Exam Code: 225503 **Paper Code: 3205**

Programme: Master of Science (Physics) Semester III

Course Title: Quantum Mechanics-II

Course Code: MPHL-3391

Time Allowed: 3 Hours **Max. Marks: 70**

Note: Attempt five questions in all, selecting at least one question from each section. Fifth question can be attempted from any section. Each question carries 14 marks. Use of Scientific Calculator is allowed.

Section-A

1. Consider the helium atom problem where the electron-electron interaction is treated as a perturbation. Using first-order perturbation theory, calculate the first-order correction to the energy of the ground state of the Helium atom due to the repulsive Coulomb interaction between the two electrons. Assume that the electrons are in the 1s orbital. (14)

2. A particle in a one-dimensional box of length L is subject to a perturbation $H' = \lambda x^2$. Using second-order perturbation theory, calculate the correction to the energy of the first excited state of the particle in the box. Assume that λ is small and show all the steps. (14)

Section-B

3. Use partial wave analysis to calculate the total cross-section for scattering by a potential V(r) in the low-energy limit. Assume the phase shift is small and expand the cross-section to first order in the phase shift. (14)

4. Find the total scattering potential for the particles scattered from a Yukawa potential. What are the conditions for the validity of Born-approximation for the potential? (9, 5)

Section-C

5. Find the covariant form of Dirac's equation for a particle moving at a relativistic speed. Find the matrix elements for invariance of Dirac's equation under rotational motion. (4, 10)

6. Find the Klein Gordon equation for a particle in coulomb potential. (14)

Section-D

7. a. What is the relation between spin and statistics? How the quantum particles are classified according to the statistics? What are the differences between bosons and fermions? (3, 2, 6)

b. Consider two non-identical bosons of mass m1 and m2 (m1>m2) in a two-dimensional potential well.

i. Write down the ground and first excited state wave function for the two-fermion system.

ii. Calculate the ground and first excited state energy of the system. (3)

8. a. Write short notes on the following:

I. Exchange degeneracy
II. Symmetrisation postulate
III. Symmetrizer and anti-symmetrizer operator (9)

b. Prove that the wave function of two identical particles can be written as a sum of symmetric and anti-symmetric operator. (5)

Exam Code: 225503 Paper Code: 3206

Programme: Master of Science (Physics) Semester III

Course Title: Electrodynamics - II

Course Code: MPHL-3392

Time Allowed: 3 Hours Max. Marks: 70

Note: Attempt five questions in all, selecting at least one question from each section. Fifth question can be attempted from any section. Each question carries 14 marks.

Section-A

1. a) Draw and compare the variation of fields near the surface of a perfect conductor and surface of a good but not perfect conductor. 4

b) Comment on the statement that the resistive lose in a good conductor is inversely proposition to skin depth and conductivity. 10

2. Prove that phase velocity of a cylindrical waveguide is infinite at cut-off frequency. 14

Section - B

3. I. Prove the following statements:

a) Moving clock runs slow.

b) Moving objects have shorter lengths.

c) Event happening at same times in one frame may not be happening at same time in another. $3 \times 3 = 9$

II. Write the four-vector notation of momentum. 5

4. Solve the Lorentz force in terms of relativistic electrodynamics. How does it relate to the invariance of Maxwell's equations? 14

Section - C

5. Explain the concept of dipole radiation. Why does a charge oscillating at a frequency Ω generate a field primarily at that frequency? 14

6. For a system with a quadrupole oscillating at angular frequency ω, derive the electric field. Calculate the time-averaged power radiated by the quadrupole. Explain how the radiation pattern for a quadrupole differs from that of a dipole. 14

Section - D

7. Using the retarded potential formulation, derive the electric and magnetic fields for a charge moving with uniform velocity. How do these fields differ from the static Coulomb field? 14

8. Derive the Abraham-Lorentz force (radiation reaction force) on an accelerating charge. Discuss its physical implications, especially in the context of self-interaction. 14

(For Reappear Candidates Only 2023-24))

Exam Code: 209003

Paper Code: 9351

Programme: Master of Science (Physics) Semester III

Course Title: Electrodynamics-II

Course Code: MPHL-3392

Time Allowed: 3 Hours

Max. Marks: 80

Note: Attempt five questions in all, selecting at least one question from each section. Fifth question can be attempted from any section. Each question carries 16 marks.

