NEP and Learning Outcome-based Curriculum Framework (LOCF)

For

M.Sc. (Physics) Programme

Academic Session (w.e.f. 2024-2025)

DEPARTMENT OF PHYSICS

GURUGRAM UNIVERSITY, GURUGRAM

(A State Govt. University Established Under Haryana Act17 of 2017)

List of Core Courses for M. Sc. (Physics)

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
CC-A1	Classical Mechanics	241/PHY/CC101	4	0	0	4	0	0	4	30	70	0	0	100
CC-A2	Mathematical Physics	241/PHY/CC102	4	0	0	4	0	0	4	30	70	0	0	100
CC-A3	Physics Lab-I	241/PHY/CC103	0	0	8	0	0	4	4	0	0	30	70	100
CC-A4	Quantum Mechanics-I	241/PHY/CC201	4	0	0	4	0	0	4	30	70	0	0	100
CC-A5	Nuclear and Particle Physics	241/PHY/CC202	4	0	0	4	0	0	4	30	70	0	0	100
CC-A6	Physics Lab-II	241/PHY/CC203	0	0	8	0	0	4	4	0	0	30	70	100
CC-A07	Quantum Mechanics-II	241/PHY/CC301	4	0	0	4	0	0	4	30	70	0	0	100
CC-A08	Electrodynamics	241/PHY/CC302	4	0	0	4	0	0	4	30	70	0	0	100
CC-A09	Physics Lab-III	241/PHY/CC303	0	0	8	0	0	4	4	0	0	30	70	100
CC-A10	Atomic and Molecular Physics	241/PHY/CC401	4	0	0	4	0	0	4	30	70	0	0	100
CC-A11	Statistical Mechanics	241/PHY/CC402	4	0	0	4	0	0	4	30	70	0	0	100

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Core Courses for M. Sc. (Physics)

Semester-I

COURSE ID: 241/PHY/CC101

CLASSICAL MECHANICS

Marks (Theory): 70 **Credits: 4**

Marks (Internal Assessment): 30 **Time: 3 Hours**

Note: The examiner will set 9 questions, asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering the entire syllabus. The question paper is expected to contain problems to the extent of 20% of the total marks. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Classical Mechanics, a student will be able to:

- *Demonstrate a basic and advanced knowledge of Lagrangian and Hamiltonian Formulations and solve related problems.*
- *Identify the cyclic coordinates and understand their importance in Hamiltonian formulation.*
- *Acquire Poisson and Lagrange Brackets knowledge and establish relationships between their properties.*
- *Demonstrate the concept of motion of a particle under central force and apply advanced methods to deal with central force problems.*
- *Develop a deep understanding of how to tackle the problems of small oscillations and the special theory of relativity.*

Unit – I

Lagrangian and Hamiltonian Formulations: Types of Constraints on dynamical systems, Generalized Coordinates Hamilton's principle, Derivation of Lagrange's equations from Hamilton's principle, Principle of Least Action and its applications, Canonical Transformation, Legendre Transformation and Hamilton's equation of motion, Physical significance of the Hamiltonian, Cyclic coordinates, Applications of Lagrangian and Hamiltonian Formulations.

Unit – II

Poisson and Lagrange Brackets: Poisson bracket and its properties, Poisson theorem, Poisson bracket and canonical transformation, Jacobi identity and its derivation, Lagrange bracket and its properties, Relationship between Poisson and Lagrange brackets and its properties, Liouville's theorem and its applications.

Unit – III

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Central Force Problem and Hamilton-Jacobi Theory: Two-body central force problem: Reduction to the equivalent one-body problem, Equation of motion and first integrals, Classification of orbits, Virial theorem, Differential equation for the orbit, Integrable power law in time in Kepler's problem; Hamilton-Jacobi Theory: Hamilton-Jacobi equation, Separation of variables in Hamilton-Jacobi equation. Solution of Harmonic Oscillator Problem and Kepler's Problem by Hamilton-Jacobi Method.

Unit – IV

Small Oscillations and Special Theory of Relativity: Theory of small oscillations: Formulation of the problem, Eigenvalue equation, and the principle axis transformation, Frequencies of free vibrations and Normal coordinates, Free vibrations of a linear triatomic molecule; Special Theory of Relativity: Postulates of Special Theory of Relativity, Lorentz Transformation, Length Contraction, Time Dilation, Relativistic addition of velocities, variation of mass with velocity, mass-energy equivalence.

References/Books:

1. Classical Mechanics (3rd ed., 2002), H. Goldstein, C. Poole, and J. Safko, Addison Wesley.

2. Classical Mechanics, J C Upadhyaya, Himalaya Publishing House.

3. Classical Mechanics, G. Aruldhas, PHI Learning Pvt. Ltd., New Delhi.

4. Classical Mechanics, John R. Taylor, University Science Books, USA.

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COURSE ID: 241/PHY/CC102

MATHEMATICAL PHYSICS

Marks (Theory): 70 **Credits: 4**

Marks (Internal Assessment): 30 **Time: 3 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Mathematical Physics, a student will be able to:

- *Acquire knowledge about the mathematical concepts used in Physics*
- *Apply mathematical methods to analyse and describe physical phenomenon*
- *Develop problem-solving skills by applying mathematical tools to solve complex problems in physics*
- *Enhance critical thinking abilities through analysis of mathematical models in the context of physical theories*
- *Explore the interdisciplinary applications of mathematical physics in the fields such as engineering, computational physics, etc.*

Unit – I

Integral Transforms: Fourier Transforms: Properties of Fourier Transforms, Sine and Cosine transform, Linearity, Change of Scale, Translation, Modulation, Fourier transforms of Derivatives, Parseval's theorem, Convolution theorem, simple applications of Fourier transformations in wave theory; Laplace Transforms: Transforms of some Elementary Functions, Properties of Laplace transform, Transform of Derivatives, Transform of Integrals, Convolution theorem, and its applications, Solution of Differential Equations by Laplace Transform.

