B.Sc. 1st Semester (Honours) Examination, 2019 (CBCS)

Subject : Physics

Paper : CC-II

Time: 2 Hours **Full Marks: 40**

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

1. Answer *any five* questions from the following: 2×5=10

(a) A particle at rest is acted upon by a force $\vec{F} = \hat{\imath}\pi \sin 2\pi t$ Newton. Calculate the linear momentum of the particle after $t = 0{\cdot}5\ sec$.

(b) A particle is under the influence of a force $\vec{F}$ and has an instantaneous velocity $\vec{v}$. Show that $\frac{dT}{dt} = \vec{F} \cdot \vec{v}$, where T is kinetic energy.

(c) Show that Newton's second law remains invariant under Gallilean transformation.

(d) A mass of 0·1 kg moving with velocity $\left(4\hat{\imath} - 3\hat{\jmath} - 10\hat{k}\right)$cm/sec collides with a mass of 0·2kg moving with velocity $\left(-5\hat{\imath} + 6\hat{\jmath} - 4\hat{k}\right) m/sec$ and they attain velocity $\left(3\hat{\imath} - 4\hat{\jmath} - 5\hat{k}\right) m/sec$ and $\left(-4\hat{\imath} + 5\hat{\jmath} - 3\hat{k}\right) m/sec$ respectively. Is the collision elastic?

(e) Derive Newton's law of gravitation from Kepler's laws of planetary motion.

(f) Two mutually perpendicular simple harmonic motions are represented by $x = 4\sin\omega t$ and $y = 3\cos\omega t$. Find the semi-major and semi-minor axes of an ellipse formed by their superposition.

(g) A muon decays with a half-life T when it is at rest. Find the velocity of muon, which is decaying with a half-life $5T$ in the laboratory.

(h) Bulk modulus of a liquid is $3 \times 10^5 N/m^2$. How much pressure needed to compress the sample of liquid by 0·2%.

2. Answer *any two* questions from the following: 5×2=10

(a) As a raindrop falls due to gravity, it increases its mass through deposition of vapour on its surface. Assume the raindrop maintains a spherical shape throughout and the rate of increase of its mass is proportional to the instantaneous surface area. Neglecting air resistance,

(i) Prove that rate of increase of radius is constant (k).

(ii) Find its velocity as function of time.

(iii) Calculate acceleration assuming it started from point mass. 2+2+1=5

(b) (i) "Two streamlines can't intersect"—Justify.

(ii) Establish the relation $Y = k(1 - 2\sigma)$ where symbols have their usual significance.

(iii) State the assumptions required deriving Poissellie's formula for the flow of a liquid through a narrow horizontal tube. 2+2+1=5

(c) (i) What is physical significance of logarithmic decrement of a damped oscillatory system?

(ii) A particle of mass m moves along the x-axis and is attracted toward a fixed point O on it by a force proportional to the distance O. Initially the particle is at distance x_a from O and is given a velocity v_0 away from O. Determine the position at any time, the velocity at any time and the frequency. 1+(2+1+1)=5

(d) (i) A particle is thrown vertically upward with velocity v_0 at a place of latitude λ. Show that it will land at a distance, $\frac{4\omega v_0^3}{3g^2} cos\lambda$ westward from the original.

(ii) Express the velocity component in a spherical coordinate system. 3+2=5

3. Answer *any two* questions from the following: 10×2=10

(a) (i) Prove that impulse of a force is equal to change in momentum.

(ii) Find the centre of mass of a solid hemisphere.

(iii) A particle of mass m moves along x-axis under the influence of a conservative force field having a potential $V(x)$. If the particle is located at positions x_1 and x_2 at respective times t_1 and t_2 and E is the total energy, prove that

$$t_2 - t_1 = \sqrt{\frac{m}{2}} \int_{x_1}^{x_2} \frac{dx}{\sqrt{E - V(x)}}.$$

(iv) A body of mass m in rest splits into two masses m_1 and m_2. After splitting the bodies move with a total kinetic energy T, in the opposite direction. Show that their relative speed can be written as $\sqrt{\frac{2Tm}{m_1 m_2}}$. 2+2+3+3=10

(b) (i) A torque of $1Nm$ is applied to a wheel of mass 10 kg and radius of gyration 0·5 m. What is the resulting acceleration?

(ii) For rotational motion of rigid bodies, derive an expression for the kinetic energy in terms of moment of inertia and angular velocity.

(iii) Find the moment of inertia of two masses m and M about an axis passing through centre of mass and perpendicular to the line joining between them. (Take the distance between m and M as d.)

(iv) Using conservation of energy principle, show that angular speed of a simple pendulum is $\dot{\theta} = \left[\frac{2}{ml^2}\{E - mgl(1 - \cos\theta)\}\right]^{1/2}$, where the symbols have their usual significance. 2+2+3+3=10

(c) (i) The kinetic energy of an electron is 0·10 MeV. Find the speed of the electron according to classical and relativistic mechanics.

(ii) Two photons approach each other. What is their relative velocity?

(iii) Two events occur at the same place and at an interval 4 sec in an inertial frame. In an another inertial frame S' the same events appear to occur at an interval of 6 sec. Find the spatial separation of these events in S'.

(iv) Explain the null result of Michelson-Morley experiment by Lorentz length contraction hypothesis. 2+2+3+3=10

(d) (i) In a double star, the two stars (masses m and 2m) distance d apart, rotate about their common centre of mass. Deduce an expression for the period of rotation. Show that the ratio of their angular momentum about the centre of mass is the same as the ratio of their kinetic energies.

(ii) Find the force of attraction of a solid uniform sphere (mass M) on a mass m placed inside it.

(iii) Writing $r = \frac{1}{u}$, show that the conservation of energy equation becomes $\left(\frac{du}{d\theta}\right)^2 + u^2 = -\frac{2(E-V)}{mh^2}$.

Hence show that $\frac{d^2u}{d\theta^2} + u = -\frac{f(Y_u)}{mh^2u^2}$, where the symbols have their usual significance.

(1½+1½)+3+(2+2)=10