Course: B.Tech Computer Science and Engineering
(Artificial Intelligence & Machine Learning)
Subject: Quantum Physics, Subject Code: ETPH102
Semester: II

Time: 03 Hours **Max Marks: 70**

Instructions to the Students:

1. This Question paper consists of two Sections. All sections are compulsory.
2. Section A comprises 10 questions of short answer type. All questions are compulsory. Each question carries 02 marks.
3. Section B comprises 8 long answer type qsuestions out of which students must attempt any 5. Each question carries 10 marks.
4. Do not write anything on the question paper.

Q.No.	SECTION –A (SHORT ANSWER TYPE QUESTIONS)	Marks
1. a.	Derive the relationship for group velocity and phase velocity (In relativistic case only).	(2)
b.	Calculate the probability current density for wave function ψ(x)=u(x), where u(x) is a real function.	(2)
c.	If ψ_1 and ψ_2 are ground and first excited states of a particle in a potential such that $\hat{A}\,\psi_1 = \psi_2$ and $\hat{A}\,\psi_2 = \psi_1$ then calculate the expectation value of $\hat{A}$ in state $\lvert\psi\rangle = 3\lvert\psi_1\rangle + 4\lvert\psi_2\rangle$.	(2)
d.	Write the Rodridge formula for the Hermite polynomial.	(2)
e.	Differentiate bound and unbound states by drawing a suitable diagram.	(2)
f.	Calculate the value of the commutation relation $[\hat{L}^2, L_z]$.	(2)
g.	What is Quantum tunneling?	(2)
h.	Distinguish the quantum and classical models of hydrogen atoms based on energy levels and quantization.	(2)
i.	Differentiate the particle motion in single and double delta potential regarding energy.	(2)
j.	Draw the probability density functions of hydrogen molecule ions for bonding and antibonding orbitals.	(2)

SECTION –B (LONG ANSWER TYPE QUESTIONS)

2. Explain the concept of wave-particle duality. Also, derive the relationship between phase velocity and group velocity for angular frequency $\omega=(gk)^{1/2}$. (10)

3. Derive the expression for a one-dimensional time-dependent Schrodinger equation. (10)

?4. Show that the eigenstates corresponding to two different eigenvalues of the Hermitian operator are orthogonal. (10)

5. Establish the Schrodinger equation for a linear harmonics oscillator and solve it to obtain eigenvalues and eigenfunction. (10)

6. Explain the construction and working of a scanning transmission microscope (STM). (10)

7. Derive the Schrodinger equation for a central potential. (10)

?8. Solve the Schrodinger equation to evaluate a hydrogen atom's energy levels and wave functions. (10)

?9. Derive the energies of a hydrogen molecule ion using molecular-orbital (MO) treatment. (10)

===END OF PAPER===