IIT JEE 2009 Test Series 5
PHYSICS PART-I

SECTION I

STRAIGHT OBJECTIVE TYPE

This section contains 6 multiple choice questions. Each question has four choices (a), (b), (c) and (d), out of which ONLY ONE is correct. 3 MARKS will be awarded for correct answer. 1 MARK will be deducted for wrong answer.

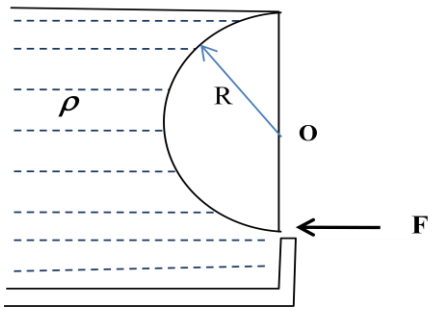
1. The figure shows a semi-cylindrical massless gate of width R pivoted at the point O holiding a stationary liquid of density ρ. A horizontal force F is applied at its lowest position to prevent it from rotating. The magnitude of the force is

   (a) $\frac{9}{2}\rho g R^3$

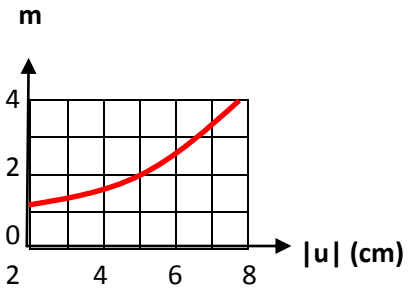
   (b) $\frac{3}{2}\rho g R^3$

   (c) $\rho g R^3$

   (d) zero

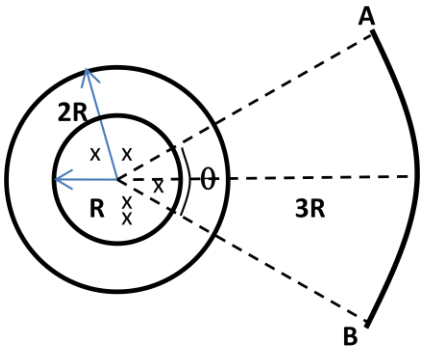


2. An object kept on the principal axis and in front of a spherical mirror, is moved along the axis itself. Its lateral magnification m is measured, and plotted versus object distance |u| for a range of u, as shown. The magnification of the object when it is placed at a distance 20 cm in front of the mirror, is
   (a) -1
   (b) 1
   (c) 8
   (d) 20

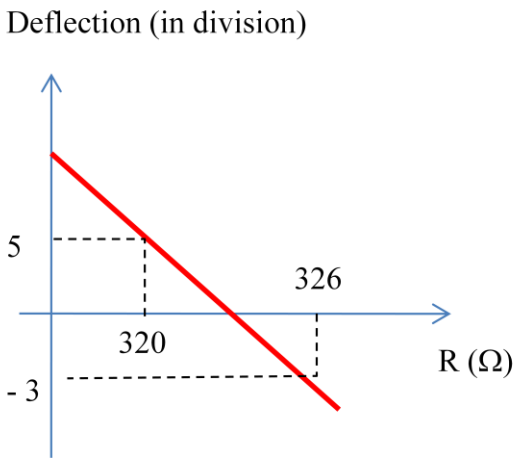


3. A particle A moves with a constant velocity $\vec{v}_1$ and a particle B moves with a constant velocity $\vec{v}_2$ wrt ground and r is the length of vector $\overrightarrow{AB}$, at any time then
   (a) $\frac{dr}{dt} < 0 \; if \;\; |\vec{v}_1| < |\vec{v}_2|$
   (b) $\frac{dr}{dt} = 0 \; if \;\; |\vec{v}_1| = |\vec{v}_2|$
   (c) $\frac{dr}{dt} = 0 \; if \;\; \vec{v}_2 . \overrightarrow{AB} = \vec{v}_1 . \overrightarrow{AB}$
   (d) $\frac{dr}{dt} > 0 \; if \;\; (\vec{v}_1 - \vec{v}_2) \; . \; \overrightarrow{BA} > 0$

