WEST BENGAL STATE UNIVERSITY

B.Sc. Honours 1st Semester Examination, 2018

PHSACOR02T-PHYSICS (CC2)

MECHANICS

Time Allotted: 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.
All symbols are of usual significance.

Answer Question No. 1 and any *two* from the rest

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

(a) Show that the total external force applied for a system of particles equals the rate of change of the system's momentum.

(b) A particle of mass m moves along the x-axis under the influence of a conservative force field having potential $V(x)$. If the particle is located at position x_1 and x_2 at respective times t_1 and t_2, prove that if E is the total energy, $t_2-t_1=\sqrt{\dfrac{m}{2}}\displaystyle\int_{x_1}^{x_2}\frac{dx}{\sqrt{E-V(x)}}$.

(c) Consider a particle of mass m moving in a potential $V(\theta)=2mg\cos\theta(L-l\cos\alpha)$, where $L,\ g,\ l,\ \alpha>0$ and $\theta<\dfrac{\pi}{2}$.

Find the condition of stable equilibrium.

(d) The moment of inertia of a circular disc about an axis perpendicular to its plane and passing through its center is $\dfrac{1}{2}Mr^2$, where M is mass of the disc and r is its radius. Show that the moment of inertia of the disc about an axis along any tangent to the circle is $\dfrac{5}{4}Mr^2$.

(e) Two bodies of masses M_1 and M_2 are placed with distance d apart. Show that at a point, where the gravitational field is zero, the potential is given by $V=-\dfrac{G}{d}\left(M_1+M_2+2\sqrt{M_1M_2}\right)$.

(f) Establish the relation $Y=K(1-2\sigma)$, where the symbols have their usual meaning.

(g) How does the coefficient of viscosity (η) of a liquid vary with temperature? Write down the dimension of η.

(h) Equation of a particle vibrating simple harmonically is $x = 10\sin\left(\omega t + \frac{\pi}{3}\right)m$.

What is the significance of $\frac{\pi}{3}$ occurring in the argument of sine?

(i) What is Reynold's number? Discuss its significance.

(j) If E_k, p and m_0 are the kinetic energy, momentum and rest mass respectively, of a relativistic particle, then show that $p = \frac{1}{C}(E_k^2 + 2m_0C^2E_k)^{1/2}$.

(k) Explain 'power-factor' using the expression for average power in case of a forced vibration. What is its value at resonance?

(l) Prove that when $v << c$, Lorentz transformations reduce to Galilean transformation.

(m) Can a reference frame attached to the earth be considered to be an inertial frame?

(n) The effective length of a simple pendulum is 'l' and its angular amplitude is θ_0. Find the velocity of the pendulum at its equilibrium position.

2. (a) What is the neutral layer? Establish the expression for the internal bending moment of a beam. 1+4

(b) At time t, the mass of a rocket moving under an external force $\vec{F}$ is M and its velocity is $\vec{v}$ with respect to certain reference frame. The fuel expulsion takes place at a constant velocity $\vec{u}$ relative to the rocket. Calculate the impulse $\vec{F}\Delta t$ and use it to show that $M\frac{d\vec{v}}{dt} + \vec{u}\frac{dM}{dt} = \vec{F}$. 3+2

Assuming a constant rate of change of mass, obtain the expression for $\vec{v}$ as a function of M from the above equation.

3. (a) Establish the equation of continuity for the flow of a fluid. 2

(b) A capillary tube of radius 'a' and length 'l' is fitted horizontally at the bottom of a cylindrical vessel of cross section 'A'. If initially the height is 'h_1' and liquid is allowed to flow, find the time required for the height to reduce to 'h_2'. (Assume the flow to be streamline). Mention any formula you have used. 3+1

(c) A particle follows an orbit given by $r = c\theta^2$ under an unknown force. Prove whether such an orbit is possible in a central field. If so, find the form of the force law. 4

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) Consider two uniform spherical concentric shells having masses M_1, M_2 and radii R_1, R_2 $(R_2 > R_1)$ respectively. Find the gravitational force on a particle of 3 mass m placed at a distance d from the centre when (i) $d > R_2$, (ii) $R_1 < d < R_2$ and (iii) $d < R_1$.

(c) The half-life of a radioactive particle is 4×10^{-8} sec when its speed is $0.8c$. If the speed of the particle is reduced by 25%, then what will be its half-life? 3

5. (a) The displacement of a particle of mass m subjected to an external periodic force $F_0e^{i\omega t}$, a restoring force proportional to displacement and resisting force proportional to its velocity is given by $y = y_1 + y_2$ 1+1+1+1

with $y_1 = Re^{-\frac{kt}{2}}\cos\left(\frac{\sqrt{4\omega_0^2 - k^2}}{2}t - \phi\right)$

and $y_2 = \dfrac{F_0}{m\sqrt{(\omega_0^2 - \omega^2)^2 + k^2\omega^2}}e^{i(\omega t - \phi)}$

(i) Explain physical meanings of y_1 and y_2.

(ii) What will be the expression for y after long time?

(iii) Name the physical phenomenon which will occur when $\omega = \omega_0$.

(b) Define coefficient of restitution. Two masses m_1 and m_2 travelling in the same straight line collide. Find the velocity of the particles after collision in terms of the velocities before collision. Hence show that kinetic energy is conserved for a perfectly elastic collision. 1+3+2

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