Unit – II

Differential Equations & Special Functions: Second-order Differential equations. Power series solution of differential equations, ordinary point, Singular points, Frobenius method, Wronskian and a general solution. Special Functions: Bessel Functions: Bessel functions of the first kind $J_n(x)$, Generating function, Recurrence relations, Expansion of $J_n(x)$ when n is half an odd integer, Orthogonality of $J_n(x)$; Legendre Polynomials $P_n(x)$: Generating function, Recurrence relations, Rodrigue's formula, Orthogonality of $P_n(x)$; Hermite and Laguerre Polynomials: generating function & recurrence relations only.

Unit – III

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Complex Analysis: Function of complex variable, Analytic function, The Cauchy-Riemann equations, Necessary and sufficient conditions for a function to be analytic, Harmonic functions, Cauchy integral theorem, Cauchy integral formula, Taylor and Laurent series, singularities and residues. Cauchy residue theorem, Jordan Lemma, Evaluation of real definite integrals. Evaluation of definite integrals of the type: $\int_0^{2\pi} f\,(Sin\,\theta, Cos\,\theta)d\theta$; $\int_{-\infty}^{+\infty} f(x)\,dx$, $\int_{-\infty}^{+\infty} f(x)\,e^{iax}\,dx$ using Cauchy's residue theorem.

Unit – IV

Group Theory & Tensors: Fundamentals of Group theory: Definition of a group and illustrative examples, conjugate elements and classes of groups, direct product. Isomorphism, homomorphism, Permutation group, Group multiplication table, rearrangement theorem, Generators of a finite group, Subgroups, cyclic group, Cosets and SU (2); Tensors: covariant, contravariant and mixed, Algebraic operations on tensors.

References/Books:

1. Mathematical Methods for Physicists: George Arfken-New York Academy, 1970.
2. Advanced Mathematical Methods for Engineering and Science Students: George Stephenson and P.M. Radmore-Cambridge Uni Press, 1990.
3. Group Theory and Quantum Mechanics: M. Tinkam, Dover Publications Inc., 2003.
4. Mathematical Physics: H.K. Dass, S. Chand Publications, 5th edition, 2017.
5. Mathematical Physics: Satya Parkash, S. Chand Publications, 6th edition, 2014.
6. Elements of Group Theory for Physicists, A W Joshi, New Age International Publishers, 5th edition, 2018.
7. Applied Mathematics For Engineers And Physicists, L A Pipes, Dover Publications Inc., 3rd edition, 2014.

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COURSE ID: 241/PHY/CC103

PHYSICS LAB-I

Marks (Internal): 30 **Credits: 4**

Marks (End Semester exam): 70 **Time: 3 Hours**

Course Outcomes:

After successful completion of the course on Physics lab, a student will be able to:

- *Demonstrate circuits of working of diodes, transistors, and their applications.*
- *Build a common emitter/base/collector amplifier and measure its voltage gain.*
- *Understand the use of logic gates for various applications.*
- *Explore the operation and advantages of operational amplifiers.*
- *Design up-down counter and 4-bit shift register using JK flip flop.*
- *Learn and understand about modulation and demodulation circuits.*
- *Construct an Astable multivibrator using a transistor and determine the frequency of oscillation.*
- *Understand voltage regulation using zener diode.*

Students assigned the electronic laboratory work will perform at least 8 experiments (Note: List of experiments may vary)

List of experiments

1. To study the frequency response of low-pass, high-pass and band-pass filters.
2. To study rectifier and filter circuits and draw wave shapes.
3. To design a JK Flip flop and realize an up-down counter using it.
4. Uni-junction Transistor and its application.
5. To study the common emitter transistor using NPN transistors.
6. To design circuits for OR, AND, NOT, NAND and NOR logic gates and verify their truth tables.
7. To measure (a) phase difference, (b) deflection sensitivity and (c) frequency of an unknown ac signal using CRO.
8. To design an astable and monostable Multivibrator using a 555 timer.
9. To study Zener diodes as a voltage regulator.
10. Application of op-amp as an integrator/differentiator amplifier.
11. To determine various parameters of a p-n junction diode.
12. To study the modulation and demodulation circuits.
13. Working of Half & Full Subtractors.
14. Working of Half & Full Adders.

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Semester-II

COURSE ID: 241/PHY/CC201

QUANTUM MECHANICS-I

Marks (Theory): 70 **Credits: 4**

Marks (Internal Assessment): 30 **Time: 3 Hours**

Note: The examiner will set 9 questions, asking two questions from each unit and one compulsory question, by taking the course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering the entire syllabus. The question paper is expected to contain problems to the extent of 20% of the total marks. The examinee will be required to attempt 5 questions, selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Quantum Mechanics-I, a student will be able to:

- *Realise basic quantum mechanical view point, learn its wave mechanical matrix formulations, and solve the Schrödinger equation for simple potentials, including harmonic and central potentials.*
- *Construct matrices for observables and wave functions in different representations, apply matrix theory to linear harmonic oscillator, and describe the time development of a quantum system in Schrödinger, Heisenberg and Interaction pictures.*
- *Calculate the eigenvalues and eigenfunctions for the orbital and general angular momenta, learn the matrix representation of angular momentum, and perform addition of two angular momenta.*
- *Grasp the concepts of identity & indistinguishability, understand symmetric and anti-symmetric wave functions, construct spin and total wave functions for a system of two spin ½ particles, and comprehend the connection among spin, symmetry, and statistics.*

