

UG18T17

Acc No.

Total Pages—7

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*

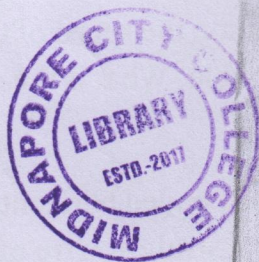
*Illustrate the answers wherever necessary*

GROUP – A

Answer any five questions : 2 × 5

1. Show that the central potential for the force

$\vec{F} = kr e^{\epsilon\theta} \hat{r}$  is spherically symmetric. 2



( Turn Over )



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 plane 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



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6. A fluid of viscosity  $\eta$  and density  $\rho$  flows through a capillary tube of radius  $a$ . Obtain the expression of critical velocity in terms of  $\eta$ ,  $\rho$  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

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

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  $V(x) = ax^3 - bx^2$ . 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



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

$$\frac{\langle P \cdot E \rangle}{\langle k \cdot E \rangle} = \frac{\omega_0^2}{\omega^2}$$

where  $\omega_0$  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 :

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

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



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

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



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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  $\nu_0$ . 5