4. In the given figure two concentric cylindrical region in which time varying magnetic field is present as shown. From the centre to radius R a magnetic field is perpendicular into the plane varying as $\frac{dB}{dt} = 2k_0$ and in a region from R to 2R magnetic field is perpendicular out of the plane varying as $\frac{dB}{dt} = 4k_0$. Then the induced emf across
   (a) $6R^2k\theta$
   (b) $5R^2k\theta$
   (c) $7R^2k\theta$
   (d) $8R^2k\theta$



5. For a post box office box, the graph of galvanometer deflection versus R (resistance pulled out of the resistance arm) for the ratio of resistances in ratio arms equal to 100 : 1 is given as shown. A careless student pulls out two non consecutive values of R (320 and 326 ohms) as shown in figure. Find the value of unknown resistance.
   (a) 3.2 ohm
   (b) 3.24 ohm
   (c) 3.206 ohm
   (d) None of these



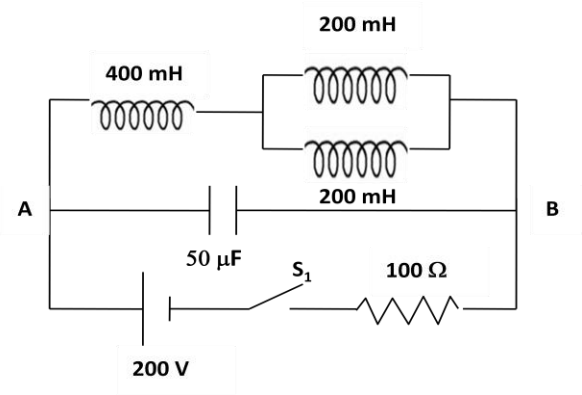
6. A wave standing on a string at a speed of 10 m/s causes each particle of the string to oscillate with a time period of 20 ms. If the displacement of a particle is 1.5 mm at a certain instant, what will be the displacement of a particle at 10 cm away from it at the same instant?
   (a) – 1.5 mm
   (b) zero
   (c) 1.5 mm
   (d) 3.0 mm

SECTION II

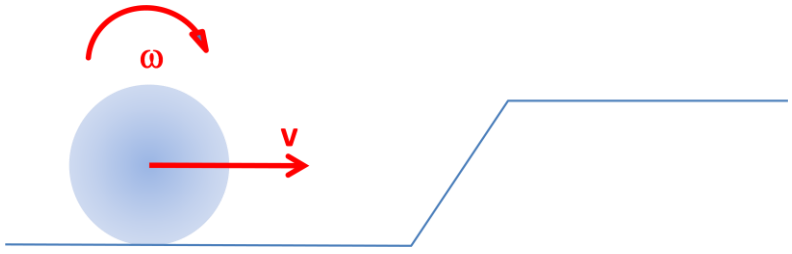
MULTIPLE CHOICE TYPE QUESTIONS

This section contains 4 multiple choice questions. Each question has 4 choices (A), (B), (C) and (D), out of which one or more options correct. NO NEGATIVE marking.

7. In the circuit shown, switch S1 was closed for a long time. At time t = 0 the switch is opened again. Then,
   (a) The potential difference across the plates of the capacitor before the switch is opened is zero volts.
   (b) The angular frequency of oscillation of the charge on the capacitor is 200 rad/s
   (c) The time period of oscillation of the charge on the capacitor is 0.005 s.
   (d) The frequency of oscillation of the charge on the capacitor is 200 Hz