Unit – I

Schrodinger formulation of Quantum Mechanics: Requirement of quantum mechanics, Quantum-mechanical view-point, Schrödinger wave equation, Properties of wave function, Expectation values, Ehrenfest theorem; Dynamical variables as Hermitian operators, Eigenvalues and Eigenfunctions, Co-ordinate and momentum representations of wave function, Time independent Schrodinger equation, Infinite and finite square well, Harmonic oscillator problem (analytical solution), Free particle solution, Wave Packet; A charged particle in a uniform static magnetic field (Eigenfunctions and Landau levels); Quantum tunneling.

Unit – II

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Matrix Formulation: Hermitian and unitary matrices; Transformation and diagonalization of matrices, Matrices of infinite rank; Representation of observables and wave functions as matrices, Transformation theory, Choice of basis, Change of basis, Unitary transformations, Hilbert space representation; Dirac's ket and bra notation; Generalized Statistical Interpretation, Uncertainty Principle, Time-development of quantum system: Schrödinger, Heisenberg and Interaction pictures, Quantization of a classical system; Application to motion of a particle in an EM field; Matrix theory of the harmonic oscillator, Matrices for position, momentum and energy operators (energy representation).

Unit – III

Quantum theory of Angular Momentum: Schrodinger equation in 3-d, Radial and Angular equations, The Hydrogen atom (reduced mass, radial wave functions and energy eigenvalues), Orbital angular momentum operator L, Commutation relations, Orbital angular momentum and spatial rotations, Eigenvalues and eigenfunctions of L^2 and L_z, Spherical harmonics; General angular momentum J: Eigenvalues and eigenfunctions of J^2 and J_z, Matrix representation of angular momentum operators, Spin angular momentum, Wave function including spin (Spinor); Spin one-half: Spin eigenfunctions, Pauli spin matrices; Addition of two angular momenta, Clebsch-Gordan coefficients and their calculations; The Wigner Eckart theorem.

Unit – IV

Many-particle systems and identical particles: Two-Particle System, Many-particle Schrödinger wave equation, Systems of identical particles, Principle of indistinguishability, Exchange forces, Exchange and transposition operators, Totally symmetric and anti-symmetric wave functions & their construction, Fermions and bosons; Spin and total wave functions for a system of two spin ½ particles, Pauli exclusion principle and Slater determinant; Application to the electronic system of the helium atom (*para-* and *ortho-*helium); Basic idea of quantum entanglement, Transformation operators, Quantum Mechanical operators for translation, inversion and rotations.

References/Books:

1. Quantum Mechanics (3rd edition) by L. I. Schiff.
2. Quantum Mechanics (3rd edition) by D. J Griffith.
3. Quantum Mechanics (3rd edition) by E. Merzbacher.
4. Quantum Mechanics by John L. Powell and B. Crasemann.
5. Quantum Mechanics by A. K. Ghatak and S. Loknathan.
6. Introductory Quantum Mechanics (4rd edition) by Richard L. Liboff.
7. Quantum Mechanics: Concepts and Applications (2nd edition) by N. Zettili.
8. A textbook of quantum mechanics, P. M. Mathew; K. Venkatesan.
9. Principles of quantum mechanics, by Shankar, Ramamurti.

COURSE ID: 241/PHY/CC202

NUCLEAR AND PARTICLE PHYSICS

Marks (Theory): 70 **Credits: 4**

Marks (Internal Assessment): 30 **Time: 3 Hours**

Note: The examiner will set 9 questions asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Nuclear and Particle Physics, a student will be able to:

- *Learn and explain stability of nuclei based on binding energy curve, liquid drop model, magic numbers, shell model.*
- *Classify and explain types of nuclear decays: alpha decay, beta decay, gamma decay.*
- *Define and calculate Q value of nuclear reactions.*
- *Grasp knowledge about quarks and its flavours, and colour quantum number.*

UNIT-I

Nuclear Models: Survey of basic nuclear properties, Binding energy curve, Liquid drop model, Semi-classical mass formula, Mass parabola and valley of stability, Fission condition, Experiment evidence for shell effect, Magic numbers, Shell model, Spin-orbit coupling, Angular momenta and parity of nuclear ground states, Magnetic moments and Schmidt lines, Nuclear Quadrupole moments, Quadrupole moments of deformed nuclei, Rotational and vibration excitation of deformed nuclei. Nilson Model (qualitatively).

UNIT-II

Nuclear Decays: Beta decay, Fermi theory of beta decay, Angular momentum and parity selection rules, Shape of the beta spectrum, Total decay rate, Kurie plots, Comparative half-life, Classification of beta transitions, Selection rules for allowed and forbidden transitions, Detection and properties of neutrino, Gamma decay: Electric and magnetic multipole gamma transitions, Angular momentum and parity selection rules, Reduced transition rates (Weisskopf formula), Alpha decay: Giger-Nuttan law and tunnelling theory, Selection rules for alpha decay, Internal conversion, Nuclear isomerism, Interaction of charged particle with matter (qualitative idea).

Nuclear Interaction: Two Nucleon Problem: Deuteron system, Exchange forces, Yukawa theory of nuclear forces, Nucleon-nucleon scattering, Effective range theory, Spin dependence and charge independence of nuclear forces.

