FYUGP B.Sc 4th Semester Sessional Examination, 2025
Paper: Quantum Mechanics I
Paper Code: PHY040204

Marks: 30 **Time: 90 minutes**

1. **Answer the following: (any two)** $2 \times 2 = 4$

   (a) What was the need for quantum mechanics?
   (b) Calculate the probability current density for the plane wave $\Psi(\square) = \square\square^{-\square\square\square}$.
   (c) Write down the orthogonality and normalisation conditions for a wave function.
   (d) What is the energy of a photon of wavelength 1A.

2. **Answer the following: (any two)** $2 \times 3 = 6$

   (a) What is quantum tunneling? Give an example.
   (b) Draw the first three wave function of a particle in an infinite deep potential well.
   (c) What are the problems associated with the determination of the trajectory of a microparticle ?
   (d) What do you mean by group velocity and phase velocity ? How are they related to each other ?

3. **Answer the following: (any four)** $4 \times 5 = 20$

   (a) Calculate the zero point energy in an infinite potential well for
   (i) a 10 g ball confined to a 10 m long line
   (ii) an oxygen atom confined to a 2Å lattice.
   (b) What is zero-point energy in a linear harmonic oscillator? Write down the expression for energy eigenvalue for it. What is the separation between two consecutive energy levels? Explain with the help of an energy level diagram.
   (c) In the light of blackbody radiation explain how the failure of classical theory lead to the development of quantum mechanics ?
   (d) Find the phase velocity and group velocity of the de-Broglie wave for a free particle moving with classical velocity v. Does your result contradict the principle of relativity ? Explain.
   (e) Obtain an un-normalized Gaussian wave function for position and momentum operators.
   (f) What is Compton scattering ? Explain it quantum mechanically. Write down the expression for Compton shift. Calculate the maximum value of this shift ?
   (g) Use any one of the following to establish the uncertainty principle
   (i) Gamma ray electron microscope
   (ii) Double slit electron diffraction
   (h) Describe any one of the following to establish the existence of matter wave
   (i) Davisson and Germer experiment
   (ii) G P Thomson experiment