S. S. Jain Subodh P.G. College, Jaipur
(Autonomous)
Academic Year 2025-26
M.Sc. (Physics) Semester - I
Subject- Physics
Paper I – Classical Mechanics
ASSIGNMENT

NOTE: Attempt any four questions.

1. What are the generalised co-ordinates? What is the advantage of using them?

2. Show that the generalised velocity dependent potential for a charged particle of mass 'm' and charge 'q' moving with velocity 'v' in an electromagnetic field is given by

$$u = q\emptyset - \frac{q}{c}\vec{A}\,\vec{v}$$

Where $\vec{A}$ and $\emptyset$ are the vector and scalar.

3. State and prove Noether's theorem.

4. State and explain Hamilton's variational Principle and derive Hamilton's canonical equation of motion from it.

5. What are the Poisson's and Lagrange's brackets? Show that Lagrange's bracket is invariant under canonical transformation.

6. Discuss Simple harmonic oscillator problem using Hamilton Jacobi equation.

7. Explain the meaning of action angle variables and discuss Kepler problem using action angle variables.

8. What is a rigid body? Obtain Euler's equation of motion for rigid body.

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Academic Year 2025-26

M.Sc. (Physics) Semester - I

Subject- Physics

Paper II – Quantum Mechanics

ASSIGNMENT

NOTE: Attempt any four questions.

Unit - I

1 (a) Explain: Hilbert Space basis state, amplitude, probability and closure relation.

(b) Show that for complete set of states the closure relation:-
$\Sigma_i |i><i| = 1$ is always valid.

2. (a)Write important properties of quantum mechanical amplitude. Explain about a complete set of basis states.

(b) Explain spin dependence of quantum mechanical amplitude on position.

Unit II

3. (a) What is the time-evolution operator and show that time-evolution operator is unitary.

(b) What do you mean by Hermiticity of Hamiltonian Matrix?

4. Explain the time independent perturbation of Ammonia molecule as two state system and obtain the perturbative solution in weak field and strong field cases.

Unit III

5. Define the Transition Probability and prove that transition probability is proportional to the square of electric field. What do you mean by golden rule of Quantum Mechanics?

6. (a) State and derive the Ehernfest theorem.

(b) Consider a general commutation between two hermitian operators $\hat{A}$ and $\hat{B}$ such that $[\hat{A}, \hat{B}] = i\hat{C}$. Prove that product of expectation value of $\triangle \hat{A}$ and $\triangle \hat{B}$.Justify the Uncertainty Principle.

Unit IV

7. (a) Let $\vec{J}$ be angular momentum (It may stand for orbital $\vec{L}$, spin $\vec{S}$ or $\vec{J}$ total). Using the fact that J_x, J_y, J_Z $(J_\pm = J_x \pm iJ_y)$ satisfy the usual angular momentum commutation relations, prove

$$J^2 = J_z^2 + J_+ J_- - \hbar J_Z$$

(b) What do you understand by Symmetry Transformation of the Coordinate? Find translation operator when a coordinate function f(x,y,z) translate the system along x direction.

8. (a) Calculate the C.G. coefficients for $j_1 = ½$ and $j_2 = ½$

(b) What is the Spherical Tensor? Explain the commutation relation of j_x , j_y and j_z with reduced spherical tensor.

S. S. Jain Subodh P.G. College, Jaipur
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Academic Year 2025-26
M.Sc. (Physics) Semester - I
Subject- Physics
Paper III – Classical Electrodynamics - I
ASSIGNMENT

NOTE: Attempt any four questions.

Unit - I

1. Discuss the differential and integral form of Gauss's law for the electric field and explain the concept of electrostatics potential.
2. Using the method of images, derive the expression for the induced surface charge density on a conducting sphere placed in a uniform electric field.

Unit - II

3. Discuss the multipole expansion of the energy of a charge distribution in an external field and define the electric quadrupole moment.
4. Explain molecular polarizability and the electric susceptibility of a medium. Derive the Clausius–Mossotti equation for molecular polarizability.

Unit - III

5. State and explain the Biot–Savart law. Derive the expression for the magnetic induction produced by a circular current loop.
6. Derive the vector potential at a point due to a magnetic dipole and hence obtain the expression for the magnetic induction of the dipole.

Unit - IV

7. Explain the Lorentz gauge and Coulomb gauge with suitable examples. Define irrotational current and solenoidal current.
8. Explain the Poynting vector for an electromagnetic field and discuss the Poynting theorem in the case of linear dispersive media.

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Academic Year 2025-26
M.Sc. (Physics) Semester - I
Subject- Physics
Paper IV – Mathematical Methods in Physics
ASSIGNMENT

NOTE: Attempt any four questions.

Unit - I

1. Prove that Kronecker delta is a mixed tensor of rank two.

2. Define Covariant $T_{\mu\nu}$ and Contravariant $T^{\mu\nu}$ tensors. How do their indices transform under a change of coordinates.

Unit - II

3. Define both isomorphism and homomorphism in the context of group theory. Discuss their significance and provide examples of each.