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UNIT-III

Nuclear Reaction: Kinematics of nuclear reactions in lab and Centre of mass reference frames, Q value calculation, Concept of Cross section, Type of nuclear reactions, Direct and compound nuclear reactions, Inelastic scattering and transfer reactions, Resonances (Isobaric Analogue, Giant), Break-up reactions. Special features of heavy ions scattering (Q-and L-window), Quasi elastic and deep elastic reactions, Complete and incomplete fusion, Fission: Spontaneous fission mass distributions and elementary model.

Nucleosynthesis in Big Bang (qualitative idea) and in stars ("r" and "s" process), EMC effect (Qualitative), Experimental observations of short-range correlations (SRC) between nucleons, Halo Nuclei (qualitative), Search for Super Heavy Nuclei (qualitative).

UNIT-IV

Classification of particles - fermions and bosons, particles and antiparticles; Basic idea of different fundamental types of interactions with suitable examples; Lepton Classification, Strange particles, Quarks as constituents of Hadrons, Quark flavours and their quantum numbers, Qualitative idea of Quark confinement and asymptotic freedom, Necessity of introducing the Colour quantum no., Quark model, Feynman Diagrams, Gell-Mann Nishijima formula, Charge conjugation, Charge, parity and Time reversal invariance, CPT theorem, Parity non-conservation in β-decay, experimental determination of parity violation, CP violation.

References/Books:

1. Physics of Atomic Nuclei, Vladimir Zelevinsky, Wiley-VCH, 2017
2. The Atomic Nucleus, J.M. Reid, Penguin Books, 1972
3. Kenneth S. Krane, Introductory Nuclear Physics, Wiley, New York, 1988
4. R.R. Roy and B.P. Nigam, Nuclear Physics, Wiley-Eastern Ltd., 1983
5. Nuclear Physics, S. B. Patel, New Age publication
6. Basic Ideas and Concepts in Nuclear Physics: K. Heyde, (Overseas Press India) (2005).
7. Nuclear Physics: Experimental and Theoretical: H. S. Hans, (New Academic Science Ltd., Second.

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COURSE ID: 241/PHY/CC203

PHYSICS LAB-II

Marks (Internal): 30 **Credits: 4**

Marks (End Semester exam): 70 **Time: 3 Hours**

Course Outcomes (COs):

After successful completion of the course on Physics lab, a student will be able to:

- *Verify the existence of different harmonics using CRO.*
- *Determine resistivity of semiconductors using four probe method.*
- *Study about optical fiber.*
- *Fourier analysis of complex signals.*
- *Demonstrate energy quantization using Franck-Hertz Experiment.*
- *Study the characteristics of Opto-Electronic Device.*
- *Determine the charge to mass ratio of an electron by using Magnetron and dielectric constant of dielectric material.*
- *Determine the value of Planck's constant using photocell/LED.*
- *Study of Hall Effect.*

Students assigned the electronic/ general physics laboratory work will perform at least 8 experiments (Note: List of experiments may vary)

List of experiments

1. Demonstration of energy quantization using the Franck-Hertz Experiment.
2. To determine the wavelength of laser light using Michelson interferometer experiment.
3. Measurement of resistivity of a semiconductor by four probe method at different temperatures.
4. Measurement of Magneto-resistance of Semiconductors.
5. To determine the value of Planck's constant using photocell/LED.
6. To determine the e/m ratio of an electron using Magnetron.
7. To measure the numerical aperture (NA) of optical fiber.
8. To study the Hall Effect and to determine Hall coefficient.
9. Fourier analysis of complex signals.
10. To verify the existence of different harmonics and measure their relative amplitudes in a complex wave using CRO (square, clipped sine wave, triangular wave, etc.).

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Semester-III

COURSE ID: 241/PHY/CC301

QUANTUM MECHANICS-II

Marks (Theory): 70 **Credits: 4**

Marks (Internal Assessment): 30 **Time: 3 Hours**

Note: The examiner will set 9 questions, asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 40% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Quantum Mechanics-II, a student will be able to:

- *Have an understanding of the Approximation Methods and apply the same for degenerate and non-degenerate systems.*
- *Formulate perturbation, variational and WKB methods for obtaining approximate solutions of the Schrödinger equation, and apply these to simple physical situations.*
- *Comprehend on how perturbation can remove the degeneracy, particularly explanation of the Zeeman and Stark effects.*
- *Apply the time-dependent perturbation theory to deal with atom-em radiation interaction and calculate explicitly the transition probability for the induced absorption and emission processes.*
- *Explicate the electronic structure of many-electron atoms in central-field approximation, and estimate the central potential using the Thomas-Fermi and Hartree methods.*
- *Grasp the basics of non-relativistic quantum scattering theory, and learn the partial waves and Green's function methods for deriving scattering cross-sections.*
- *Calculate and analyze scattering cross-sections for finite square well, hard sphere and screened Coulomb potentials.*
- *Grasp the basics of relativistic quantum mechanics, and learn about the K-G and Dirac equations.*

Unit – I

Approximate methods for bound states-I: Stationary perturbation theory: Non-degenerate case- First-order and second-order corrections to energy eigenvalues and eigenfunctions, Perturbation of an oscillator, Degenerate case- Removal of degeneracy in first and second order, Zeeman effect without electron spin, First-order Stark effect in n=2 state of Hydrogen, Fine structure of hydrogen atom (Relativistic and spin-orbit coupling corrections); Rayleigh-Ritz variational method and its applications.

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Unit – II

Approximate methods for bound states-II: The WKB approximation method and its application, First-order time-dependent perturbation theory, Transition probability for constant and harmonic perturbations, Transition to a group of final states- The Fermi golden rule, Application to constant and harmonic perturbations. Sudden and adiabatic approximations.

