M.Sc. 1st Semester Examination, 2018

PHYSICS

Course Title : Quantum Mechanics-I & Classical Electrodynamics-I

Paper : PHYS 102C

Course ID : 12452

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

The figures in the 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: 2×3=6

(a) Two kets are given by $|\alpha> = i|1> -2|2> -i|3>, |\beta\ge = i|1> +2|3>$, where $|1>, |2>, |3>$ are orthonormal basis. Find $<\beta|$ and $<\alpha|\beta>$. 2

(b) Show that $[\hat{p}_x, f(x)] = i\hbar f'(x)$. 2

(c) (i) Show that the operator $T = \begin{pmatrix} 1 & 1-i \\ 1+i & 0 \end{pmatrix}$ is Hermitian.

(ii) What do you mean by stationary states? 1+1=2

(d) Show that eigenvalues of all Hermitian operators are real. 2

(e) Show that the operator $\frac{\partial}{\partial x}$ is not a Hermitian operator. 2

2. Answer *any two* questions: 4×2=8

(a) A particle is subject to a potential given by: $V(x) = -\alpha\, \delta(x) (\alpha > 0)$, here $\delta(x)$ is the Dirac delta function. Find the possible energy of the particle in its bound state. 4

(b) Find the uncertainty $\Delta x = [<x^2> - <x>^2]^{\frac{1}{2}}$ in the *n*th eigenstate of a linear harmonic oscillator. 4

(c) What is a coherent state? Show that the position-momentum uncertainty product in a coherent state is same as that of the ground state of a I–D harmonic oscillator. 1+3=4

(d) Show that if $\hat{A}$ and $\hat{B}$ represent two observables such that the commutator $[\hat{A}, \hat{B}] = 0$, then they must have a simultaneous eigenstate. 4

3. Answer *any one* question: 6×1=6

(a) Imagine a system in which there are just two linearly independent states:

$|1> \begin{pmatrix}1\\0\end{pmatrix}, |2> \begin{pmatrix}0\\1\end{pmatrix}$

suppose the Hamiltonian of the system has the specific form

$H = \begin{pmatrix}h & g\\ g & h\end{pmatrix}$, where g and h are real constants.

(i) Find the normalized eigenvectors and eigenvalues of H

(ii) Suppose that the initial state $|\Psi(0) > |I >$. Expand $|\Psi(0) >$ as a linear combination of eigenvectors of H

(iii) Show that $|\Psi(t) > = e^{-iht/\hbar} \begin{pmatrix}\cos(gt/\hbar \\ -i\sin(gt/\hbar\end{pmatrix}$ 3+1+2=6

(b) In case of a linear harmonic oscillator, let $|n >$ represent the set of orthonormal eigenkets of H.

(i) Evaluate $< 4|x^2|6 >$

(ii) Evaluate the matrix elements $< m|a|n >$ and write the matrix representing the annihilation operator '*a*'. 3+3=6

Unit – II

1. Answer *any three* questions: 2×3=6

(a) State the physical significance of Coulomb condition. 2

(b) What is the physical significance of $\vec{\nabla}.\vec{B} = 0$? 2

(c) Write down the Lorentz-Gauge condition. 2

(d) What do you mean by retarded potential? 2

(e) What is Maxwell's stress tensor? 2

2. Answer *any two* questions: 4×2=8

(a) Show that retarded potential satisfies Lorentz-Gauge condition. 4

(b) Rewrite Maxwell's Equation using potential formalism of electrodynamics. 4

(c) Consider an infinite parallel plate capacitor with the lower plate (at $z = -\frac{d}{2}$) carrying surface charge density –σ and the upper plate (at $z = +\frac{d}{2}$) carrying surface charge density +σ. Determine all the nine elements of the stress tensor, in the region between the plates. 4

(d) Discuss oscillating electric dipole radiation. 4

3. Answer *any one* question: 6×1=6

(a) Derive the Poisson's equation for the vector potential. 6

(b) Discuss about the power radiated by a moving point charge. 6