

**B.Sc. DEGREE (C.B.C.S.S.) EXAMINATION, OCTOBER 2014****Fifth Semester****Core Course—CLASSICAL AND QUANTUM MECHANICS**

(Common for Model I and Model II B.Sc. Physics, B.Sc. Physics-EEM and B.Sc. Physics-Instrumentations)

Time : Three Hours

Maximum Weight : 25

**Part A***Answer all questions.**Objective type questions-weight 1 for each bunch.***BUNCH I**

Choose the most appropriate answer :

1. The generalized co-ordinates are :

- (a) Dependent. (b) Independent.  
(c) Spherical polar co-ordinates. (d) Definitely not Cartesian co-ordinates.

2. The areal velocity of a planet in terms of angular momentum  $L$  and reduced mass  $\mu$  It is given by :

- (a)  $\frac{L}{\mu}$ . (b)  $\frac{L}{2\mu}$ .  
(c)  $\frac{2L}{\mu}$ . (d)  $\sqrt{2\mu L}$ .

3. The duration of radar pulse is  $10^{-6}$  s, the uncertainty in energy would be :

- (a)  $6.62 \times 10^{-19}$  J. (b) 0.  
(c)  $10^{-35}$  J. (d)  $10^{-28}$  J.

4. The normalized Eigenfunction of a particle in a one dimensional box of length  $L$  is :

- (a)  $\sqrt{\frac{L}{2}} \sin\left(\frac{n\pi x}{L}\right)$ . (b)  $\frac{2}{L} \sin\left(\frac{n\pi x}{L}\right)$ .  
(c)  $\sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right)$ . (d)  $\frac{L}{2} \sin\left(\frac{n\pi x}{L}\right)$ .

**Turn over**

## BUNCH II

Choose the most appropriate answer :

5. A non- holonomic constraint may be expressed in the form of :
  - (a) Equality.
  - (b) Inequality.
  - (c) Vector.
  - (d) None of these.
6. Davisson and Germer experiment relates :
  - (a) Interference.
  - (b) Polarization.
  - (c) Electron Diffraction.
  - (d) Phosphorescence.
7. The de- Broglie wavelength of material particles which are in thermal equilibrium at temperature T is :
  - (a)  $\frac{h}{\sqrt{2mkT}}$
  - (b)  $\frac{h}{\sqrt{mkT}}$
  - (c)  $\frac{h}{\sqrt{mkT}}$
  - (d)  $\frac{h}{\sqrt{2kT}}$

8. The wave function of a certain particle is  $\psi = A \cos^2 x$  for  $-\frac{\pi}{2}$  to  $\frac{\pi}{2}$ . Then the value of A is :

- (a)  $\sqrt{\frac{8}{3\pi}}$
- (b)  $\sqrt{\frac{3}{8\pi}}$
- (c)  $\sqrt{\frac{1}{2\pi}}$
- (d)  $\sqrt{\frac{3}{2\pi}}$

## BUNCH III

Fill in the blanks :

9. For orbits under inverse square law of force, the effective potential energy is \_\_\_\_\_.
10. The first excitation potential of a given atom is 10.2 volts. Its ionization potential would be \_\_\_\_\_.
11. The expectation value of momentum of a particle whose wave function is  $\psi(x) = Ne^{-\frac{x^2}{2a^2} + ikx}$  is \_\_\_\_\_.
12. The value of  $[L_z, L_-] =$  \_\_\_\_\_.

## BUNCH IV

Fill in the blanks :

13. If a co-ordinate corresponding to displacement is cyclic, \_\_\_\_\_ is conserved.
14. The zero point energy of harmonic oscillator is \_\_\_\_\_.
15. Electrons are emitted from a metal surface when light falling on it has a minimum \_\_\_\_\_.
16. The explicit expression for the operator  $\left(\frac{d}{dx} + x\right)^2$  is \_\_\_\_\_.

(4 × 1 = 4)

## Part B

*Answer any five questions.  
Short Answer Questions. Weight 1 each.*

17. What are constraints ?
18. Explain D' Alembert's principle.
19. Why do we say that Compton Effect can not be explained by Classical physics ?
20. Derive the one dimensional form of the Schrodinger equation for a free particle of mass m.
21. Explain degeneracy.
22. Obtain the Eigenvalues of the operators  $L^2$  and  $L_x$ .
23. Write a note on the physical interpretation of probability current density.
24. What do you mean by expectation values ?

(5 × 1 = 5)

## Part C

*Answer any four questions.  
Short Essays/ Problems- Weight 2 each.*

25. Set up the Lagrangian for a simple pendulum and hence obtain the equation describing its motion.
26. The operator  $\left(x + \frac{d}{dx}\right)$  has the Eigenvalue  $\alpha$ . Derive the corresponding Eigenfunction.
27. Show that the size of the hydrogen atom is a direct consequence of the uncertainty principle.
28. Find the energy of an X-ray photon which can impart a maximum energy of 50keV to an electron.

Turn over



29. Find the phase and group velocities of the de Broglie waves of an electron whose speed is  $0.9c$ .
30. A monochromatic X-ray of wavelength  $55.8\text{pm}$  is scattered through  $46^\circ$ . Find the wavelength of the scattered beam.

(4 × 2 = 8)

#### Part D

Answer any **two** questions.

*Essays-Weight 4 each.*

31. Formulate Hamilton's least action principle. Derive Lagrange's equation from Hamilton's principle.
32. What is photoelectric effect? Describe the laws of photoelectric effect. Give the quantum mechanical explanation of photoelectric effect and hence obtain the Einstein's equation for it.
33. Set up the Schrödinger equation for a one dimensional harmonic oscillator. Solve the equation and hence find the energy Eigenvalues of the oscillator.

(2 × 4 = 8)