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H-003-001501 Seat No. ________

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

May / June – 2017

Physics : Paper - 501

(Mathematical Physics, Classical Mechanics & Quantum Mechanics)

Faculty Code : 003

Subject Code : 001501

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

Instructions : (1) All questions are compulsory.
(2) Symbols have their usual meaning.
(3) Figures on right side indicate full marks.

1 Answer in brief : **20**

(1) What are the transformation and inverse transformation equations ?

(2) What are the Lagrange's equations of motion for conservation as well as non-conservative forces?

(3) What is the kinetic energy in terms of generalized coordinates?

(4) What $\nabla . B = 0,$ suggests about B?

(5) A particle is moving under the action of gravity on the surface of a smooth sphere of radius a, what will be the equation of constraint?

(6) What are the Hamilton's equations of motion?

(7) For a system

$$H = \frac{1}{2m\sin^2\theta}\left(p_y^2 + \frac{p\theta^2}{l^2} - \frac{2p_y p\theta\cos\theta}{l}\right) + mgl(1-\cos\theta),$$

then $\dot{y} = ?$

(8) What are the Fourier coefficients of a series?

$$\frac{h}{2} + \frac{2h}{\pi}\left(\sin x + \frac{\sin 3x}{3} + \frac{\sin 5x}{5} + ...\right)?$$

(9) If $f(x)$ is an odd function in interval $(-\pi, \pi)$, then what will be the $a_0, a_n \; and \; b_n$?

(10) If the Fourier coefficient a_n is zero, then what will be the Fourier series?

(11) What is the Fourier coefficient b_n for a piecewise, monotonic and periodic function,

$$f(x) = \frac{\pi^2}{12} - \frac{\pi^2}{4} \; for -\pi < x < \pi \, ?$$

(12) What is the Fourier sine series ?

(13) What is the time dependent form of Schrodinger equation in three dimensions?

(14) The kinetic energy in terms of momentum is $E = \frac{p^2}{2m}$, What will be the kinetic energy operator?

(15) What is the property of a wave function having odd parity ?

(16) $< y \, p_y > = < x$ ______ $>$, fill up the blank.

(17) What is the quantum mechanical operator of angular momentum, L_x ?

(18) $\left[p, x^3 \right] = ?$

(19) An eigen function of the operator $\frac{d^2}{dx^2}$ $is \; \psi = e^{2x}$, what will be the corresponding Eigen value?

(20) What is the probability of a one dimensional particle in a square well potential nearer to wall but outsides?

2 (A) Answer any **three** of the following questions. **6**

(1) What is called cyclic coordinate?

(2) State Hamilton's principle.

(3) Obtain equation of motion of a simple pendulum using Lagrange's undetermined multipliers.

(4) What are the potential across each element of an LCR series circuit carrying current 1 ?

(5) The Lagrangian of a system is $L = \frac{1}{2}\left(x^2 + y^2 + z^2\right) -$ mgz, then for equation of constraint $x^2 + y^2 + z^2 = r^2$, , what will be the Lagrange's equation of motion in terms of y ?

(6) Lagrangian for a spherical pendulum is $L = \frac{1}{2} m r^2 \left(\theta^2 + \sin^2 \theta \varphi^2 \right) - mgl \cos \theta.$

Derive Lagrange's equation of motion in terms of θ.

(B) Answer any **three** of the following questions : **9**

(1) Find kinetic energy of a double pendulum.

(2) Discuss Rayleigh's dissipation function.

(3) Explain configuration space.

(4) Prove that the Lagrange's and Newton's equations are equivalent.

(5) Obtain Hamilton's equations of motion for a compound pendulum.

(6) Find Hamiltonian for the following Lagrangian,

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

(C) Answer any **two** of the following questions : **10**

(1) Obtain Lagrange's equations of motion for conservative as well as non-conservative forces.

(2) Explain velocity dependent potential of electromagnetic field.

(3) Derive Hamilton's principle from Newton's equation.

(4) Obtain Hamilton's equations of motion;

$$L\left(x, \dot{x}, \theta, \dot{\theta}\right) = \frac{1}{2} m \left(l^2 \dot{\theta}^2 - 2l\theta \dot{z} \sin \theta \right) + mgl \cos \theta + \frac{1}{2} z^2 + mgz.$$

(5) Find the Fourier series for the periodic function,

$$f(x) = -\pi, \ -\pi < x < 0,$$
$$= x, \ 0 < x < \pi.$$

3 (A) Answer any **three** of the following questions : **6**

(1) Obtain Fourier constant a_0 for the full wave rectifier.

(2) A particle limited to the $x-axis$ has the wave function $\psi = ax$ between $x = 0$ and $x = L; \psi = 0$ elsewhere, what will be the expectation value $< x >$ of the particle's position?

(3) Show that the product of two self adjoint operators is not necessarily self adjoint.

(4) Define Eigen function and Eigen value spectrum.

(5) Describe self adjointness.

(6) Define non-normalizable wave function.

(B) Answer any **three** of the following questions : **9**

(1) A square wave is defined as

$f(x) = 0, \quad for\ -\pi < x < 0$

$\quad = h, \quad for\ 0 < x < \pi$

Find Fourier coefficient b_n.

(2) A particle limited to the $x-axis$ has the wave function $\psi = ax$ between $x = 0$ and $x = 1; \psi = 0$ elsewhere, what will be the probability that the particle can be found between $x = 0.45$ and $x = 0.55$?

(3) Normalize the wave function.

$$\psi(x) = Ae^{ikx} \text{ over the region } -a \leq x \leq a$$

(4) Describe the general features of a particle in a square well potential.

(5) Prove that $i\hbar L_z = [L_x, L_y]$

(6) Show that $< p_x x > - < x, p_x > = -i\hbar$

(C) Answer any **two** of the following questions : **10**

(1) Expand the function $f(x) = x + x^2; -\pi < x < \pi,$ in a Fourier series.

(2) Obtain the Schrodinger equation for a free particle in one dimension.

(3) Explain even and odd parity of an Eigen function in case of a square well potential Explain penetration into classical forbidden region.

(4) Discuss the bound states of a square well potential and obtained admissible conditions of wave function.

(5) Discuss fundamental postulates of wave mechanics. Explain Dirac Delta Function.