Unit – III

Quantum Theory of Scattering: Scattering experiments and cross-sections, The method of partial waves: Phase shift, Differential and total cross-sections, Relation between phase shift and scattering potential, Convergence of the partial-wave series, Scattering by a finite square well, The Born series, The first Born approximation, Scattering of an electron by a screened Coulomb potential in Born approximation and validity criterion; Scattering of two identical spinless bosons, and spin-1/2 fermions.

Unit – IV

Relativistic Quantum Mechanics: Introduction to Klein-Gordon equation, Plane wave solution, Probability and current densities, Difficulties of K-G equation. Dirac's relativistic equations. Properties of Dirac matrices. Free particle solutions of Dirac equation. Probability and current densities, Existence of Spin angular moment of electron.

References/Books:

1. L. I. Schiff: Quantum Mechanics (3rd edition)
2. B. H. Bransden and Joachain : Quantum Mechanics (2nd edition)
3. David J. Griffiths: Introduction to Quantum Mechanics (2nd edition)
4. A. K. Ghatak and S. Loknathan : Quantum Mechanics
5. P. M. Mathews and K. Venkatesan: A Textbook of Quantum Mechanics
6. John L. Powell and B. Crasemann: Quantum Mechanics
7. N. Zettili: Quantum Mechanics: Concepts and Applications (2nd edition)

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COURSE ID: 241/PHY/CC302

ELECTRODYNAMICS

Marks (Theory): 70 **Credits: 4**

Marks (Internal Assessment): 30 **Time: 3 Hours**

Note: The examiner will set 9 questions, asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Classical Mechanics, a student will be able to:

- *Apply electrostatic principles—including Gauss's law, potential theory, and boundary-value problems—to solve field configurations in free space and dielectric media.*
- *Analyze magnetostatic fields and formulate Maxwell's equations in both vacuum and material media, including boundary conditions and displacement current.*
- *Interpret electromagnetic potentials and gauge transformations and explain the covariant formulation of electrodynamics in the context of special relativity.*
- *Solve electromagnetic wave propagation problems in free space, dielectrics, and conductors; examine energy transport and wave behavior at interfaces and in waveguides.*
- *Evaluate electromagnetic radiation from moving charges using retarded potentials and derive expressions for radiated power, including relativistic corrections.*
- *Understand fundamental plasma parameters and wave phenomena, derive fluid equations from the kinetic approach, and analyze wave dispersion and plasma instabilities.*

Unit-I

Review of Electrostatic and Magnetostatic: Review of Electrostatics, Energy stored in charge distribution, Poisson's and Laplace's equations, Uniqueness theorems, Solution of Laplace's equation in various coordinates through separation of variables, Multipole expansion of potential, Field of a Polarized Dielectric, Bound charges, Review of Magnetostatics, Biot-Savart Law, The magnetic field of a Steady Current, Magnetic field inside a linear dielectric, Ampere's Law, Faraday's Law, Maxwell's Equations in vacuum and dielectric media, boundary conditions on the fields at interfaces

Unit II

Scalar and Vector Potentials, Maxwell's equations in terms of scalar and vector potentials, Non-uniqueness of Electromagnetic potentials, Gauge Transformation, Lorentz gauge and Coulomb gauge. Minkowski Space and Four vectors, Mathematical Properties of the Space-Time of Special Relativity, Electromagnetic field strength tensors, Covariance of Maxwell's and Lorentz force equations.

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Unit-III

Electromagnetic Waves: Poynting's Theorem, Electromagnetic Waves in vacuum, Energy and Momentum in Electromagnetic Waves. Electromagnetic Waves in Matter: Propagation in Linear Media, Reflection and Transmission at Normal Incidence, Reflection and Transmission at Oblique Incidence. Electromagnetic Waves in Conductors, Reflection at a Conducting Surface, Scattering and absorption of radiations, Normal and anomalous dispersion, Wave Guides, TE and TM Waves in a Rectangular Wave Guide, Transmission lines

Unit- IV

Radiation: Radiation from moving charges and dipoles, Retarded Time, Lienard-Wiechert Potentials for a point charge, Total power radiated by a point charge: Larmor's formula and its relativistic generalization.

Plasma Physics: Occurrence of Plasmas in Nature, Quasi-neutrality of plasma, Debye Shielding, The Plasma Parameter, Criteria for Plasmas, Plasma Oscillations, Electron Plasma Waves, Sound Waves, Ion Waves, Dispersion relations in plasma, Momenta equation.

References/Books:

1. Classical Electrodynamics by J.D. Jackson.
2. Introduction to Electrodynamics by D. J. Griffiths.
3. Introduction to Electrodynamics by A. Z. Capri and P. V. Panat.
4. Electrodynamics by S. P. Puri.
5. Introduction to Plasma Physics by F. F. Chen.
6. Introduction to Plasma Theory by D. R. Nicholson

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COURSE ID: 241/PHY/CC303

PHYSICS LAB-III

Marks (Internal): 30 **Credits: 4**

Marks (End Semester exam): 70 **Time: 3 Hours**

Course Outcomes (COs):

After successful completion of the course on Physics lab, a student will be able to:

- *Verify the existence of different harmonics using CRO.*
- *Determine resistivity of semiconductors using four probe method.*
- *Study about optical fiber.*
- *Fourier analysis of complex signals.*
- *Demonstrate energy quantization using Franck-Hertz Experiment.*
- *Study the characteristics of Opto-Electronic Device.*
- *Determine the charge to mass ratio of an electron by using Magnetron and dielectric constant of dielectric material.*
- *Determine the value of Planck's constant using photocell/LED.*
- *Study of Hall Effect.*

