WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 1st Semester Examination, 2021-22

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.
Answers must be precise and to the point to earn credit.
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: 2×10 = 20

(a) Show that Newton's 2nd law is invariant under Galilean transformation.

(b) An object of mass m slides on the surface of a block, whose coefficient of friction is μ. Initially, the speed of the block is v_0 and it comes to rest after travelling a distance x_0. Find the value of μ.

(c) Determine whether the force field,

$$\vec{F} = (y^2 z^3 - 6xz^2)\hat{i} + (2xyz^3)\hat{j} + (3xy^2z^2 - 6x^2z)\hat{k}$$

is "conservative" or not.

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

(e) Find the moment of inertia of a solid circular cylinder of radius a, height h and mass M, about an axis passing through the center of the cylinder and parallel to its height.

(f) Show that the areal velocity of a particle moving under central force is constant.

(g) State Kepler's law of planetary motion.

(h) What is Reynolds number? What is the significance of it?

(i) A plate of area 200 cm^2 rests on a layer of castor oil 1 mm thick. The coefficient of viscosity of castor oil is 15.5 poise. Calculate the force required to move the plate horizontally with a speed of 4 cm/sec.

(j) A rod of circular cross-section of length l and radius r is stretched such that the volume of the rod is not changed. Show that Poisson's ratio is $\frac{1}{2}$.

(k) The potential energy of a particle is $V = 3x^4 - 8x^3 - 6x^2 + 24x$. Find the points of stable and unstable equilibrium.

(l) What do you understand by Quality factor? What is its importance?

(m) What is the 'apparent mass' of an object with 1 kg rest mass when it has been accelerated to 92.9% of light's speed. Speed of light, $c = 3 \times 10^8$ m/sec. Give your answer in kg.

(n) A particle of mass 100 gm is placed in a field of potential $U = 5x^2 + 10$ ergs/gm. Find the frequency of small oscillations.

2. (a) A body is thrown at an angle with the horizontal. Prove that the mechanical energy is conserved at every point of its motion.   3

(b) Write the general conditions for equilibrium of a system. What do you mean by stable and unstable equilibrium?   3

(c) An upward force $F = 196$ Newton is applied on a body of mass 10 kg till it is raised vertically upwards by a distance of 10 meters. Here the work done by F is much greater than the gain in gravitational potential energy. Show that the law of conservation of energy is satisfied here $(g = 9.8 \text{ m/s}^2)$.   3

(d) Define the centre of mass of a body.   1

3. (a) Show that the torsional rigidity of a hollow cylinder of outer and inner radii r_1 and r_2 respectively is given by $\dfrac{n\pi(r_1^4 - r_2^4)}{2l}$, where l is the length of the cylinder and n is the modulus of rigidity of the material.   4

(b) Show that for a body undergoing combined rotational and translational motion, the total angular momentum can be written as, $\vec{L} = \vec{L}_{CM} + M(\vec{r}_0 \times \vec{v}_0)$, where, $\vec{L}_{CM}$ is the angular momentum in the center of mass frame, $\vec{r}_0$ is position vector of the center of mass and $\vec{v}_0$ is the velocity of center of mass.   3

(c) Find the diameter of a gold wire which elongates by 1 mm when stretched by a force of 330 gm-wt and twists through 1 radian when equal and opposite torques of 145 dyne - cm are applied at its ends. Poisson's ratio for gold is 0.435.   3

4. (a) Derive Poiseuilles formula for the steady flow of an incompressible viscous liquid through a horizontal capillary tube of uniform cross section.   4

(b) An artificial satellite is moving in a circular orbit 600 km above the surface of a planet of radius 5.85×10^3 km. The period of revolution of the satellite around the planet is 3.5 hours. Determine the average mass density of the planet.   3

(c) Water flows through a horizontal tube of length 20 cm and internal radius of 0.081 cm under a constant head of the liquid 20 cm high. In 12 minutes 864 c.c. of liquid issue from the tube. Calculate the viscosity of water and verify that the conditions of streamline flow exist. Given $r = 1000$, ρ of water is 1 gm/cc and $g = 981$ cm/s^2.   3

5. (a) What is length contraction? Obtain the expression for the relativistic length contraction from Lorentz transformation equation. 3

   (b) Draw the potential energy curve for a simple pendulum with respect to angular position ' θ ', clearly indicating the positions of stable and unstable equilibrium. 2

   (c) What are non-inertial frames and fictitious forces? Is the centrifugal force a fictitious one? Explain. 3

   (d) State the postulates of special theory of relativity. 2

N.B. : *Students have to complete submission of their Answer Scripts through E-mail / Whatsapp to their own respective colleges on the same day / date of examination within 1 hour after end of exam. University / College authorities will not be held responsible for wrong submission (at in proper address). Students are strongly advised not to submit multiple copies of the same answer script.*

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