STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086.
(For candidates admitted during the academic year 2011-12 & thereafter)

SUBJECT CODE : 11PH/MC/QR64

B.Sc. DEGREE EXAMINATION APRIL 2016
BRANCH III - PHYSICS
SIXTH SEMESTER

REG. No._____

COURSE : MAJOR – CORE
PAPER : QUANTUM MECHANICS AND RELATIVITY
TIME : 30 MINS. MAX. MARKS : 30

SECTION – A
TO BE ANSWERED IN THE QUESTION PAPER ITSELF

ANSWER ALL QUESTIONS: (30 x 1 = 30)

I Choose the Correct Answer:

1. de – Broglie proposed that wave length λ associated with any moving particle of momentum P is
   a) hγ/2 b) h/mv c) h/w d) hγ

2. The wave associated with material particle is called
   a) Square wave b) matter waves c) sine wave d) triangular wave

3. The phase velocity V_p is given by
   a) $V_p = k/\omega$ b) $V_p = dk/d\omega$ c) $V_p = \omega/k$ d) $V_p = d\omega/dk$

4. The quantum mechanical operator for kinetic energy k is
   a) $– h/2m + \nabla^2$ b) $– \hbar^2/2m \nabla^2$ c) $– \hbar/2m \nabla$ d) $– \hbar/2m \nabla^2$

5. Since the particle is moving freely with zero potential energy, its total energy E is the kinetic energy given by
   a) $E = p_x/m$ b) $E = p^2x/2m$ c) $E = - p^2x/m$ d) $E = - p_x/m$

6. Quantum mechanical operator for y – component of momentum is
   a) $\hbar/i \ \partial/\partial y$ b) $h/i \ \partial/\partial y$ c)) $- h/i \ \partial/\partial y$ d) $- \hbar/i \ \partial/\partial y$

7. Number of nodes of particle in one dimensional box when n = 3 is
   a) 1 node b) 2 nodes c) 3 nodes d) 4 nodes

8. Value of $[L_y, L_z]$ is
   a) $i \hbar L_z$ b) $i\hbar L_y$ c) $i\hbar L_x$ d) $- i\hbar L_y$

9. The value of $[x, p_x]$ is
   a) 0 b) $– i\hbar$ c) $i\hbar$ d) $i/ \hbar$

10. As the velocity of the body approaches velocity of light, then the mass m of the body becomes
    a) 1 b) 0 c) ∞ d) none

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11. Un accelerated frames are called
    a) Galilean or Inertial frames b) non- Inertial frames c) static frames d) none

12. Galilean transformation equations are
    a) $z' = y' - vt$, $y' = y$, $z' = z$, $t' = t$ b) $y' = x - vt$, $y' = y$, $z' = z$, $t' = t$
    c) $x' = x - vt$, $y' = y$, $z' = z$, $t' = t$ d) none

13. Mesons have a speed of
    a) 3.8×10^7 ms^{-1} b) 2.994×10^8 ms^{-1} c) 2.99×10^7 ms^{-1} d) 2.99×10^6 ms^{-1}

14. The four dimensional manifold which appears as a linking together of space and time is known as
    a) Time dilation b) world line c) Minkowski world d) none

15. The point of the orbit at which the planet is nearest to the sun is
    a) ellipse b) perihelion c) circle d) none

II Fill in the blanks:

16. The de Broglie wave length for charged particle of charge q and accelerated through a potential difference of V volts is _____.
17. In Davisson and Germer's experiment, when the accelerating voltage is increased the length of the bump is _____.
18. The energy spectrum in an infinitely deep potential well is _____.
19. In the barrier penetration problem, transmission co-efficient T is _____.
20. The mass of the body in motion is given by _____.

III State whether true or false:

21. Particle velocity V is always less than C.
22. De- Broglie wave length of particle of kinetic energy is $\lambda = h/\sqrt{2mEk}$.
23. In wave packet, group velocity V_g will be equal to the particle velocity V.
24. In Davission and Germer's experiment the bump becomes most prominent in the curve for 64v electrons at $\phi = 30^0$.
25. Acceleration is invariant under Galilean transformation.

IV Answer briefly:

26. State the postulates of special theory of relativity.

27. What is rest mass of a particle?

28. Define proper length.

29. State Heisenberg uncertainty principle.

30. Give the operator representations of momentum.

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SECTION – B

ANSWER ANY FIVE QUESTIONS: (5 x 5 = 25)

1. Calculate the K.E of an electron moving with a velocity of 0.98C.
2. State the fundamental postulates of quantum mechanics.
3. Derive expression for group velocity and obtain the relation between group velocity and phase velocity.
4. 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.
5. Derive Schrödinger's time dependent equation.
6. Explain the normalization and orthogonal process of wave function. Also define the parity operator.
7. What is the length of the meter stick moving parallel to its length when its mass is 3/2 of its rest mass?

SECTION – C

ANSWER ANY THREE QUESTIONS: (3 X 15 = 45)

8. (a) Calculate the de- Broglie wave length of an α – particle accelerated through a potential difference of 2000 volts.
   (b) Describe Davisson – Germer's experiment and discuss its Importance in relation to de-Broglie's hypothesis of matter Waves.

9. Solve the Schrodinger's equation for particle in a one dimensional box. Calculate its values of energy and normalised wave function. Also, indicate graphically the first three normalised wave functions for such a particle.

10. (a) Find the commutation relation between momentum and free particle Hamiltonian.
    (b) Find the commutation relation of L^2 with components of orbital angular momentum.

11. Describe the Michelson-Morley experiment and explain the physical significance of negative results.

12. Deduce the formula for relativistic variations of mass with velocity. Briefly explain it's significant.