

## AIEEE - (25-04-2010)

## PART A — PHYSICS

**Directions :** Questions number 1 – 3 are based on the following paragraph.

An initially parallel cylindrical beam travels in a medium of refractive index  $\mu(I) = \mu_0 + \mu_2 I$ , where  $\mu_0$  and  $\mu_2$  are positive constants and  $I$  is the intensity of the light beam. The intensity of the beam is decreasing with increasing radius.

- The initial shape of the wavefront of the beam is
  - planar
  - convex
  - concave
  - convex near the axis and concave near the periphery
- The speed of light in the medium is
  - maximum on the axis of the beam
  - minimum on the axis of the beam
  - the same everywhere in the beam
  - directly proportional to the intensity  $I$
- As the beam enters the medium, it will
  - travel as a cylindrical beam
  - diverge
  - converge
  - diverge near the axis and converge near the periphery

**Directions :** Questions number 4 – 5 are based on the following paragraph.

A nucleus of mass  $M + \Delta m$  is at rest and decays into two daughter nuclei of equal mass  $\frac{M}{2}$  each. Speed of light is  $c$ .

4. The speed of daughter nuclei is

(1)  $c \sqrt{\frac{\Delta m}{M + \Delta m}}$

(2)  $c \frac{\Delta m}{M + \Delta m}$

(3)  $c \sqrt{\frac{2\Delta m}{M}}$

(4)  $c \sqrt{\frac{\Delta m}{M}}$

5. The binding energy per nucleon for the parent nucleus is  $E_1$  and that for the daughter nuclei is  $E_2$ . Then

(1)  $E_1 = 2E_2$

(2)  $E_2 = 2E_1$

(3)  $E_1 > E_2$

(4)   $E_2 > E_1$

**Directions :** Questions number 6-7 contain Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.

6. **Statement-1 :** When ultraviolet light is incident on a photocell, its stopping potential is  $V_0$  and the maximum kinetic energy of the photoelectrons is  $K_{\max}$ . When the ultraviolet light is replaced by X-rays, both  $V_0$  and  $K_{\max}$  increase.

**Statement-2 :** Photoelectrons are emitted with speeds ranging from zero to a maximum value because of the range of frequencies present in the incident light.

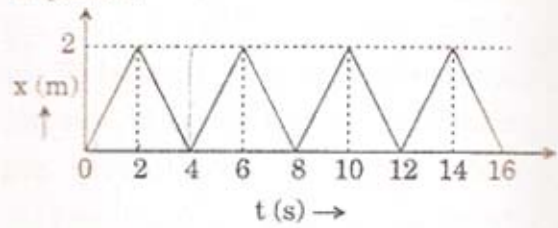
- (1) Statement-1 is true, Statement-2 is false.
- (2) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1.
- (3) Statement-1 is true, Statement-2 is true; Statement-2 is *not* the correct explanation of Statement-1.
- (4) Statement-1 is false, Statement-2 is true.

7. **Statement-1 :** Two particles moving in the same direction do not lose all their energy in a completely inelastic collision.

**Statement-2 :** Principle of conservation of momentum holds true for all kinds of collisions. Solved By - TCYonline.com

- (1) Statement-1 is true, Statement-2 is false.
- (2) Statement-1 is true, Statement-2 is true; Statement-2 is the correct explanation of Statement-1.
- (3) Statement-1 is true, Statement-2 is true; Statement-2 is *not* the correct explanation of Statement-1.
- (4) Statement-1 is false, Statement-2 is true.

