M.Sc. 2nd Semester Examination, 2021

PHYSICS

(Quantum Mechanics-II and Classical Electrodynamics-II)

Course Code: 202C

Course ID: 22452

Time: 2 Hours **Full Marks: 40**

The figures in the right hand side margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Unit-I

1. Answer *any three* of the following questions: **2x3=6**

(a) What are the limitations of time independent perturbation theory?

(b) Show that any wave function can be expressed as the sum of even and odd parity wave functions.

(c) Write down the matrix form of L_+.

(d) Show that orbital angular momentum is the generator of infinitesimal spatial rotations.

(e) What is transition probability? Write its expression.

2. Answer *any two* of the following questions: **4x2=8**

(a) Show that using degenerate perturbation theory the degeneracy can be partly remove in the first excited state of hydrogen atom.

(b) By using Born approximation, calculate the scattering cross section for the Gaussian potential $V(r) = -V_0 e^{-\frac{r^2}{2a^2}}$.

(c) Obtain the ground state wave function of Helium atom under independent particle approximation.

(d) Consider a half-harmonic oscillator with potential $V(x) = \infty$ for $x < x_1$ and $V(x) = \frac{1}{2}m\omega^2x^2$ for $x > x_1$. Use JWKB approximation to get energy levels and hence calculate first excited state energy.

3. **Answer *any one* of the following questions:** **6x1=6**

(a) Find the Clebsch–Gordan coefficients associated with the coupling of the spins of the electron and the proton of a hydrogen atom in its ground state.

(b) By using time dependent perturbation theory, Establish the Fermis Golden rule and hence discuss the validity of Fermi Golden rule.

Unit-II

4. Answer *any three* of the following questions: **2x3=6**

(a) What are the cut off wave length and guided wave length in rectangular waveguide.

(b) What is Debye shielding?

(c) Explain what a magnetic Reynold number is?

(d) What is Hartmann number?

(e) With schematic diagram, physically explain the pinch effect.

5. Answer *any two* of the following questions: **4x2=8**

(a) Obtain the Kramers Kronig relation and hence discuss its physical significance.

(b) Consider a waveguide of square cross-section having side *a* and filled with a dielectric medium of permeability μ and permittivity ε. Find the range of frequencies of EM waves which can propagate through the guide only as TE_{10} or TE_{01} mode.

(c) Derive an expression for Debye length and explain its physical significance.

(d) By using the model of a damped forced harmonic oscillator of a bound electron in a dielectric, obtain the frequency dispersion.

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6. **Answer *any one* of the following questions:** **6x1=6**

(a) On the basis of Lorentz theory of dispersion, show that for a transparent dielectric solid at a particular frequency,

$$\frac{n^2-1}{n^2+2}\frac{M}{\rho} = \text{constant},$$

where n is the refractive index, ρ is the density and M is the molecular weight of the dielectric.

(b) What are the ordinary and extraordinary waves in a plasma? The dispersion relation for the extraordinary wave in a plasma is given by $c^2/v_\phi^2 = 1 - [\omega_p^2(\omega^2-\omega_p^2)]/[\omega^2(\omega^2-\omega_h^2)]$, where symbols have their usual meaning. Use this relation to draw the dispersion diagram for the extraordinary wave and indicate clearly different cut-off and resonance frequencies as well as regions of propagation and nonpropagation.
