B.Sc. 1st Semester (Honours) Examination, 2017 (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* of the following: 2×5=10

(a) Two circular metal discs have the same mass M and same thickness t. Disc 1 has a uniform density ρ_1 which is less than the uniform density ρ_2 of disc 2. Which disc has larger moment of inertia? Justify your answer.

(b) A particle of mass m moves on a path given by the equation, $\vec{r} = a\cos\omega t\,\hat{\imath} + b\sin\omega t\,\hat{\jmath}$. Calculate the torque about the origin.

(c) Two satellites A & B of same mass are orbiting the earth at altitudes R and 3R respectively where R is the radius of the earth. Taking their orbits to be circular, obtain the ratio of their kinetic energies.

(d) A rocket of mass 1000kg is ready for vertical take-off. The exhaust velocity of its fuel is 4·5 km/s. Find the minimum rate of its fuel ejection so that the rocket weight is just balanced.

(e) Two bodies of masses 2kg and 10kg have their position vectors $(3\hat{\imath} + 2\hat{\jmath} - \hat{k})$ and $(\hat{\imath} - \hat{\jmath} + 3\hat{k})$ respectively. Find the position vector and distance of centre of mass from the origin.

(f) Show that the strain energy of a twisted wire is $\frac{1}{2}\,C_m\,\theta_m$ where C_m is the couple for maximum twist θ_m.

(g) A spaceship is 50m long on the ground. When it is in flight, its length appears to be 49m to an observer on the ground. Find the speed of the spaceship.

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

2. Answer *any two* questions: 5×2=10

(a) Establish the relations connecting Young's modulus, Bulk modulus, Rigidity modulus and Poisson's ratio of a material. 5

(b) (i) Find the expression for the moment of inertia of a rectangular lamina about an axis perpendicular to its plane and passing through its centre of gravity.

(ii) A solid sphere of mass 0.1kg and radius 0.025m rolls down without slipping with a uniform velocity of 0.1m s^{-1} along a straight line on a horizontal table. Calculate its total energy. 3+2=5

(c) (i) If two capillaries of radii r_1 and r_2 and lengths l_1 and l_2 are joined in series, derive an expression for the rate of flow of the liquid through the arrangement using Poiseuille's formula.

(ii) What do you mean by Reynold's number? Explain its significance. 3+2=5

(d) (i) Find the intensity of gravitational field due to a thin spherical shell at points external to the shell and inside the shell.

(ii) If the mass of sun is 2×10^{30}kg, distance of sun from the earth is $1{\cdot}5 \times 10^{11}$km and period of revolution of earth around the sun is 365·3 days, then find the value of gravitational constant G. (2+1)+2=5

3. Answer *any two* of the following: 10×2=20

(a) (i) A reference frame 'A' rotates with respect to another reference frame 'B' with an angular velocity $\vec{\omega}$. If the position, velocity and acceleration of a particle in frame 'A' are represented by $\vec{r}, \vec{v}_A$ and $\vec{a}_A$ respectively, then show that the acceleration of the particle in frame 'B' is given by, $\vec{a}_B = \vec{a}_A + 2(\vec{\omega} \times \vec{v}_A) + \vec{\omega} \times (\vec{\omega} \times \vec{r}) + \frac{d\vec{\omega}}{dt} \times \vec{r}$. Identify the coriolis and centrifugal accelerations in the above equation.

(ii) Show that the distance between two points is invariant under Galilean transformation. 8+2=10

(b) (i) Show by means of substitution $r = \frac{1}{u}$ that the differential equation for the path of the particle in a central force field is given by $\frac{d^2u}{d\theta^2} + u = -\frac{f\left(\frac{1}{u}\right)}{mh^2u^2}$, where $r^2\theta = h$ and other symbols have their usual meaning.

(ii) Show that the square of time period of revolution of a planet is proportional to the cube of the semi-major axis of the elliptic orbit. 4+6=10

(c) (i) State the fundamental postulates of the Special Theory of relativity.

(ii) Prove that four dimensional volume element $(dx\, dy\, dz\, dt)$ is invariant under Lorentz transformation.

(iii) A clock keeps correct time on earth. It is put on a spaceship moving uniformly with a speed of $1 \times 10^8 \text{ms}^{-1}$. How many hours does it appear to lose per day? 2+4+4=10

(d) (i) What is sharpness of resonance? What factors govern the sharpness of resonance?

(ii) Show that the energy of vibrations of a damped harmonic oscillator decreases exponentially with time.

(iii) A damped oscillator consists of a mass 200gm attached to a spring of spring constant 100Nm^{-1} and damping constant $5\text{Nm}^{-1}\text{s}$. It is driven by a force $F = 6\cos\omega t\ N$, where $\omega = 30\ s^{-1}$. If the displacement in steady state is given by $x = A\sin(\omega t - \phi)$meter, find A and ϕ. Also calculate the power supplied to oscillator. 2+4+4=10