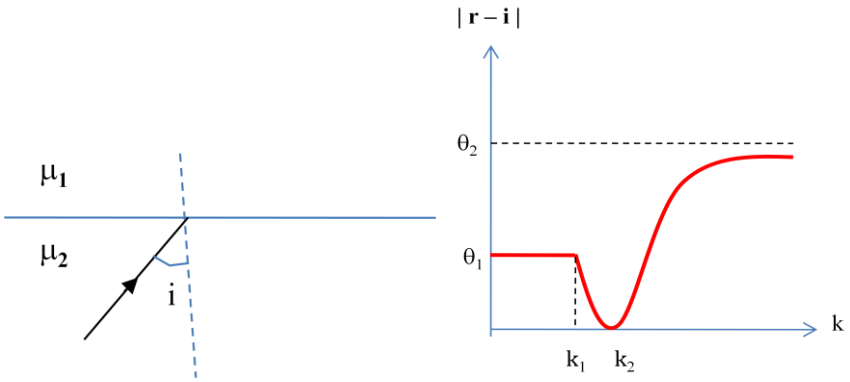


8. A solid sphere is rolling on a frictionless surface without slipping as shown in figure with a translational velocity v and angular velocity ω. It climbs over the inclined surface which is also smooth. When it reaches to upper surface
   (a) Its motion will be pure rolling
   (b) Its kinetic energy will be conserved
   (c) Its linear momentum remain same
   (d) None of these



9. The figure shows a ray incident at an angle i = $\pi/3$. The ray is refracted and angle of refraction is r. The value of r changes between 0 to $\pi/2$ when the ratio $\frac{\mu_1}{\mu_2} = k$ is changed. If the plot drawn shown the variation of $|r - i|$ versus $\frac{\mu_1}{\mu_2} = k$,

   (a) the value of k_1 is $2/\sqrt{3}$
   (b) the value of θ_1 is $\pi/6$
   (c) the value of θ_2 is $\pi/3$
   (d) the value of k_2 is 1



10. Hydrogen atom absorbs radiations of wavelength λ_0 and consequently emits radiations of 6 different wavelengths of which two wavelengths are shorter than λ_0. Choose the correct alternative(s)
   (a) The final excited state of the atom is n = 4
   (b) The initial state of the atom may be n = 2
   (c) The initial state of the atom may be n = 3
   (d) There are three transitions belonging to Lyman series.

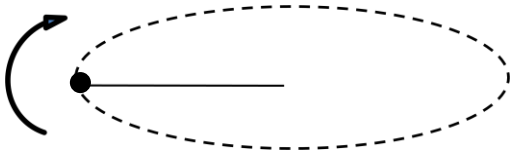
SECTION III

ASSERTION-REASON TYPE

This question contains 4 reasoning type questions. Each question has 4 choices (a), (b), (c) and (d), out of which ONLY ONE is correct. 3 MARKS will be awarded for correct answer. 1 MARK will be deducted for wrong answer. NO MARKS WILL BE GIVEN OR DEDUCTED IF A QUESTION IS NOT ANSWERED.

11. STATEMENT-1: The electric field in two dielectric slabs of different dielectric constants placed in same parallel capacitor may be equal.
STATEMENT-1: The electric field intensity at interface of two dielectric is always continuous.
    (a) STATEMENT-1 is True, STATEMENT-2 is true; STATEMENT-2 is a correct explanation for STATEMENT 1
    (b) STATEMENT-1 is True, STATEMENT-2 is true; STATEMENT-2 is NOT a correct explanation for STATEMENT-1
    (c) STATEMENT-1 is True, STATEMENT-2 is False
    (d) STATEMENT-1 is False, STATEMENT-2 is true

12. STATEMENT-1: A small ball of mass m secured on a light string rotates with a constant velocity v on a horizontal smooth table as shown. The kinetic energy of the ball in a co-ordinate system stationary with respect to the axis of rotation is constant and equal to ½ mv^2.
The kinetic energy changes with time from zero to $4mv^2/2$ with respect to a co-ordinate system that moves rectilinearly in a horizontal plane with velocity v relative to the axis.
STATEMENT-2: The change in kinetic energy in moving frame is because of work done by the centrifugal force in this frame.