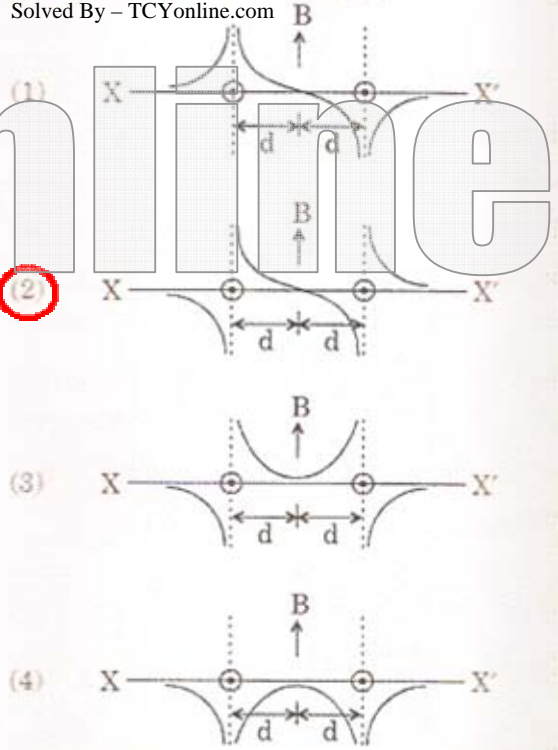
8. The figure shows the position-time ( $x-t$ ) graph of one-dimensional motion of a body of mass 0.4 kg. The magnitude of each impulse is



- (1) 0.2 Ns
- (2) 0.4 Ns
- (3) 0.8 Ns
- (4) 1.6 Ns

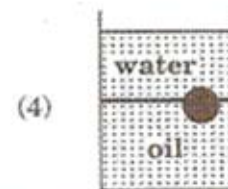
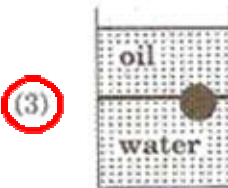
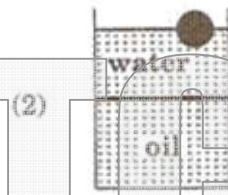
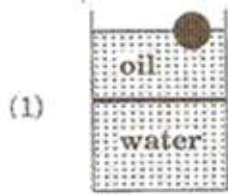
9. Two long parallel wires are at a distance  $2d$  apart. They carry steady equal currents flowing out of the plane of the paper as shown. The variation of the magnetic field  $B$  along the line  $XX'$  is given by

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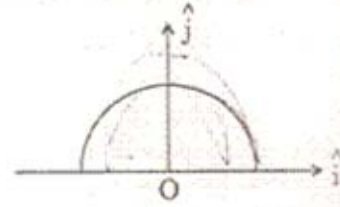


10. A ball is made of a material of density  $\rho$  where  $\rho_{oil} < \rho < \rho_{water}$  with  $\rho_{oil}$  and  $\rho_{water}$  representing the densities of oil and water, respectively. The oil and water are immiscible. If the above ball is in equilibrium in a mixture of this oil and water, which of the following pictures represents its equilibrium position?

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11. A thin semi-circular ring of radius  $r$  has a positive charge  $q$  distributed uniformly over it. The net field  $\vec{E}$  at the centre  $O$  is



(1)  $\frac{q}{2\pi^2 \epsilon_0 r^2} \hat{j}$

(2)  $\frac{q}{4\pi^2 \epsilon_0 r^2} \hat{j}$

(3)  $-\frac{q}{4\pi^2 \epsilon_0 r^2} \hat{j}$

(4)  $-\frac{q}{2\pi^2 \epsilon_0 r^2} \hat{j}$

12. A diatomic ideal gas is used in a Carnot engine as the working substance. If during the adiabatic expansion part of the cycle the volume of the gas increases from  $V$  to  $32V$ , the efficiency of the engine is

(1) 0.25

(2) 0.5

(3) 0.75

(4) 0.99

13. The respective number of significant figures for the numbers 23.023, 0.0003 and  $2.1 \times 10^{-3}$  are Solved By - TCYonline.com

