PAP-003-1015025 Seat No. ________

B. Sc. (Sem. V) (CBCS) Examination

October / November – 2018

Physics-501 : Mathematical Physics, Classical Mechanics & Quantum Mechanics

(New Course)

Faculty Code : 003
Subject Code : 1015025

Time : $2\frac{1}{2}$ Hours] [Total Marks : **70**

Instructions :

(1) All questions are compulsory.
(2) Symbols have their usual meanings.
(3) Figures to the right indicate marks.

1 (a) Answer the following objective questions : **4**

1. The Kronecker delta function, $\delta_{mn} =$ ----- when $m = n$ and $\delta_{mn} =$ ----- when $m \neq n$.
2. The Dirac delta function $\delta(x-a) =$ ----for $x \neq a$ and $\delta(x-a) =$ ------ for $x = a$.
3. Cosine series is applicable for even functions. True or False.
4. Write the value b_n for an odd function (sine series.)

(b) Answer any one question : **2**

1. Explain $f(x) = x$, between limit-π to π.
2. Explain $f(x) = 0$, for $-\pi \leq x \leq 0$ and $f(x) = 1$, for $0 \leq x \leq \pi$.

(c) Answer any one question : **3**

1. Explain Fourier integral.
2. Explain the action of a full wave rectifier based on Fourier analysis.

(d) Answer any one in detail : **5**

1, What is Fourier series ? Derive Fourier coefficients.
2. Define Dirac delta function in one dimension and explain its representations.

2 (a) Answer the following objective questions : **4**

1. Write the equation of D' Alembert's principle.
2. Write the Lagrange's equation of motion in terms of generalized coordinates.
3. The product $Q_j \delta q_j$ must have the dimension of _______.
4. Write the expression of generalized displacement.

(b) Answer any one equation : **2**

1. For a compound pendulum, kinetic energy $T = \frac{1}{2} I \dot{\theta}^2$ and potential energy V = -mglcosθ. Find the Lagrange's equation of motion.
2. The kinetic energy and potential energy of a simple harmonic oscillator are $T = \frac{1}{2} m y^2$ and $V = \frac{1}{2} m \omega^2 y^2$. Find the Lagrange's equation of motion.

(c) Answer any one question : **3**

1. Explain D' Alembert's principle.
2. Obtain the equation of simple pendulum using Lagrange's equations.

(d) Answer any one in detail : **5**

1. Derive Hamilton's principle from D' Alembert's principle.
2. Deduce Newton's second law of motion from Hamilton's principle.

3 (a) Answer the following objective questions : **4**

1. In a conservative system,. the potential energy is only position dependent. True or False.
2. The specification of a point on the path in phase space provides ______ number of initial values.
3. If $\frac{\partial L}{\partial q_j} = 0$, then q_j is referred to as ______.
4. A rigid body capable of oscillating in a vertical plane above a fixed horizontal axis is known as a ________ pendulum.

(b) Answer any one question : **2**

1. Find the Hamiltonian for the Lagrangian

$$L(x,\dot{x}) = \frac{\dot{x}^2}{2} - \frac{\omega^2 x^2}{2} - ax^3 + \beta x\dot{x}^2.$$

2. Lagrangian of the system is

$L = \frac{1}{2}m(\dot{x}^2 + \dot{y}^2) - \frac{1}{2}k(x^2 + y^2)$. Calculate p_x and p_y.

(c) Answer any one question : **3**

1. Explain the advantages of Hamiltonian approach.
2. Obtain the Hamilton's equation for a linear harmonic oscillator.

(d) Answer any one in detail : **5**

1. Explain conservation of angular momentum using Hamiltonian formulation.
2. Derive the Hamilton's Canonical equations of motion.

4 (a) Answer the following objective questions : **4**

1. $[x, p_x] =$ ------
2. Write the one dimensional operator correspondence of energy and momentum.
3. Emission of electrons from a metal surface when electromagnetic waves of suitable frequency falls on it is known as --------
4 $\int \psi^* \psi d\tau$ represents the probability of finding a particle in a given volume. True or False.

(b) Answer any one question : **2**

1. An electron of momentum 8×10^{-19} gm cm/sec is passed through a circular hole of radius 10^{-4} cm. What is the uncertainty introduced in the angle of emergence ? Take $\hbar = 10^{-27}$ erg sec.
2. A particle limited to the *x*-axis has the wave function $\psi = ax$, between x=0 and x=1; $\psi = 0$ elsewhere. What is the expectation value of the position $\langle x \rangle$ of the particle ?

(c) Answer any one question : **3**

1. Explain the wave nature of matter.
2. Explain Compton effect and its experimental arrangement.

(d) Answer any one question in detail : **5**

1. Derive the one dimensional Schrodinger equation and extend it to three dimensions.
2. Obtain the normalized wave function of a particle in a three dimensional box.

5 (a) Answer the following objective questions : **4**

1. The symbol of ket vector A is ------ and the symbol of bra vector of A is --------.
2. In quantum mechanics, $L_x = -i\hbar\left(y\frac{\partial}{\partial z} - z\frac{\partial}{\partial y}\right)$. True or False.
3. For a self adjoint operator, $\overline{\alpha} =$------
4. The equation $\frac{\partial^2 u}{dy^2} - 2y\frac{du}{dy} + (\lambda - 1)u = 0$ is known as ------- differential equation.

(b) Answer any one question : **2**

1. If $H = \frac{P^2}{2m} + \frac{1}{2}m\omega^2 x^2$ then, prove that $[x, H] = \frac{i\hbar P}{m}$.
2. If $H = \frac{P^2}{2m} + \frac{1}{2}m\omega^2 x^2$, find $[P, H]$.

(c) Answer any one question : **3**

1. Obtain the Schrodinger wave equation for an oscillator.
2. Obtain the equation for density operator.

(d) Answer any one question in detail : **5**

1. Find the solution of Hermite's differential equation.
2. Explain angular momentum operator and derive the expressions for L_x, L_y and L_z.