Students assigned the electronic/ general physics laboratory work will perform at least 8 experiments (Note: List of experiments may vary)

List of experiments

1. To demonstrate the splitting of spectral lines using Zeeman Effect
2. To measure the Lande's g-factor in a free radical using an electron spin resonance spectrometer
3. To determine the ionization potential of mercury.
4. Study of Characteristics of Opto-Electronic Device.
5. To determine of lattice parameters using XRD.
6. To determine of crystallite size using XRD.
7. To synthesise the nanoparticles using the Sol-Gel Method.
8. Synthesis of nanoparticles using the Microwave Method.
9. Synthesis of nanoparticles using the auto combustion Method.
10. Measurement of photoconductivity
11. To find out the wavelength of a monochromatic light using Fabry-Parot interferometer
12. To study the operational characteristics of a GM Counter.
13. To study the statistical nature of nuclear decay using a GM Counter.
14. Measurement of the dead time of a GM counter

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COURSE ID: 241/PHY/CC401

ATOMIC AND MOLECULAR PHYSICS

Marks (Theory): 70 **Credits: 4**

Marks (Internal Assessment): 30 **Time: 3 Hours**

Note: The examiner will set 9 questions, asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 20% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Classical Mechanics, a student will be able to:

- *Understand the quantum mechanical structure of atoms, including fine, hyperfine, and Zeeman effects.*
- *Study the principles and applications of molecular spectroscopy, including rotational, vibrational, Raman, and electronic spectra.*
- *Explore the fundamental concepts and mechanisms of laser physics, NMR, and ESR spectroscopy.*
- *Analyze energy levels, selection rules, and coupling schemes in one- and many-electron atoms.*
- *Apply spectroscopic methods to interpret atomic and molecular transitions, including line broadening and dissociation phenomena.*

Unit I

Atomic Structure and Spectra: Review of one-electron and two-electron atoms: Derivation of quantum numbers and their physical interpretation, Spectra of hydrogen and helium atoms, Electric dipole selection rules, Fine structure of spectral line: relativistic correction, spin orbit interaction, Lamb shift, Hyperfine structure and isotope shifts, Many-electron atoms: LS-coupling, jj-coupling, Lande interval rule, Spectra of alkalis, Characteristic X-rays spectra, Moseley's law and Auger transitions. Normal and anomalous Zeeman effect, Paschen-Back effect, First and second order Stark effect.

Unit II

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Magnetic Resonance and Laser Principles: Nuclear magnetic resonance (NMR): Basic principles, Bloch equations, Spin-spin and spin-lattice relaxation, Chemical shift and coupling constant; Electron spin resonance (ESR), Laser: Absorption, spontaneous and stimulated emission. Einstein coefficients, Population inversion, Optical resonator, Gain coefficient, Laser rate equation of three level systems, Ruby laser, He-Ne Laser, Semiconductor laser, Line broadening mechanism: natural, Doppler, and collision broadening.

Unit III

Molecular Rotational and Vibrational Spectroscopy: Rotational spectra of rigid diatomic molecules, Isotope effect in rotational spectra, Intensity of rotational lines, Non rigid rotator, Infrared spectroscopy: Vibrational Energy of diatomic molecule, Infrared selection rule, Molecule as anharmonic oscillator, Spectra of the vibrating diatomic molecule, Vibrational-rotational spectra of diatomic molecules, Raman Spectroscopy: Raman effect, Pure rotational Raman spectra, Vibrational Raman Spectra, Nuclear Spin and intensity alternation in Raman spectra.

Unit IV

Electronic Spectroscopy: Born Oppenheimer approximation, Basics of Vibrational coarse structure of electronic levels, Deslanders table, Progression and sequences, Intensity of electronic levels: Frank Condon Principle, Rotational fine structure of electronic bands, The Fortrat parabole, Dissociation and pre-dissociation of molecules, Fluorescence spectroscopy: Fluorescence and Phosphorescence, Jablonski Diagram.

References/Books:

1. Bransden, B.H., & Joachain, C.J. (2003). Atomic, Molecular and Optical Physics. Pearson Education.
2. Kumar, R. (2013). Atomic and Molecular Physics. Campus Books International.
3. Aruldhas, G. (2007). Molecular Structure and Spectroscopy (2nd ed.). Prentice-Hall of India.
4. Banwell, C.N., & McCash, E.M. (1994). Fundamentals of Molecular Spectroscopy (4th ed.). McGraw-Hill.
5. Haken, H., & Wolf, H.C. (2005). The Physics of Atoms and Quanta: Introduction to Experiments and Theory (7th ed.). Springer.
6. Chang, R. (2005). Principles of Molecular Spectroscopy. McGraw-Hill Education.

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COURSE ID: 241/PHY/CC402

STATISTICAL MECHANICS

Marks (Theory): 70 **Credits: 4**

Marks (Internal Assessment): 30 **Time: 3 Hours**

Note: The examiner will set 9 questions, asking two questions from each unit and one compulsory question by taking course learning outcomes (CLOs) into consideration. The compulsory question (Question No. 1) will consist of at least 4 parts covering entire syllabus. The question paper is expected to contain problems to the extent of 40% of total marks. The examinee will be required to attempt 5 questions; selecting one question from each unit and the compulsory.

