Ionosphere**:

Introduction to ionosphere, photochemical processes, Chapman's theory of photo ionization, production of ionospheric layers, loss mechanisms and chemistry of ionospheric regions, morphology of the ionosphere

**Unit 3** **08 HRS**

**Ionosphere Propagation and Measurement Techniques**:

Effect of Ionosphere on radiowave propagation, Refraction, Dispersion and polarization, Magnetoionic theory, critical frequency and virtual height, Oblique propagation and maximum usable frequency, Ground based techniques: ionosondes, radars, scintillation and TEC, ionospheric absorption, rocket and satellite borne techniques: Langmuir probe, electric field probe mass spectrometer

**Unit 4** **06 HRS**

**Elements of Solar Physics:**

Structure and composition of the Sun, sun as a source of radiation, sunspots an solar cycles, solar flares, coronal mass ejection

**Magnetosphere of Earth:**

Solar wind and its characteristics, Interplanetary magnetic field and sector structure, Formation of geomagnetic cavity, magnetopause, magnetosheath and bow shock, polar cusp and magnetotail, Plasmasphere and Van Allen radiation belts

**Unit 5** **04 HRS**

**Concepts and Foundations of Remote Sensing:**

Energy sources and Radiation principles, Energy interactions in the atmosphere, energy interactions with earth surface features, Data acquisition and Interpretations, Reference data, The Global Positioning System An ideal remote sensing system, Characteristics of real remote sensing system, Practical applications of remote sensing, Land and Geographic Information System

# M. Sc. (Physics) Semester II: Core Paper CT-8

**Title of Course: Solid State Physics**

No. of credits: **03**

Teaching Hours: 40
Internal Examination,
Preparation and Evaluation: 05

Total contact hours: **45**

Total Marks: **100**
External marks: 70
Internal Marks: 30

**Structure of Semester End Examination**

Maximum Marks: **70** Time: **3 HRS**

Q. 1 Objective type answers covering all the five units. EIGHT questions will be asked, out of which, students have to answer any FIVE Marks: 5 × 2 = **10**

Q. 2 Three numerical problems (wherever possible) or conceptual questions will be asked. Students have to solve any TWO out of THREE Marks: 2 × 5 = **10**

Q. 3-7 Descriptive questions, each having internal option (3 or 3, 4 or 4 etc…). One from each unit, carrying 10 Marks each. Marks: 5 × 10 = **50**

**Detailed Syllabus**

**Unit 1** **08 HRS**

**Physics of Crystalline Solids and Defects in Solids:**

Crystalline state, Basic definitions, Bravais and non Bravais lattices, Elements of symmetry, Crystal planes and Miller indices, Examples of Simple Crystal structures, Principals of X-Ray, Neutron and Electron Diffraction in Crystalline solids, Bragg's Law, Concept of Reciprocal lattice Experimental techniques of X-Ray Diffraction, Types of defects - point defects, line defects, plane defects, Grain boundaries, stacking faults, Diffusion in solids

**Unit 2** **08 HRS**

**Band Theory of Solids:**

Electron in periodic potential, Bloch Theorem, Kronig-Penney model, Effective mass, Tight binding approximation, Brillouin Zones, Cellular and pseudo potential methods, Fermi surfaces, De Hass Van Alfon Effect, Cyclotron resonance, classification of solids, limit of Band theory-metal insulator transition

**Unit 3** **08 HRS**

**Superconductivity:**

Definition, Types of superconductors, Properties, Meissner effect, Isotope effect, BCS theory – Qualitative approach, outcomes of BCS theory, Josephson effects, SQUID, Applications of superconductivity

**Unit 4** **08 HRS**

**Diamagnetism and Paramagnetism:**

Classical theory, Paramagnetism-origin of paramagnetic moment, Langevin's theory, Quantum theory, Paramagnetism in rare earth and iron group ions, paramagnetism of conduction electrons

**Unit 5** **08 HRS**

**Ferromagnetism, Antiferromagnetism and Ferrimagnetism:**

Weiss theory, Temperature dependence of Saturation magnetization ($M_S$), Heisenberg's exchange model, Slater's criterion, concept of magnons, Ferromagnetic domains, origin of domains, Antiferromagnetism and ferrimagnetism, ferrites

**Text and Recommended Books:**

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|---|---|---|
| Introduction to Solid State Physics | - C. Kittel | (Wiley Eastern) |

**Reference Books:**

| | | |
|---|---|---|
| Elementary Solid State Physics | - M. Ali Omar | (Addison Wesley) |
| Elements of solid state physics | - J. P. Srivastava | (Prentice Hall India) |
| Solid State Physics | - M.A. Wahab | (Nerosa Publishers) |
| Solid State Physics | - Dan Wei | (Cengage Learning) |