 B.Sc.-CBCS/IS/PHS/H/C2T/17

2017

PHYSICS

[Honours]

(CBCS)

PAPER – C2T

Full Marks : 40

Time : 2 hours

Answer **five** questions from Group—A **four** from Group—B and **one** from Group—C

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

GROUP – A

Answer any **five** questions : 2 × 5

1. Show that the central potential for the force $\vec{F} = kre^{c\theta}\hat{r}$ is spherically symmetric. 2

2. An observer sees two spaceships flying apart with speed 0·99c. Find the speed of one spaceship as viewed by the other. 2

3. A particle moves under a potential $V = ax - bx^2$, where a and b are positive constants. Find the equilibrium position of the particle. Determine whether the equilibrium is stable or unstable or neutral. 2

4. A planet is revolving around the sun in a circular orbit. Due to some reason the speed of the planet suddenly becomes double. What is the new orbit of the planet. 2

5. A rectangular bar is suspended horizontally from its centre of mass by a straight wire of circular cross section of radius a, length l and composed of an elastic material of rigidity modulus n. The bar executes angular oscillation in horizontal place about the wire as axis and moment of inertia of the bar about this axis is I. Find the expression of time period of this oscillation. 2

6. A fluid of viscosity η and density ρ flows through a capillary tube of radius a. Obtain the expression of critical velocity in terms of η, ρ and a by the method of dimensions. 2

7. Prove that momentum of a particle of rest mass m_0 and kinetic energy k is

$$p = \frac{1}{c}\sqrt{k\left(k + 2m_0 c^2\right)}.$$ 2

8. Show that at resonance, velocity is in phase with the driving force. 2

GROUP – B

Answer any **four** questions : 5×4

9. (*a*) Find the position of centre of mass of a uniform thin hemispherical shell. 2

(*b*) A gun fires a bullet of mass m with horizontal velocity $\vec{v}$ into a wooden block of mass M which is moving away from the gun with velocity $\vec{V}$ on a horizontal frictionless table.

If the bullet becomes embedded in the wood, then determine the subsequent velocity of the system and the loss in kinetic energy. 3

10. Two particles each of rest mass m_0 move with speed v w.r.t. an inertial frame but in opposite direction. Calculate the energy of one particle in the rest frame of the other particle. 5

11. A particle of mass 'm' is moving under potential $V(k) = ax^3 - bx^2$. Initially the particle is at rest at stable point. What minimum speed be given to the particle so that it reaches unstable point. Plot the potential versus x. 5

12. A solid sphere of mass M and radius R has non-uniform mass density which varies linearly with distance from the centre. Calculate the moment of inertia of the sphere about its diameter. 5

13. Prove that $E^2 = p^2c^2 + m_0^2c^4$ where the symbols have usual meanings. 5

14. Show that in forced vibration the total energy of the vibrating system is not constant. Also show that

$$\frac{\langle P \cdot E \rangle}{\langle k \cdot E \rangle} = \frac{w_0^2}{w^2}$$

where w_0 is natural frequency. 5

GROUP – C

Answer any **one** question : 10×1

15. (*a*) A rocket moves under an external force $\vec{F}$. It ejects fuel at a constant velocity $\vec{u}$ with respect to itself. If $\vec{v}$ is the instantaneous velocity of the rocket with respect to a rest frame and m be its instantaneous mass then show that :

$$m\frac{d\vec{v}}{dt} - \vec{u}\frac{dm}{dt} = \vec{F}.$$ 3

(*b*) Given that the instantaneous velocity of a particle executing forced vibration in steady state is :

$$v = \frac{F\cos(\omega t - \alpha)}{\sqrt{k^2 + \left(\omega m - \frac{s}{\omega}\right)^2}},$$

where the symbols used have their usual meanings.

(*i*) Show that the average power over a complete cycle is given by : 2

$$P_{av} = \frac{F^2 k}{2\left[k^2 + \left(\omega m \frac{s}{\omega}\right)^2\right]}.$$

(*ii*) Obtain the expressions of resonant frequency and bandwidth. 2

(*c*) Two stars at 16·5 light years distance explode simultaneously as measured by synchronized clocks of a frame with respect to which the stars are at rest. What will be the time gap between the explosions of the stars as measured by synchronized clocks of a frame moving at velocity 0·8c parallel to the line joining the stars ? 3

16. (*a*) A particle of mass '*M*' initially at rest breaks up into a particle of mass '*m*' and another particle of zero rest mass. Calculate the speed of the particle whose rest mass is '*m*'. 5

(*b*) A light source is moving along $+Y$ direction and light detector is placed at $(a, 0)$ along X axis. What is the frequency of light measured by the detector at the moment when the source is at origin. Actual frequency of light is ν_0. 5