Section-A

1. a) Draw and compare the variation of fields near the surface of a perfect conductor and surface of a good but not perfect conductor. 5

   b) Comment on the statement that the resistive lose in a good conductor is inversely proposition to skin depth and conductivity. 11

2. Prove that phase velocity of a cylindrical waveguide is infinite at cut-off frequency. 16

Section - B

3. I. Prove the following statements:

   a) Moving clock runs slow.

   b) Moving objects have shorter lengths.

   c) Event happening at same times in one frame may not be happening at same time in another. $3\times3=9$

   II. Write the four-vector notation of momentum. 7

4. Solve the Lorentz force in terms of relativistic electrodynamics. How does it relate to the invariance of Maxwell's equations? 16

Section – C

5. Explain the concept of dipole radiation. Why does a charge oscillating at a frequency Ω generate a field primarily at that frequency? 16
6. For a system with a quadrupole oscillating at angular frequency ω, derive the electric field. Calculate the time-averaged power radiated by the quadrupole. Explain how the radiation pattern for a quadrupole differs from that of a dipole. 16

Section - D

7. Using the retarded potential formulation, derive the electric and magnetic fields for a charge moving with uniform velocity. How do these fields differ from the static Coulomb field? 16
8. Derive the Abraham-Lorentz force (radiation reaction force) on an accelerating charge. Discuss its physical implications, especially in the context of self-interaction. 16

Exam Code: 225503 Paper Code: 3207

Programme: Master of Science (Physics) Semester III

Course Title: Condensed Matter Physics - II

Course Code: MPHL-3393

Time Allowed: 3 Hours Max. Marks: 70

Note: Attempt five questions in all, selecting at least one question from each section. Fifth question can be attempted from any section. Each question carries 14 marks.

Section-A

1. (a) Explain in detail regarding Langevin quantum theory of Paramagnetism (7)
(b) Explain the concept of origin of permanent magnetic dipoles. (7)
2. (a)Write in detail about quenching of orbital angular momentum and adiabatic demagnetisation (7)
(b) Explain in detail about paramagnetic susceptibility of conduction electrons. (7)

Section - B

3. (a) Explain in detail (i) Ferromagnetic domain theory (ii) Weiss theory of spontaneous magnetisation of Ferromagnetism (7)
(b) Explain the concept of anisotropy energy of ferromagnetic solid. (7)
4. Explain each in detail (a) Bloch wall and its thickness (b) Quantization of Spin Waves (c) Two Sub Lattice Model (14)

Section - C

5 (i)Write a note on each (a) Type 1 and Type II Superconductors (b) critical magnetic field and Critical temperature (c) Meissner effect (7)
(ii) Explain in detail the following (a) Flux Quanatisation in a superconducting ring (b) a.c and d.c Josephson's effect (7)

6. (i) What is (a) B.C.S theory of Superconductors (b) Thermodynamics of superconducting transition (7)
(ii) Derive London's equation for Superconductors (7)

Section - D

7. Explain the following in detail (a) Decay Mechanism (b) Reflection and refraction (c) absorption and transmission (d) luminescence (14)

8. Explain the following (a) luminescence of thalium activated halides (b) sulphide phosphors (14)

Exam Code: 225503 **Paper Code: 3208**

Programme: Master of Science (Physics) Semester III

Course Title: Nuclear Physics

Course Code: MPHL-3394

Time Allowed: 3 Hours **Max. Marks: 70**

Note: Attempt five questions in all, selecting at least one question from each section. Fifth question can be attempted from any section. Each question carries 14 marks. Use of Non-Scientific calculators or logarithmic tables is allowed.

Section - A

1. Discuss the partial wave analysis of neutron-proton scattering and find the expression for total scattering crossection and hence find the scattering length. (14)

2. (a) Explain the meson theory of nuclear forces as proposed by Yukawa. Derive the expression for the potential between two nucleons due to meson exchange. (7)

(b) Find the ground state wavefunction of deutron and the depth of square well potential assuming the binding energy to be 2.2 MeV and deutron radius as 2 fm. (7)

Section - B

3. Derive the semi-empirical mass formula for nuclear binding energy. How this formula can be used to find the most stable isobar. (14)

4. What is role of spin orbit coupling in the development of shell model? Discuss how shell model successfully explain the angular momenta, parities and magnetic moments of various nuclie? Also find ground states angular momenta and parities of $_{13}Al^{27}$, $_{16}S^{33}$ and $_{18}A^{41}$. (14)

Section - C

5. Discuss how the introduction of the neutrino resolved the issue of energy conservation in beta decay. Include in your discussion the expression for the transition probability and how it accounts for the continuous beta spectrum observed experimentally. (14)

6. Discuss the selection rules for gamma decay transitions and find the relations for electric and magnetic transition probabilities in terms of electric and magnetic multipole moments. (14)

Section - D

7. (a) What do you mean by Q-value of a nuclear reaction? Find an expression of Q-value in terms of measurable quantities? (7)

(b) Consider the nuclear reaction:

$$^{14}N + {}^{4}He \rightarrow {}^{17}O + {}^{1}H$$

Mass of ^{14}N =14.003074 u, Mass of ^{4}He=4.002603 u, Mass of ^{17}O=16.999132 u, Mass of ^{1}H=1.007825 u, Calculate the QQ-value of the reaction. (1 atomic mass unit, or u, is approximately equal to 931.5 MeV in energy equivalent.) (7)

8. Derive expression for total reaction crossection by using partial wave analysis and also discuss the phenomenon of shadow scattering. (14)