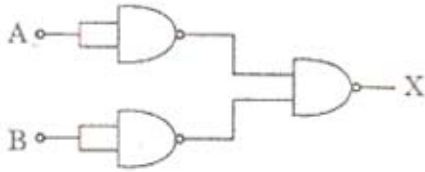
(1) 4, 4, 2

(2) 5, 1, 2

(3) 5, 1, 5

(4) 5, 5, 2

14. The combination of gates shown below yields



- (1) NAND gate
- (2) OR gate
- (3) NOT gate
- (4) XOR gate

15. If a source of power 4 kW produces  $10^{20}$  photons/second, the radiation belongs to a part of the spectrum called

- (1)  $\gamma$ -rays
- (2) X-rays
- (3) ultraviolet rays
- (4) microwaves

16. A radioactive nucleus (initial mass number A and atomic number Z) emits 3  $\alpha$ -particles and 2 positrons. The ratio of number of neutrons to that of protons in the final nucleus will be

- (1)  $\frac{A-Z-4}{Z-2}$
- (2)  $\frac{A-Z-8}{Z-4}$
- (3)  $\frac{A-Z-4}{Z-8}$
- (4)  $\frac{A-Z-12}{Z-4}$

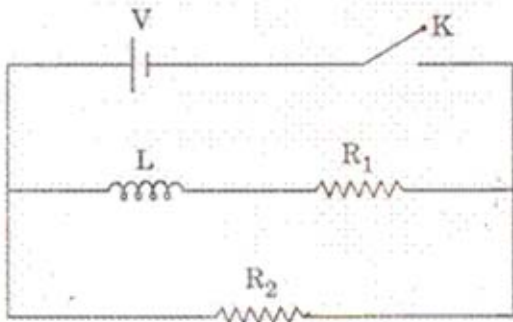
17. Let there be a spherically symmetric charge distribution with charge density varying as  $\rho(r) = \rho_0 \left( \frac{5}{4} - \frac{r}{R} \right)$  upto  $r = R$ , and  $\rho(r) = 0$  for  $r > R$ , where  $r$  is the distance from the origin. The electric field at a distance  $r$  ( $r < R$ ) from the origin is given by

- (1)  $\frac{\rho_0 r}{3\epsilon_0} \left( \frac{5}{4} - \frac{r}{R} \right)$
- (2)  $\frac{4\pi\rho_0 r}{3\epsilon_0} \left( \frac{5}{3} - \frac{r}{R} \right)$
- (3)  $\frac{\rho_0 r}{4\epsilon_0} \left( \frac{5}{3} - \frac{r}{R} \right)$
- (4)  $\frac{4\rho_0 r}{3\epsilon_0} \left( \frac{5}{4} - \frac{r}{R} \right)$

18. In a series LCR circuit  $R = 200 \Omega$  and the voltage and the frequency of the main supply is 220 V and 50 Hz respectively. On taking out the capacitance from the circuit the current lags behind the voltage by  $30^\circ$ . On taking out the inductor from the circuit the current leads the voltage by  $30^\circ$ . The power dissipated in the LCR circuit is

- (1) 242 W
- (2) 305 W
- (3) 210 W
- (4) Zero W

19. In the circuit shown below, the key K is closed at  $t = 0$ . The current through the battery is



(1)  $\frac{V(R_1 + R_2)}{R_1 R_2}$  at  $t = 0$  and  $\frac{V}{R_2}$  at  $t = \infty$

(2)  $\frac{V R_1 R_2}{\sqrt{R_1^2 + R_2^2}}$  at  $t = 0$  and  $\frac{V}{R_2}$  at  $t = \infty$

(3)  $\frac{V}{R_2}$  at  $t = 0$  and  $\frac{V(R_1 + R_2)}{R_1 R_2}$  at  $t = \infty$

(4)  $\frac{V}{R_2}$  at  $t = 0$  and  $\frac{V R_1 R_2}{\sqrt{R_1^2 + R_2^2}}$  at  $t = \infty$

20. A particle is moving with velocity  $\vec{v} = K(y\hat{i} + x\hat{j})$ , where K is a constant. The general equation for its path is

(1)  $y^2 = x^2 + \text{constant}$

(2)  $y = x^2 + \text{constant}$

(3)  $y^2 = x + \text{constant}$

(4)  $xy = \text{constant}$

21. Let C be the capacitance of a capacitor discharging through a resistor R. Suppose  $t_1$  is the time taken for the energy stored in the capacitor to reduce to half its initial value and  $t_2$  is the time taken for the charge to reduce to one-fourth its initial value.