Course Outcomes:

After successful completion of the course on Classical Mechanics, a student will be able to:

- *Understand postulates of classical and quantum statistical mechanics*
- *Learn the ensemble formulation of statistical mechanics, and it's application for the calculation of thermo-dynamical quantities for simple systems.*
- *Formulate the quantum mechanical ensemble theory and it's usefulness for the derivation of laws of quantum statistics such as Fermi-Dirac (FD) and Bose-Einstein (BE) statistics.*
- *Able to apply the ideas of phase-transitions of first and second order, ferromagnetism using Ising models.*
- *Able to differentiate between Bosonic and Fermionic systems and understand phenomenon such as black-body radiation, Bose-Einstein condensations*

Unit I

Review of thermodynamics: Extensive and intensive Thermodynamic Variables, Quasistatic and non- quasistatic processes, laws of thermodynamics, Concept of Entropy, Second Law of Thermodynamics in terms of Entropy, entropy of a probability distribution, Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Maxwell's thermodynamic Relations and their applications, Random Walk.

Unit II

Classical ensemble theory: Phase space, Microstates and Macrostates, Postulate of equal a priori probability, Concept of Statistical Ensembles, Ensembles average, Liouville's theorem, The microcanonical ensemble, Boltzmann relation for entropy, Sackur-Tetrode equation, Canonical ensemble; partition function; Helmholtz free energy, Grand-canonical ensemble, Equivalence of

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the various ensembles. Classical Ideal gas and Harmonic Oscillator using canonical and grand-canonical ensamble.

Unit III

Quantum Statistics: The density matrix, Equation of motion for density matrix, Indistinguishable particles in quantum mechanics. Bosons and Fermions. Bose-Einstein statistics, Ideal Bose gas, photons, Bose-Einstein condensation. Fermi-Dirac statistics, Fermi energy, Ideal Fermi gas, Black Body Radiation.

Unit IV

Interacting systems and P hase transitions: Thermodynamic description of phase transitions, phase transition of first and second order, Interacting spin systems. The Ising model. Exact solution of Ising model in one-dimension (1D), Mean-Field solution in Higher Dimensions. Paramagnetic and Ferromagnetic Phases. Critical exponents, Landau theory of Phase transition.

References/Books:

1. Statistical Physics of Particles, Mehran Kardar (Cambridge University Press, 2007).
2. Statistical Mechanics, Kerson Huang (2nd Edition, Wiley-India, 2008).
3. Statistical Mechanics, R.K. Pathria (Butterworth-Heinemann, 1996).
4. Statistical Mechanics:An Advanced course with problems and solutions, Ryogo Kubo (North-Holland, 1965).
5. Fundamentals of Statistical & Thermal Physics, F. Reif.

PHYSICS LAB

(For 4th semester)

Marks (Internal): 50 **Credits: 6**

Marks (End Semester exam): 100 **Time: 3 Hours**

Course Outcomes:

After successful completion of the course on Physics lab, a student will be able to:

- *Demonstrate circuits of working of diodes, transistors, and their applications.*
- *Build a common emitter/base/collector amplifier and measure its voltage gain.*

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- *Understand the use of logic gates for various applications.*
- *Explore the operation and advantages of operational amplifiers.*
- *Design up-down counter and 4-bit shift register using JK flip flop.*
- *Learn and understand about modulation and demodulation circuits.*
- *Construct an Astable multivibrator using a transistor and determine the frequency of oscillation.*
- *Understand voltage regulation using zener diode.*

Students assigned the electronic laboratory work will perform at least 10 experiments (Note: List of experiments may vary)

List of experiments

1. To study the gamma spectra of NaI(Tl) scintillator for 137Cs source
2. To study the alpha spectrum from natural sources, Th and U.
3. To determine the gamma-ray absorption coefficient for different elements.
4. To study the absorption of beta rays in Al and deduce end-point energy of a beta emitter.
5. To calibrate the given gamma-ray spectrometer and determine its energy resolution.
6. Magnetic susceptibility of hydrated copper sulfate.
7. Determine the crystallite size of nanomaterial using Debye Scherer method.
8. Transition temperature of a ferroelectric material.
9. Determination of band gap energy of metal-oxide nanoparticles using UV Spectrophotometer.
10. Study of surface morphology of a material by scanning electron microscopy (SEM)
11. High temperature superconductivity experiment.
12. Study of infrared spectroscopy of a material by FTIR
13. Electron paramagnetic resonance experiment.
14. Thermo-luminescence studies.

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NEP and Learning Outcome-based Curriculum Framework (LOCF)

For

M.Sc. (Physics) Programme

Academic Session (w.e.f. 2024-2025)

DEPARTMENT OF PHYSICS

GURUGRAM UNIVERSITY, GURUGRAM

(A State Govt. University Established Under Haryana Act17 of 2017)

Scheme of Programme

Scheme PG A1: M.Sc. (Physics) Programme

Semester I

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
						Core Course(s)								
CC-A1	Classical Mechanics	241/PHY/ CC101	4	0	0	4	0	0	4	30	70	0	0	100
CC-A2	Mathematical Physics	241/PHY/ CC102	4	0	0	4	0	0	4	30	70	0	0	100
CC-A3	Physics Lab-I	241/PHY/ CC103	0	0	8	0	0	4	4	0	0	30	70	100
						Discipline Specific Elective Course(s)								
DSE-1	Electronics	241/PHY/ DS101	3	0	0	3	0	0	3	25	50	0	0	75
						Multidisciplinary Course(s)								
MDC-1	One From Pool													
						Ability Enhancement Course(s)								
AEC-1	One From Pool													
						Value-added Course(s)								
VAC-1	One From Pool													