4 State and explain the representation theorem of finite groups. Provide an example to illustrate the theorem.

Unit - III

5. Derivation of the Single- Slit Diffraction pattern using the Fourier transformation.

6. Find Fourier transform of wave train using with Gaussian amplitude.

Unit – IV

7 State the Convolution theorem for Laplace transforms. Use the Convolution theorem to compute the Laplace transform of the function

$$H(t)= \int e^{\tau}\sin(\tau)d\tau$$

8. Find the Laplace transform of

(i) t^2e^{-at} (ii) $t^2\sin at$

S. S. Jain Subodh P.G. College, Jaipur
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Academic Year 2025-26
M.Sc. (Physics) Semester - III
Subject- Physics
Paper I – Advanced Quantum Mechanics
ASSIGNMENT

NOTE: Attempt any four questions.

Unit - I

1. Define differential and total scattering cross sections. Explain the solution of a scattering problem using the method of partial wave analysis with a suitable example.

2. Discuss the Born approximation and its range of validity in scattering problems. Explain the Coulomb scattering problem under the first Born approximation for elastic scattering.

Unit - II

3. Derive the Klein–Gordon equation for relativistic quantum mechanics. Discuss the interpretation of negative probability current density and negative energy solutions.

4. Explain the properties of gamma matrices and derive the Dirac equation for relativistic quantum mechanics.

Unit - III

5. Explain the Lorentz covariance of the Dirac equation. Derive the Lorentz boost and rotation matrices for Dirac spinors.

6. Explain the projection operators for four-momentum and spin of a particle. Define the CPT operators for Dirac spinors.

Unit - IV

7. Explain the quantization of a radiation oscillator. Define and discuss the roles of creation, annihilation, and number operators.

8. Explain Thomson scattering and discuss the Raman Effect in the context of quantum radiation.

S. S. Jain Subodh P.G. College, Jaipur
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Academic Year 2025-26
M.Sc. (Physics) Semester - III
Subject- Physics
Paper II – Statistical and Solid State Physics

ASSIGNMENT

NOTE: Attempt any four questions.

Unit - I

1 Derive an expression of the entropy of an ideal gas using the microcanonical ensemble.

2 Establish the relation between various thermodynamic functions for canonical ensemble.

Unit - II

3 Determine the translational, Rotational and Vibrational contributions to the partition function of an ideal diatomic gas

4 Use B-E statistics for the derivation of Plank's distribution law for radiation.

Unit - III

5 Discuss Drude-Lorentz theory. State its successes and its limitations and also deduce an expression for electrical resistivity of metals.

6 (a) Using Fermi-Dirac statistics obtain an expression for electrical conductivity of metals.
(b) What do you mean by Fermi Energy? Explain its temperature dependence.

Unit - IV

7 (a) State and prove Bloch Theorem.
(b) Discuss Pseudo Potential Method.

8 (a) Discuss the tight binding method and calculate energy band width in simple cubic lattice.
(b) Explain the periodic character of the crystal potential.

S. S. Jain Subodh P. G. College, Jaipur
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Academic Year 2025-26
M.Sc. Physics Semester- III
Subject – Physics
Paper – III Nuclear Physics -I
ASSIGNMENT

NOTE: Attempt any four questions.

Unit-I

1. Study the excited state of deuteron by using generalized form of wave equation and find out magnitude of centrifugal potential in $\boldsymbol{l = 1}$ state.

2. Calculate the electric quadropole and magnetic dipole moments of the nucleus and discuss the results.

Unit-II

3. Study the effective range theory of neutron – proton scattering. Discuss how the result can be reconciled with the deuteron data.

4. **(**a) Explain why diprotons and dineutrons does not found in a state of stationary state.
(b)Discuss general features of two body scattering at high energy effect of exchange forces

Unit-III

5. (a) Obtain energy loss per unit length when a charged particle passes through matter.
(b)Discuss Compton Scattering and obtain Compton Absorption Coefficient.

6. Write short notes on the following :
(a) Pair production
(b) Bremsstrahlung
(c) Straggling

Unit-IV

7. Explain the construction, working, plateau region and counting efficiency of the G.M. counter.

8. Explain the design and principle of working of proton synchrotron.

S. S. Jain Subodh P.G. College, Jaipur
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Academic Year 2025-26
M.Sc. (Physics) Semester - III
Subject- Physics
Paper IV – Microwave Electronics - I
ASSIGNMENT

NOTE: Attempt any four questions.

Unit - I

1. Derive wave equation for fields in a rectangular waveguide and then solve to obtain field distribution inside the wavelength for the TM-mode.

2. Discuss the causes of attenuation in waveguide. Derive expression for Q- factor for a waveguide. How does quality factor of a waveguide depends on attenuation constant.

Unit - II

3. Describe construction and working of a cylindrical resonator. Derive an expression for Q-factor of the cylindrical cavity resonator.

4. Write in brief about Faraday rotation. Show that Faraday rotation in an non-reciprocal phenomenon. Draw necessary diagram.

Unit - III

5. Explain the construction and working of precision pariable attenuator. Discuss its frequency response and reflection losses.

6. Describe the shift of minima method to measure the dielectric constant of liquids. Draw block diagram and write relevant relations.

Unit - IV

7. Describe construction and working of a two cavity klystron. Derive expression for its power efficiency. Draw necessary diagram.

8. Describe the working of Magnetron. How is its frequency and power measured? Also differentiate between Traveling Wave Tube (TWT) and Klystron.