Then the ratio  $t_1/t_2$  will be

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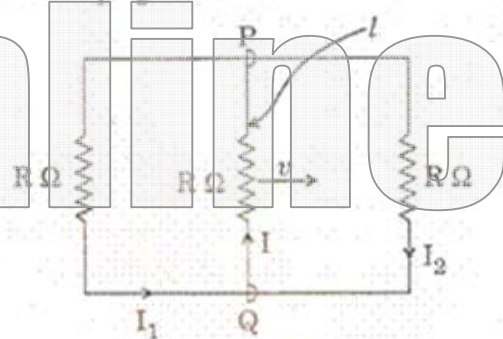
(1) 2

(2) 1

(3)  $\frac{1}{2}$

(4)  $\frac{1}{4}$

22. A rectangular loop has a sliding connector PQ of length  $l$  and resistance  $R \Omega$  and it is moving with a speed  $v$  as shown. The set-up is placed in a uniform magnetic field going into the plane of the paper. The three currents  $I_1$ ,  $I_2$  and  $I$  are



(1)  $I_1 = I_2 = \frac{Blv}{6R}$ ,  $I = \frac{Blv}{3R}$

(2)  $I_1 = -I_2 = \frac{Blv}{R}$ ,  $I = \frac{2Blv}{R}$

(3)  $I_1 = I_2 = \frac{Blv}{3R}$ ,  $I = \frac{2Blv}{3R}$

(4)  $I_1 = I_2 = I = \frac{Blv}{R}$

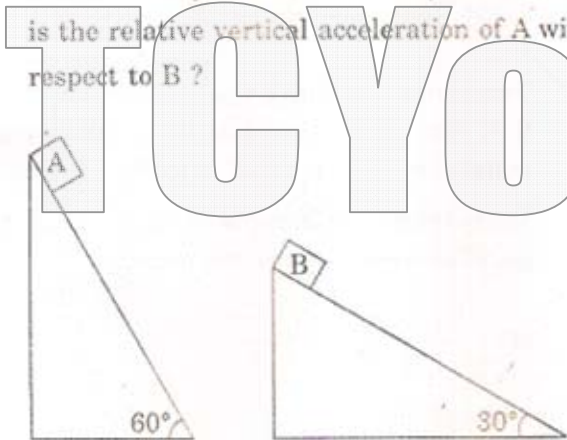
23. The equation of a wave on a string of linear mass density  $0.04 \text{ kg m}^{-1}$  is given by

$$y = 0.02(m) \sin \left[ 2\pi \left( \frac{t}{0.04(s)} - \frac{x}{0.50(m)} \right) \right]$$

The tension in the string is

- (1) 6.25 N
- (2) 4.0 N
- (3) 12.5 N
- (4) 0.5 N

24. Two fixed frictionless inclined planes making an angle  $30^\circ$  and  $60^\circ$  with the vertical are shown in the figure. Two blocks A and B are placed on the two planes. What is the relative vertical acceleration of A with respect to B?



