WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 1st Semester Examination, 2022-23

PHSACOR02T-PHYSICS (CC2)

MECHANICS

Time Allotted: 2 Hours | Full Marks: 40

The figures in the margin indicate full marks.
Candidates should answer in their own words and adhere to the word limit as practicable.
All symbols are of usual significance.

Question No. 1 is compulsory and answer any *two* from the rest

1. Answer any ***ten*** questions from the following: $2\times10 = 20$

(a) What is geostationary satellite? What is its time period of revolution?

(b) A solid sphere and a solid cylinder having same mass and same radii roll down an inclined plane without slipping. Show that the sphere will reach the bottom first.

(c) Show that theoretically Poisson's ratio lies between -1 and 0.5.

(d) Show that Lorentz transformation leads to Galilean transformation when the relative velocity (v) is much less than the velocity of light (c).

(e) Prove that the force field,
$\vec{F} = (yz - y)\hat{i} + (xz - x - 1)\hat{j} + (xy - 2z)\hat{k}$ is conservative.

(f) Prove that Kepler's first and second laws lead to the conservation of angular momentum.

(g) What is Coriolis force? Write down an expression for this force in terms of the angular velocity of the rotating frame of reference.

(h) What do you understand by the terms "proper length of a body" and "proper time"?

(i) What do you understand by Quality factor (Q)? Give brief explanation.

(j) A bar pendulum oscillates about a point 15 cm away from its C.G., with a period of 1 sec. Calculate the distance between the C.G. and centre of oscillation.

(k) A particle moves along the curve $r = ae^{\theta}$ with constant angular velocity. Show that the radial acceleration is zero and the cross-radial acceleration varies with its distance from the origin.

(l) Using Newton's law of gravity, determine the dimension of the universal Gravitational constant.

(m) Calculate the angular momentum $\vec{L}$ of a rigid body spinning steadily about a fixed axis with angular velocity $\vec{\omega}$. Are the directions of $\vec{\omega}$ and $\vec{L}$ necessarily the same? Explain.

(n) A flat plate of area $2\times10^{-2}\,m^2$ is separated from a large flat surface by a film of oil of uniform thickness 1.5×10^{-3} m and viscosity $2\,N\text{-}s/m^2$. Determine the force required to slide the plate over the surface at a velocity of 4.5×10^{-2} m/s.

2. (a) Derive the continuity equation for fluid motion, clearly describing the notations used. 4

(b) Establish the expression for the internal bending moment of a beam. 3

(c) A metal rod of length L and cross-section α suffers a small longitudinal strain and is streched by l in length. Show that the potential energy stored in the rod due to this strain is $\frac{Y\alpha l^2}{2L}$, where Y is the Young's modulus of the material. 3

3. (a) Show that the differential equation of motion of a particle of mass 'm' under the influence of a central force $F(r)$ can be written as 4

$$\frac{d^2u}{d\theta^2}+u=-\frac{m}{L^2u^2}F\left(\frac{1}{u}\right),$$

where L is the angular momentum and $u=\frac{1}{r}$, r and θ being the polar coordinates.

(b) Show that under a central force, the total energy of the system remains constant. 3

(c) Two balls of masses m and $3m$ moving with velocities of equal magnitude but opposite direction undergo linear elastic collision. Find the final velocities of the two balls. 3

4. (a) Prove that the total angular momentum of a system of particles about any point is the sum of the angular momentum of the total mass assumed to be located at the centre of mass and the total angular momentum of the system about the centre of mass. 4

(b) Solve the equation of motion of a simple harmonic oscillator subject to the following forces: 3

(i) a damping force which is proportional to velocity and

(ii) an external sinusoidal force.

(c) Show that the self gravitational potential energy of an uniform sphere of mass M and radius R is $-\frac{3}{5}\frac{GM^2}{R}$. 3

5. (a) State the postulates of Galilean relativity and special relativity. 3

(b) Two reference frames S_1 and S_2 are moving with a uniform velocity 'v' relative to each other. If 'u_1' and 'u_2' are velocities of a body in the two frames respectively, then using Lorentz transformation equations, show that, 4

$$u_1=\frac{u_2+v}{1+\frac{u_2v}{c^2}},$$

where 'c' is the velocity of light.

(c) Quality Factor for a damped oscillator is 10^3. Its frequency is 512 Hz. Find the time taken for its energy to get reduced to $1/e$ of its energy in the absence of damping. 3

How many oscillations are executed during this time?

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