STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086
(For candidates admitted during the academic year 2019-2020 & thereafter)

B.Sc. DEGREE EXAMINATION APRIL 2024
BRANCH III - PHYSICS
SIXTH SEMESTER

COURSE : MAJOR – CORE
PAPER : QUANTUM MECHANICS AND RELATIVITY
SUBJECT CODE : 19PH/MC/QR64
TIME : 3 HOURS

MAX. MARKS :100

SECTION – A

ANSWER ALL QUESTIONS: 25 MARKS
I CHOOSE THE CORRECT ANSWER: (10 X 1 = 10)

1. The momentum (p) and wavelength (λ) of photon are related as
   (a) $p = 2\lambda$ (b) $p = h\lambda$ (c) $p = \frac{h}{\lambda}$ (d) $p = \frac{h^2}{2\lambda}$
2. Group velocity and wave velocity are equal in
   (a) Dispersive medium (b) non-dispersive medium
   (b) Glass (d) water
3. The state function for a particle is given by $\psi = Ae^{-ikx}$. The positive probability density is
   (a) A (b) $\frac{A}{2}$ (c) A^2 (d) 1
4. Quantum mechanical tunneling largely depends on
   (a) Height of barrier (b) width of barrier (c) wave function
   (d) Temperature
5. The quantum mechanical operator for momentum is
   (a) $\frac{-\hbar}{\nabla}$ (b) $\frac{-h}{\nabla}$ (c) $-i\hbar\nabla$ (d) $i\hbar\frac{\partial}{\partial t}$
6. For an operator A, if $A^{\dagger}$ is the transpose of A^{-1} is the inverse and if the $A^{\dagger} = A^{-1}$, the operator is
   (a) Linear (b) Hermitian (c) unitary (d) unitary
7. The Lorentz transformation equations relating to x and x' is given by
   (a) $x' = k(vt - x)$ (b) $x' = k(x - x)$ (c) $x' = k(x - vt)$ (d) $k' = k(vt - x^2)$
8. Newtonian's laws of motion hold good in which of the following frame of reference
   (a) Inertial frame of reference (b) non-inertial frame of reference (c) both (d) none of the above
9. Which of the following equation is true for length contraction?
   (a) $l_0 = \sqrt{1 - (\frac{v^2}{c^2})}$ (b) $l = \sqrt{1 - (\frac{v^2}{c^2})}$ (c) v= $l_0\sqrt{1 - (\frac{v^2}{c^2})}$ (d) $l = l_0\sqrt{1 - (\frac{v^2}{c^2})}$
10. Relativistic formula for kinetic energy is
    (a) mc^2 (b) mc^3 (c) (m-m_0)c^2 (d) (m-m_0)c^3

II. FILL IN THE BLANKS (5 x 1 = 5)

11. _____ is an experimental evidence for quantum theory.
12. Possible energies of particle in one dimensional box are _____.
13. The potential energy of free particle is _____
14. Accelerated frames are called _____ frames.
15. The total relativistic energy of particle is _____

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III. ANSWER BRIEFLY: **(5 x 2 =10)**

16. Define dual nature of particle. Give an example.
17. Write the normalized wave function for one dimensional potential well.
18. Show that the momentum of a free particle is constant of motion.
19. What is Newtonian relativity?
20. Define length contraction.

SECTION - B

ANSWER ANY FIVE QUESTIONS: **(5 x 6 = 30)**

21. Electrons are accelerated through 344 volts and are reflected from a crystal. The first reflection maximum occurs when glancing angle is 60^0. Determine the spacing of the crystal.
22. A particle trapped in one dimensional infinite potential well of width L is given by $\psi = Asin\left(\frac{n\pi x}{L}\right)$ in the region: $\begin{cases} x > 0 \\ x < L \end{cases}$.
23. State the commutation relation between linear momentum and Hamiltonian H.
24. An event occurs at $x = 200m$, y = 5m, z= 1m, and t= 1×10^{-4} sec in a frame S. Find the coordinates of the event in a frame S' which is moving with a velocity 2.7×10^5 m/s to the frame along the $x - x'$ axis using Lorentz transformation.
25. What is the length of the meter stick moving parallel to its length when its mass is 3/2 of its rest mass?
26. Obtain the energy eigenvalues and eigenfunctions of a particle trapped in the potential V(x) = 0 for 0 < x < a and V(x) = ∞ otherwise. Show that the wave functions for the different energy levels of the particle trapped in the square well are orthogonal.
27. With examples explain linear operator.

SECTION - C

ANSWER ANY THREE QUESTIONS: **(3 x 15 = 45)**

28. Describe Davisson and Germer experiment on electron diffraction and show how the wave nature of electron in motion could be proved experimentally.
29. Derive Schrodinger's one-dimensional time-independent wave equation. What are the characteristics of this wave equation?
30. Define a Hermitian operator. Show that the eigenvalues of Hermitian operator are real.
31. Describe the Michelson-Morley experiment and explain the physical significance of negative results.
32. Deduce the formula for relativistic variation of mass with velocity. Briefly explain its significance.

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