STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086.
(For candidates admitted during the academic year 2008-09)

SUBJECT CODE : PH/MC/QR64

B.Sc. DEGREE EXAMINATION APRIL 2011
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. Variation of mass with velocity
   a) $M = \frac{M_0}{\sqrt{1-\frac{v^2}{c^2}}}$ b) $M_1 = \sqrt{1-\frac{{v_1}^2}{c^2}}$ c) $M_2 = \sqrt{1-\frac{{v_2}^2}{c^2}}$
2. Einstein's mass energy equivalence
   a) $F = ma$ b) $E = m_0c^2$ c) $E = mc^2$
3. A normalized wave function
   a) $\int \psi\, \psi^* dV = 0$ b) $\int \psi\, dV = 0$ c) $\int \psi^* A(\psi) dV$
4. Relation between group velocity (V_g) and phase velocity or wave velocity (V_p) is
   a) $V_p = \frac{w}{k}$ b) $V_g = \frac{dw}{k}$ c) $V_g = V_p - \lambda \frac{dVp}{d\lambda}$
5. The Quantum mechanical operator for the total energy is $H = i\hbar \frac{\partial}{\partial t}$ _____ is
   a) time independent b) time dependent c) linear operator
6. De-Broglie wave length for accelerated electron is _____
   a) $½\, m_o v^2$ b) $\lambda = \frac{h}{\sqrt{2m_o v^2}}$ c) $\lambda = ev$
7. The uncertainty principle is _____
   a) $\Delta x . \Delta p \geq \frac{h}{4\pi}$ b) $\frac{\Delta x}{\Delta t} = \hbar$ c) $\frac{d\lambda}{dp} = \hbar$
8. Schrodinger's equation in terms of the Hamilton operator is _____
   a) $E = K + V$ b) $\frac{\hbar^2}{2m} \nabla^2$ c) $H\psi = E\psi$
9. The frequency of oscillation of the harmonic oscillator is given by
   a) $V = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$ b) $½\, mw^2$ c) $½\, mwx^2$

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10. The coordinate system chosen to describe motion is known as _____
    a) special theory of relativity b) Frame of reference c) Galilean transformation

11. Unaccelerated reference frames in uniform motion of translation, relative to one another are called _____.
    a) non-inertial frames b) inertial frames c) Newtonian relativity

12. Relationship between the total energy, rest energy and the momentum is
    a) $E^2 = {m_o}^2\, c^4 + p^2c^2$ b) $E = mc^2$ c) $m = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$

13. According to Bohr's theory the stable state of electrons in the atom are governed by _____.
    a) de-Broglic wave length b) integer rules c) Group velocity

14. The steady state form of Schrodinger's equation in three dimension is _____.
    a) $\frac{ih}{2\pi}\,\frac{\partial\psi}{\partial t}$ b) $\nabla^2\psi + \frac{8h^2m}{h^2}(E-V)\psi = 0$ c) $\frac{-ih}{2\pi}\; r \times \psi$

15. Angular momentum Quantum operator is _____
    a) $i\,\frac{h}{2\pi}\,\nabla$ b) $i\left(\frac{h}{2\pi}\right)\frac{\partial}{\partial t}$ c) $-i\,\frac{h}{2\pi}\; r \times \nabla$

II. FILL IN THE BLANKS:

16. Accelerated frames are called _____.
17. The time interval measured by a clock at rest relative to the observer is called _____.
18. Each wave function ψ_n consist of a polynomial $H_n(Y)$ called a _____.
19. A particle moving without any force acting on it is called _____.
20. The minimum value of the energy of the Harmonic oscillator corresponding to $n = 0$ is _____.

III. STATE WHETHER TRUE OR FALSE:

21. The velocity of light in free space is constant.
22. Each dynamical variable relating to the motion of a particle can be represented by a linear operator.
23. Angular momentum Quantum operator is $p^2(2m + E_p(r))$.
24. Schrodinger's time independent wave equation is $\nabla^2\psi + \frac{8\pi^2m}{h^2}\,(E-V)\psi = 0$.
25. Every physical observable is associated with a linear Hamilton operator.

IV. ANSWER THE FOLLOWING:

26. Postulates of special theory of relativity:-

27. Postulates of wave mechanics:-

28. What is meant by matter waves?

29. Explain Heisenberg's uncertainty principle.

30. Explain Max Born's interpretation of the wave function.

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SECTION – B

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

1. The equivalent wave length of a moving electron is $0.24 \times 10^{-10} m$ what voltage applied between two grids will bring it to rest.
2. Calculate the KE in eV of (i) an electron (ii) a neutron having a de-Broglie wave length of $I^o A$. What will be the corresponding wave of x-ray of wave length $I^o A$?
3. An atomic particle has a rest mass of 2.5×10^{-25} kg find its total mass energy when (a) at rest and (b) when it has a velocity of 0.9 the speed of light.
4. Calculate the rest energy of an electron in joules and in electron volts.
5. How fast would a rocket have to go relative to an observer for its length to be contracted to 99% of its length at rest?
6. Derive Hermitian operator?
7. What is the wave length that is associated with an electron?

SECTION – C

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

8. Describe the Michelson-Morley experiment and explain the physical significance of negative results.
9. What is the meaning of mass-energy equivalence? Obtain Einstein's mass energy relation, show that 1 amu = 931 Mev.
10. Discuss briefly the wave nature of matter and obtain an expression of de-Broglie wavelength for matter waves.
11. Calculate the values of the energy of a particle in a one dimensional box. Indicate graphically the first three wave functions four such a particle.
12. Establish Schrodinger's equation for a linear harmonic oscillator and solve it to obtain its eigen values and eigen functions.

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