

109/Phs

UG/1st Sem./Phys(H)-CC-02-T/19

U.G. 1st Semester Examination - 2019

PHYSICS

[HONOURS]

Course Code : PHS(H)-CC-02-T
(Mechanics)

Full Marks : 40

Time : $2\frac{1}{2}$ Hours

1. Answer any **five** questions: $2 \times 5 = 10$

- a) Deduce the expression of critical velocity v_c by the method of dimension.
- b) For a particle moving under a central force field, show that torque about the force is zero.
- c) A uniform plate having the shape of a parabola $y=x^2$ and $y=h$ in x - y plane. Find centre of mass for the system.
- d) What is the physical significance of quality factor?
- e) Show that a shear is equivalent to an elongation strain and an equal compression strain at right angles to each other.

[Turn Over]

- f) Give the definition of modulus of decay of damped oscillatory motion. How it is related to damping co-efficient.
- g) Prove that the orbit of a particle moving under a centre force lies in a plane.
- h) Suppose a circle of radius 'b' is set in motion. Calculate the relativistic speed parameter $\beta(=v/c)$ such that the circle is seen as an ellipse of semi minor axis 'a' and semi major axes 'b', where $a < b$.

2. Answer any **two** questions: 5×2=10

- i) a) Prove that for a system of particles, the total angular momentum about any point in the sum of angular momentum about that point of the total mass located at its centre of mass and the angular momentum of the individual particles about the centre of mass. 3
- b) A particle of mass 'm' moves along the X-axis under the influence of conservative force field having potential $V(x)$. Show that for location x_1 and x_2 at t_1 and t_2 is given by

$$t_2 - t_1 = \sqrt{\frac{m}{2}} \int_{x_1}^{x_2} \frac{dx}{\sqrt{E - V(x)}} \quad 2$$

- ii) a) Prove that two successive Lorentz transformations are equivalent to a Lorentz transformation. Hence obtain Einstein's velocity addition formula.

3

- b) Prove the potential at a point on the circumference of a circular disc of uniform surface density of mass σ and radius 'a' is $-4G\sigma a$.

2

- iii) a) Establish the relation $E^2 = C^2 P^2 + m_0^2 C^4$ for a particle rest mass m_0 and momentum P .

2

- b) Two bodies of masses M_1 and M_2 are placed with distance 'd' apart show that a point, where the gravitational field is zero, the potential is given by

$$V = -\frac{G}{d} (M_1 + M_2 + 2\sqrt{M_1 M_2}). \quad 3$$

- iv) a) Two vessels of equal Cross Section 'a' are joined near their bases by a horizontal narrow tube of length 'l' and internal radius 'r'. Initially liquid surfaces are at height '3h' and 'h' respectively above the capillary tube. Calculate the time taken for the

difference in levels to become 'h'. If the co-efficient of viscosity ' η ' and density ' σ '. The flow is assumed to be slow. 3

- b) A spring stretches 0.03m when subjected to a force of 6N. A 0.5 kg mass is attached to the free end of the spring suspended vertically from a rigid support. The mass is given an initial displacement of 0.015m and initial velocity of 0.4m/s. Find the period and amplitude of the motion. 2

3. Answer any **two** questions: 10×2=20

- i) a) Define elastic and inelastic collision between particles. 2
- b) A particle of mass ' m_1 ' moving with velocity ' u ' undergoes head on elastic collision with another particle of mass $m_2 = km_1$ initially at rest. Show that after collision the kinetic energy transferred by ' m_2 ' is

$$\Delta E = \frac{1}{2} m_1 u^2 \frac{4k}{(1+k)^2}$$

where 'K' is constant. 4

- c) A particle of mass 'm' moves under the action of a central field of force. $\vec{F} = f(r)\hat{r}$. Establish the differential equation of the path of the particle. 4
- ii) a) Show that under Galelian transformation velocity is variant but accleration is invariant. 2
- b) A particle moves under influence of a force field $\vec{F} = a(\hat{i} \sin \omega t + \hat{j} \cos \omega t)$. If the particle be initially at rest, prove that at any instant of time, the work done on the particle is $\frac{a^2}{m\omega^2}(1 - \cos \omega t)$. 4
- c) A particle has potential energy $V = V_0(1 + \cos ax)$ where $a > 0$. Sketch 'V' as a function of x. Find the positions of stable equilibrium. If the particle is displaced slightly from its stable equilibrium. Show that particle executes simple harmonic motion. Find its angular frequency. 4

iii) a) Derive the formula for the flow of a liquid through capillary tube. Why does the formula fail in the case of a wide bore?

2

b) Define co-efficient of viscosity for a liquid. Describe how the co-efficient of viscosity is determined for water.

6

c) Show that the angular momentum of a rigid body can be expressed as

$$\vec{L} = \sum_i m_i [\omega r_i^2 - (\vec{r}_i \cdot \vec{\omega}) \cdot \vec{r}_i].$$

2

iv) a) Show graphically the variation of relativistic mass with velocity of a particle. A body of rest mass ' m_0 ' breaks up into two parts spontaneously with rest mass ' m_{01} ' and ' m_{02} ' with speed v_1 and v_2 respectively. Prove that $m_0 > m_{01} + m_{02}$.

1+3

b) Establish the relation connecting Y , K , η and σ and show that σ lies between 0.5 to -0.1.

3+1

- c) A circular solid cylinder of radius ' r ' and mass ' m ' is connected to a spring of spring constant ' k '. Determine the frequency of horizontal oscillations of the system, if the cylinder rolls on the surface without slipping neglect friction. 2
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