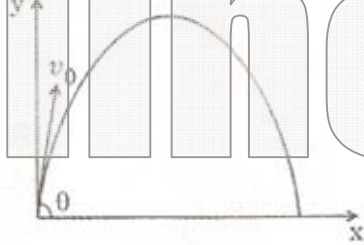
- (1)  $4.9 \text{ ms}^{-2}$  in vertical direction
- (2)  $4.9 \text{ ms}^{-2}$  in horizontal direction
- (3)  $9.8 \text{ ms}^{-2}$  in vertical direction
- (4) Zero

25. For a particle in uniform circular motion, the acceleration  $\vec{a}$  at a point P ( $R, \theta$ ) on the circle of radius R is (Here  $\theta$  is measured from the x-axis) Solved By - TCYonline.com

- (1)  $\frac{v^2}{R} \hat{i} + \frac{v^2}{R} \hat{j}$
- (2)  $-\frac{v^2}{R} \cos \theta \hat{i} + \frac{v^2}{R} \sin \theta \hat{j}$
- (3)  $-\frac{v^2}{R} \sin \theta \hat{i} + \frac{v^2}{R} \cos \theta \hat{j}$
- (4)  $-\frac{v^2}{R} \cos \theta \hat{i} - \frac{v^2}{R} \sin \theta \hat{j}$

26. A small particle of mass m is projected at an angle  $\theta$  with the x-axis with an initial velocity  $v_0$  in the x-y plane as shown in the figure. At a time  $t < \frac{v_0 \sin \theta}{g}$ , the angular momentum of the particle is

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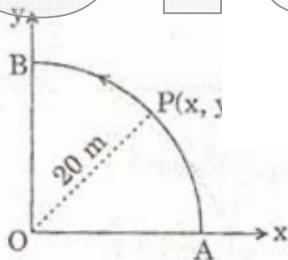
- (1)  $\frac{1}{2} mg v_0 t^2 \cos \theta \hat{i}$
- (2)  $-mg v_0 t^2 \cos \theta \hat{j}$
- (3)  $mg v_0 t \cos \theta \hat{k}$
- (4)  $-\frac{1}{2} mg v_0 t^2 \cos \theta \hat{k}$

where  $\hat{i}$ ,  $\hat{j}$  and  $\hat{k}$  are unit vectors along x, y and z-axis respectively.

27. Two identical charged spheres are suspended by strings of equal lengths. The strings make an angle of  $30^\circ$  with each other. When suspended in a liquid of density  $0.8 \text{ g cm}^{-3}$ , the angle remains the same. If density of the material of the sphere is  $1.6 \text{ g cm}^{-3}$ , the dielectric constant of the liquid is

- (1) 1
- (2) 4
- (3) 3
- (4) 2

28. A point P moves in counter-clockwise direction on a circular path as shown in the figure. The movement of P is such that it sweeps out a length  $s = t^3 + 5$ , where s is in metres and t is in seconds. The radius of the path is 20 m. The acceleration of P when  $t = 2 \text{ s}$  is nearly



- (1)  $14 \text{ m/s}^2$
- (2)  $13 \text{ m/s}^2$
- (3)  $12 \text{ m/s}^2$
- (4)  $7.2 \text{ m/s}^2$

29. The potential energy function for the force between two atoms in a diatomic molecule is approximately given by  $U(x) = \frac{a}{x^{12}} - \frac{b}{x^6}$ , where a and b are constants and x is the distance between the atoms. If the dissociation energy of the molecule is  $D = [U(x = \infty) - U_{\text{at equilibrium}}]$ , D is

- (1)  $\frac{b^2}{6a}$
- (2)  $\frac{b^2}{2a}$
- (3)  $\frac{b^2}{12a}$
- (4)  $\frac{b^2}{4a}$

30. Two conductors have the same resistance at  $0^\circ \text{C}$  but their temperature coefficients of resistance are  $\alpha_1$  and  $\alpha_2$ . The respective temperature coefficients of their series and parallel combinations are nearly

- (1)  $\frac{\alpha_1 + \alpha_2}{2}, \frac{\alpha_1 + \alpha_2}{2}$
- (2)  $\frac{\alpha_1 + \alpha_2}{2}, \alpha_1 + \alpha_2$
- (3)  $\alpha_1 + \alpha_2, \frac{\alpha_1 + \alpha_2}{2}$
- (4)  $\alpha_1 + \alpha_2, \frac{\alpha_1 \alpha_2}{\alpha_1 + \alpha_2}$