Reg. No………………………………………….. Name…………………………………………… **20U507**

B.Sc. DEGREE END SEMESTER EXAMINATION OCT. 2020: JANUARY 2021

SEMESTER – 5: PHYSICS (CORE COURSE)

COURSE: 15U5CRPHY05: CLASSICAL AND QUANTUM MECHANICS

(Common for Regular 2018/Improvement 2017 / Supplementary 2017/2016/2015 admissions)

Time: Three Hours Max. Marks: 60

PART A (Very short answer questions)

Answer all questions Each question carries 1 Mark

1. A simple pendulum with a rigid support is an example of a ……………….. system.
   (a) non-conservative (b) unilateral (c) rheonomic (d) scleronomic
2. The dimension of Lagrangian is that of ……………………
   (a) time (b) momentum (c) angular momentum (d) energy
3. The curve joining two points along which a particle falling from rest under the influence of gravity reaches the lower point in least time is a ………………
   (a) straight line (b) parabola (c) ellipse (d) cycloid
4. Wien's law matches with Planck's law at …………………
   (a) low wavelengths (b) high wavelengths (c) all wavelengths (d) none of these
5. Compton effect confirms the localization of …………….
   (a) momentum of photon (b) momentum of electron (c) position of photon (d) momentum of Electron
6. For two commuting operators *A* and *B*, which of the following statement is true?
   (a) $AB\psi = BA\psi$ (b) $[A,B] \neq 0$ (c) $AB\psi = -BA\psi$ (d) $[A,B] = -1$
7. For a Hermitian operator, the eigenvalues are ……………….
   (a) infinite (b) real (c) zero (d) complex
8. The quantum mechanical operator for energy is
   (a) $-i\hbar\frac{\partial}{\partial x}$ (b) $i\hbar\frac{\partial}{\partial x}$ (c) $-i\hbar\frac{\partial}{\partial t}$ (d) $i\hbar\frac{\partial}{\partial t}$
9. For a stationary state ……………………
   (a) ψ is independent of time (b) $|\psi|^2$ is independent of time (c) ψ depends on time
   (d) $|\psi|^2$ depends on time
10. For a rigid rotator, the eigenfunctions are ……………………
   (a) Hermite polynomials (b) Hankel polynomials (c) spherical harmonics (d) Bessel functions

(1 x 1 0 = 10)

PART B (Short answer)

Answer any Seven questions. Each question carries 2 Marks

11. Explain the terms generalized co-ordinates and the generalized momenta. How are they related?
12. Discuss the principle of virtual work.
13. Write down the law of conservation of Hamiltonian.
14. Give Planck's radiation law.
15. Write down Einstein's photoelectric equation and explain the terms used.
16. Discuss the probability interpretation of wave function.
17. What do you mean by the terms phase velocity and group velocity? Give expressions for the same.
18. What are orthogonal eigenfunctions? What is the nature of the corresponding eigenvalues?
19. Write down the expression for the energy levels of a harmonic oscillator and explain the terms involved. (2 x 7 = 14)

PART C (Problem/Derivations)

Answer any Four question. Each question carries 4 Marks

20. What do you mean by a cyclic co-ordinate? Show that the Lagrangian in central force problem is cyclic in the angular co-ordinate.
21. Obtain the equation of motion of a one dimensional harmonic oscillator using Hamiltonian formalism.
22. Determine the de Broglie wavelength of an electron accelerated through a potential difference of 100 V.
23. The average period that elapses between the excitation of an atom and the time it emits radiation is 10^{-10} s. Determine the width of the excited state.
24. Obtain the expectation value of the momentum of a particle enclosed in a one-dimensional box.
25. What do you mean by a rigid rotator? Give an expression for its energy eigen values and explain the terms used. (4 x 4 = 16)

PART D (Long answer questions)

Answer any 2 question. Each question carries 10 Marks

26. What is Hamilton's principle? Obtain Lagrange's equations from Hamilton's principle for a system in which the Lagrangian is not an explicit function of time.
27. Derive the least action principle for a conservative system.
28. Setup the time dependent Schrödinger equation for a free particle.
29. Show that the square of angular momentum operator commutes with any of its components and any two of the angular momentum components are non-commuting. What are the eigen functions and eigen values of L^2 and L_z? (10 x 2 = 20)