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

SUBJECT CODE : 11PH/MC/QR64

B.Sc. DEGREE EXAMINATION APRIL 2014
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. The relation between the energy E of a photon and the frequency ν of the associated electromagnetic wave is E=
   (a) hν (b) hν/2 (c) h/w (d) None of these.

2. The wave associated with material particle is called
   (a) Sine wave (b) Square wave (c) Matter wave (d) Triangular wave

3. Expression for group velocity is
   (a) u = du/dv (b) u = dω/dk (c) v = dk/ dω (d) v = dv/du

4. The sum of reflectance and transmission must be equal to
   (a) E (b) V_0 (c) 1 (d) 0.5

5. The transmission coefficient T is
   (a) (A_3/ A_1) $(^{A^*}{}_3/ A^*_1)$ (b) (A_1/ A_2) $(^{A^*}{}_2/ A^*_1)$
   (c) (A_1/ A_2) $(^{A^*}{}_3/ A^*_2)$ (d) None of these.

6. The energy spectrum in an infinitely deep potential well is
   (a) standard (b) discrete (c) 1operator (d) zero

7. An operator which has no reciprocal is called a
   (a) singular operator (b) Non singular 1operator
   (c) Null operator (d) Identity operator.

8. Value of $[\mathbf{L_x}, \mathbf{L_y}]$ is
   (a) $i (h/2\pi)L_z$ (b) ihLz (c) –ihL (d) iħ

9. The value of $[\mathbf{x}, \mathbf{P_x}]$ is
   (a) 0 (b) 1 (c) -1 (d) iħ

10. Acceleration is invariant under
    (a) Galilean transformation (b) Lorentz transformation
    (c) special theory of relativity (d) general theory of relativity.

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11. Galilean transformation equations are
    (a) y'=x-vt, y'=y, z'=z, t'=t (b) x'=x-vt, y'=y, z'=z, t'=t
    (c) z'=y'-vt, y'=y, z'=z, t'=t (d) None of these.

12. Unaccelerated reference frames in uniform motion are called
    (a) dynamic frames (b) static frames
    (c) non-inertial frames (d) inertial frames

13. The mean life of π-mesons is
    (a) 3×10^{-5} sec. (b) 2×10^{-8} sec. (c) 2×10^{-5} sec. (d) 2.5×10^{-6} sec.

14. All clocks on the space ship will go slow by a factor
    (a) ½ $(1-v^2/c^2)^{1/2}$ (b) $(1-v^2/c^2)^{1/2}$ (c) $(1-v^2/c^2)^{-1/2}$ (d) v^2/c^2

15. The rest mass energy is
    (a) mc^2 (b) m_0c^2 (c) m_0c^4 (d) mc

II Fill in the blanks:

16. The phase velocity of a moving particle is = _____

17. For the particle in one dimensional box the number of nodes in the ground state is _____.

18. The expectation value for momentum of the particle is, $< P_x > =$ _____.

19. According to time dilation concept in relativity the clock in the moving rocket will appear to go _____ than the clock on the surface of the earth.

20. If the velocity of the body approaches velocity of light, then mass of the body, m = _____.

III State whether true or false:

21. According to complimentarity principle,the particle and wave aspects of matter or radiation are complimentarity and can be exhibited at the same time.

22. In stationary orbit, angular momentum of electron is an integral multiple of $h/2\pi$.

23. The value of $V_p.V_g = c^2$.

24. The concept of simultaneity has only a relative and not an absolute meaning.

25. In Michelson - Morley experiment, the negative result suggests that it is impossible to measure the speed of the Earth relative to the Ether.

26. The laws of physics are the same in all inertial frame of reference.

IV Give short answer:

27. Define phase velocity.

28. Write the potulates of special theory of relativity.

29. Explain eigen functions and eigen values.

30. What is non- inertial frame of reference?

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SECTION – B

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

1. State the fundamental postulates of quantum mechanics.
2. a) Obtain an expression for the de Broglie wavelength of an electron.
   b) Calculate the deBroglie wavelength of an elctron accelerated through a potential of 150 volts.
3. Find (a) $[\mathbf{x^n}, \mathbf{P_x}]$ and (b) $[\mathbf{L_x}, \mathbf{L_y}]$.
4. In the laboratory the life time of a particle is moving with a speed of $2.5 \times 10^{-6} s$. Calculate the proper lifetime of the particle.
5. An event occurs at $x = 100m, y = 5m, z = 1m$ and $t = 1 \times 10^{-4} sec$ in a frame S. Find the coordinates of the event in a frame S' which is moving with a velocity $2.7 \times 10^5\ m/s$ with respect to the frame along the $x - x'$ axis using Lorentz transformation.
6. The rest mass of a proton 2000 times the rest mass of an electron. Calculate the speed at which the electron should move so that its mass will be equal to the rest mass of the proton.
7. Explain the normalization and orthogonal processes of wave function. Also define parity operator?

SECTION – C

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

8. a) Explain with neat diagram Davisson and harmer experiment.
   b) Derive length contraction and time dilation in relativity.
9. Use Schrodinger's equation to calculate the eigen values and normalised eigen functions for a simple harmonic oscillator.
10. (a) Find the commutation relation between momentum and free particle Hamiltonian.
    (b) Find the commutation relation of $\mathbf{L^2}$ with the components of orbital angular momentum.

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11. Derive $E = mc^2$. Find the relation between total energy (E), rest energy ($E_{0)}$ and momentum of the particle (p).
12. Derive Lorentz transformation equations.