P.G. Semester-II Examination, 2023

PHYSICS

Course ID : 22452 **Course Code : PHS-202C**

Course Title : Quantum Mechanics-II and Classical Electrodynamics-II

Time : 2 Hours Full Marks : 40

The figures in the right-hand margin indicate 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 : 2×3=6

   a) Discuss the limitations of the perturbation theory and JWKB approximation.

   b) Why do we need time reversal symmetry operator to be anti-linear?

   c) Evaluate $\left[J^2, J_{1z}\right]$, where $J = J_1 + J_2$.

   d) Determine the eigen values and eigen vectors of S_x.

   e) Establish that for symmetric potential, the Hamiltonian keeps the parity conserved.

[Turn over]

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

   a) Prove that the L_x is the generator of infinitesimal rotation about the *x*-axis.

   b) Distinguish between ortho and para-Helium. Write down the wave function for ortho- and para-Helium states. 2+2

   c) Use the variational method to estimate the ground state energy of the hydrogen atom.

   d) Show that under the application of JWKB approximation the energy eigen value of a linear harmonic oscillator is $E_n = \left(n + \frac{1}{2}\right)\hbar\omega$.

3. Answer any **one** of the following questions : 6×1=6

   a) Derive the transition probability of a harmonic potential and hence calculate the limitation of Fermi-golden rule.

   b) Under what conditions the Born approximation is used? By using Born approximation, calculate the differential scattering cross section by the following square well potential

$$V(r) = -V_0 \quad for\ r < a$$
$$= 0 \quad for\ r > a.$$

1+5

UNIT-II

4. Answer any **three** of the following questions : 2×3=6

   a) In the context of EM wave what do you mean by dispersion? What is the physical significance of a complex wave vector?

   b) Graphically show the variations of Refractive index and Absorption Coefficient as functions of frequency of the incident EM wave in the case of anomalous dispersion.

   c) What is plasma oscillation?

   d) With schematic diagram, physically explain the pinch effect.

   e) Define cavity resonator. What is Q of the cavity?

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

   a) Derive an expression for Debye length and explain its physical significance. 4

   b) i) Write down Cauchy's Dispersion Formula. Under what conditions it is valid.

      ii) Why are Kramers-Kronig relations important? What is the basic phenomena of a primary assumption (mention at least any one) that helps you derive the relations? (No derivations are required.) (1+1)+(1+1)

   c) What do you mean by TE, TM and TEM waves in case of EM fluids? How do you differentiate between them? 3+1

   d) Considering a rectangular waveguide, show that the dominant TE mode has the lowest cut-off frequency and it is lower by a factor of $\left(1+\frac{a^2}{b^2}\right)^{-\frac{1}{2}}$ than the dominant TM mode. *a, b* are the dimensions of the waveguide with $a > b$. 4

6. Answer any **one** of the following questions : 6×1=6

   a) Assuming electrons in a non-conducting medium to be a set of oscillators, derive the Lorentz Dispersion relation when an EM wave falls on the medium.

   b) Discuss basics differences between Magnetohydrodynamic wave and Plasma oscillations. Write Magnetohydrodynamic equations and explain the terms properly. Explain how is the concept of magnetic hydrostatic pressure coming from force equation? 1+2+3

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