WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 1st Semester Examination, 2020, held in 2021

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: $2\times10 = 20$

   (a) A solid spherical ball rolls on a table. What fraction of its total kinetic energy is rotational?

   (b) What is the significance of "quality factor"?

   (c) A 5 kg stone is dropped on a nail and drives the nail 0.025 m into a piece of wood. If the stone is moving at 10 m/s, when it hits the nail, calculate the average force exerted by the stone on the nail.

   (d) A particle of mass m is moving in a circular path of radius r such that its centripetal acceleration a varies with time t as $a = k^2 r t^2$, where k is a constant. Calculate the power delivered to the particle by the forces acting on it.

   (e) A ball is dropped from a height h. When it bounces off the floor, its speed is 80% of what it was just before it hit the floor. Determine the height up to which the ball will now rise.

   (f) Find the ratio of the radii of gyration of two objects, one of which is a solid sphere and the other is a thin spherical shell, both having same mass and same radius.

   (g) A particle of unit mass undergoes one-dimensional motion such that its velocity varies according to $v(x) = \beta x^{-n}$, where β and n are constants, and x is the position of the particle. Obtain the acceleration of the particle as a function of x.

   (h) What is the difference between angle of twist and angle of shear?

   (i) What is a cantilever? What is its difference with an ordinary lever?

   (j) A satellite of mass m orbits a planet of mass M in a circular orbit of radius R. Find out the time required for one revolution of the satellite around the planet.

   (k) A wire of length L and radius r is elongated by applying a force. If the volume of the wire remains unchanged during the process, then determine the Poisson's ratio of the material of the wire.

   (l) What are the differences between "streamline" flow and "turbulent" flow of fluid?

   (m) Using Lorentz transformation relations express $(x^2 - c^2 t^2)$ in terms of transformed spacetime coordinates (x', t').

(n) A particle moves on the x-axis according to the equation $x = A + B\sin\omega t$. Show that this is a simple harmonic motion.

2. (a) In a nonrelativistic, one dimensional collision, a particle of mass $2m$ collides with a particle of mass m initially at rest. If the particles stick together after the collision, what fraction of the initial kinetic energy is lost in the collision?   3

(b) The smallest and the largest speeds of a satellite are given by v_{min} and v_{max} respectively. The time period is T. Show that the semi major axis of the elliptic orbit is given by $\dfrac{T}{2\pi}\sqrt{v_{min}\,v_{max}}$.   3

(c) A cylinder is released from rest from the top of an inclined plane of angle θ. If the cylinder rolls without slipping through a distance l, what will be its final speed?   4

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

(b) The potential of an object is given by $U(x) = 5x^2 - 4x^3$. Determine the positions where the object is in equilibrium and find the nature of the equilibria.   2+2

(c) If the speed of water in pipe with a diameter of 12 cm is 10 cm/s, what is the speed of water in a pipe with a diameter of 8 cm?   2

4. (a) State the postulates of Galilean relativity. State the postulates of special theory of relativity.   2+2

(b) Two inertial frames S and S' move with respect to each other with a constant speed $0.8c$ along the common y-axis. Write down the Lorentz transformation equations between the S and S' frames.   3

(c) Determine the theoretically admissible range of values of the Poisson's ratio.   3

5. (a) Determine the gravitational potential at a distance r from the centre, inside a homogeneous solid sphere of radius R and mass M.   4

(b) For a damped harmonic oscillator the equation of motion is given by   2+2+2

$$m\frac{d^2x}{dt^2} + \gamma\frac{dx}{dt} + kx = 0$$

Using the solution of the above equation, calculate

(i) The period of oscillation.

(ii) The number of oscillations in which its mechanical energy will drop to one-half of its initial value.

(iii) The quality factor.

Given that $m = 0.25\,\text{kg}$, $\gamma = 0.7\,\text{kg/s}$ and $k = 85\,\text{N/m}$.

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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