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Semester II

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)														
CC-A4	Quantum Mechanics-I	241/PHY/CC201	4	0	0	4	0	0	4	30	70	0	0	100
CC-A5	Nuclear and Particle Physics	241/PHY/CC202	4	0	0	4	0	0	4	30	70	0	0	100
CC-A6	Physics Lab-II	241/PHY/CC203	0	0	8	0	0	4	4	0	0	30	70	100
Discipline Specific Elective Course(s)														
DSE-2	Solid State Physics	241/PHY/DS201	3	0	0	3	0	0	3	25	50	0	0	75
Multidisciplinary Course(s)														
MDC-2	One From Pool													
Ability Enhancement Course(s)														
AEC-2	One From Pool													
Skill Enhancement Course(s)														
SEC-1	One From Pool													

Note: Four credits earned during a summer internship after the second semester will be counted in the third semester of a student who pursues a two-year PG Programme without taking the exit option.

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Semester III

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
						Core Course(s)								
CC-A07	Quantum Mechanics-II	241/PHY/ CC301	4	0	0	4	0	0	4	30	70	0	0	100
CC-A08	Electrodynamics	241/PHY/ CC302	4	0	0	4	0	0	4	30	70	0	0	100
CC-A09	Physics Lab-III	241/PHY/ CC303	0	0	8	0	0	4	4	0	0	30	70	100
						Discipline Specific Elective Course(s)								
DSE-03	i) Condensed Matter Physics-I ii) Material Science – I	241/PHY/ DS301	3	0	0	3	0	0	3	25	50	0	0	75
						Multidisciplinary Course(s)								
MDC-03	One From Pool													
						Skill Enhancement Course(s)								
SEC-02	One From Pool													
						Value Added Course(s)								
VAC-02	One From Pool													
						Seminar								
Seminar									2					50
						Internship/Field Activity								
Internship									4					100

Semester IV

Course Code	Course Title	Course ID	L	T	P	L	T	P	Total Credits	MARKS				
			(Hrs)			Credits				TI	TE	PI	PE	Total
Core Course(s)														
CC-A10	Atomic and Molecular Physics	241/PHY/ CC401	4	0	0	4	0	0	4	30	70	0	0	100
CC-A11	Statistical Mechanics	241/PHY/ CC401	4	0	0	4	0	0	4	30	70	0	0	100
Discipline Specific Elective Course(s)														
DSE-04	i) Condensed Matter Physics-II ii) Material Science – II	241/PHY/ DS401	3	0	0	3	0	0	3	25	50	0	0	75
Multidisciplinary Course(s)														
MDC-04	One from Pool													
Ability Enhancement Course (s)														
AEC-03	One from Pool													
Community Engagement/Field Work/Survey/Project/Seminar														
Seminar	Physics Lab/ Academic Project								6					150

** During teaching a core/minor course, students will be given at least five tutorials (each containing at least six numerical problems).*

Gurugram University, Gurugram

(Established by the State Legislature Act 17/2017)

Sector-51, Gurugram -122003 (Haryana)

Minutes of the Meeting of the ~~UG~~/PG Board of Studies in the Dept. of Physics of Gurugram University, Gurugram held on 30/05/25 at 11.00AM in Phy. Dept. of the University

[illegible] in the Dept. of Physics of
[illegible]ugram University, Gurugram held on 30/05/25 at 11.00 AM in
Phy. Dept. of the University

Members Present:

1.	Dr. Ranjeet (Chairperson, Dept. of Physics)	Member
2.	Dr. Vibha Chopra	Member
3	Dr. Sushil Kumar	Member
4.	Dr. Balvinder Singh	Member
5.	Prof. Manish Kumar	Member
6.	Prof. Vipin Bhatnagar	Member
7.	Prof. Sushila Srivastava	Member
8.	Dr. Premlata Yadav	Member
9.	Dr. Parmod Kumar	Special Invitee
10	Dr. Ashish Kumar	Special Invitee

At the outset the Convener of PGBOS&R extended a hearty welcome to all the members for attending the meeting of the Board of Studies. Thereafter, the agenda items were taken up and after detailed deliberations, the following decisions were taken:

Item No. PGBOS&R /01:

Agenda: Discuss the scheme & syllabi of M.Sc. (Physics) to be effective from 2025-26.

Resolution/ Decision: Approved after ~~[illegible]~~ discussion

Item No PGBOS&R /02 Discuss the scheme & syllabi of M.Sc. Physics (Integrated) to be effective from 2025-26

Agenda: List of examiners (Theory & Practical)

Resolution/ Decision: Approved. The detailed scheme & syllabi is approved after discussion.

Item No PGBOS&R /03

Agenda: List of examiners (Theory & Practical)

Resolution/ Decision: Approved. The board authorised the chairperson of the dept. to recommend the panel of Examiners for theory & practicals exams for session 2025-26.

The meeting ended with a vote of thanks to the Chair.

***Meeting Number**

****Agenda Number**

Prof. Manish Kumar
(Outside Expert)

Vipin Bhatnagar
Prof. Vipin Bhatnagar
(Outside Expert)

Dr. Sushil Kumar
(Member)

Dr. Sushil Kumar
(Member)

Dr. Balvinder Singh
(Member)

Premlata
Dr. Premlata Yadav
(Member)

Porf. Sushila Srivastava
(Member)

30/5/2025
Dr. Parmod Kumar
(Special Invitee)

31/12
Dr. Ashish Kumar
(Special Invitee)

30/5/25
Dr. Vibha Chopra
(Member)

Ranjeet
Dr. Ranjeet
(Member & chairperson)