    (a) STATEMENT-1 is True, STATEMENT-2 is true; STATEMENT-2 is a correct explanation for STATEMENT 1
    (b) STATEMENT-1 is True, STATEMENT-2 is true; STATEMENT-2 is NOT a correct explanation for STATEMENT-1
    (c) STATEMENT-1 is True, STATEMENT-2 is False
    (d) STATEMENT-1 is False, STATEMENT-2 is true

13. STATEMENT-1: When momentum of given intensity falls on a surface, the pressure it exerts on the surface is independent of frequency.
STATEMENT-2: Momentum of a photon is directly proportional to its frequency and number of photons hitting the surface per unit time is inversely proportional to frequency.
    (a) STATEMENT-1 is True, STATEMENT-2 is true; STATEMENT-2 is a correct explanation for STATEMENT 1
    (b) STATEMENT-1 is True, STATEMENT-2 is true; STATEMENT-2 is NOT a correct explanation for STATEMENT-1
    (c) STATEMENT-1 is True, STATEMENT-2 is False
    (d) STATEMENT-1 is False, STATEMENT-2 is true

14. STATEMENT-1: Consider an ideal gas undergoing reversible adiabatic process. In such a case, the temperature changes without adding any heat.
STATEMENT-2: The work done by the ideal gas in an adiabatic process reversible process equals the decrease in its internal energy.
    (a) STATEMENT-1 is True, STATEMENT-2 is true; STATEMENT-2 is a correct explanation for STATEMENT 1
    (b) STATEMENT-1 is True, STATEMENT-2 is true; STATEMENT-2 is NOT a correct explanation for STATEMENT-1
    (c) STATEMENT-1 is True, STATEMENT-2 is False
    (d) STATEMENT-1 is False, STATEMENT-2 is true

SECTION IV

LINKED COMPREHENSION TYPE

This section contains 2 paragraphs. Based upon each paragraph, 3 multiple choice questions have to be answered. Each question has four choices (a), (b), (c) and (d), out of which ONLY ONE is correct. 4 MARKS will be awarded for correct answer. 1 MARK will be deducted for wrong answer. NO MARKS WILL BE GIVEN OR DEDUCTED IF A QUESTION IS NOT ANSWERED.

Paragraph for Questions numbers 15 to 17

A nucleus at rest undergoes α-decay according to the equation:

$$^{225}_{92}X \rightarrow Y + \alpha$$

At time t = 0, the emitted α-particle enters in a region of space where a uniform magnetic field $\vec{B} = B_0\hat{i}$ and electric field $\vec{E} = E_0\hat{i}$ exist. The α-particle enters in the region with velocity $\vec{v} = v_0\hat{j}$ from x = 0. At time t = $3\times10^7 \dfrac{m_\alpha}{q_\alpha E_0}$ sec, the particle was observed to have speed twice the initial velocity v_0.

Given: Charge on α-particle, q_α = 6.4 x 10^{-19} C, Mass of α-particle, m (α) = m_α = 4.003 u, m (Y) = 221.03 u, m (n) = 1.009u, m (p) = 1.0084 u, 1 u = 1.67 x 10^{-27} kg = 931 MeV/c^2. Then,

15. The velocity of α-particle at time t is

(a) $\left(\dfrac{q_\alpha E_0}{m_\alpha}t\right)\hat{i} + v_0\cos\theta\,\hat{j}$ *where* $\theta = \omega t$ & $\omega = \dfrac{q_\alpha B_0}{m_\alpha}$

(b) $v_0\cos\theta\hat{i} + \left(\dfrac{q_\alpha E_0}{m_\alpha}t\right)\hat{j}$ *where* $\theta = \omega t$ & $\omega = \dfrac{q_\alpha B_0}{m_\alpha}$

(c) $\left(\dfrac{q_\alpha B_0}{m_\alpha}t\right)\hat{i} + v_0\cos\theta\,\hat{j}$ *where* $\theta = \omega t$ & $\omega = \dfrac{q_\alpha E_0}{m_\alpha}$

(d) $v_0\cos\theta\hat{i} + \left(\dfrac{q_\alpha B_0}{m_\alpha}t\right)\hat{j}$ *where* $\theta = \omega t$ & $\omega = \dfrac{q_\alpha E_0}{m_\alpha}$

16. The initial velocity v_0 of the α-particle is
    (a) 10^6 m/s
    (b) 10^7 m/s
    (c) 3×10^8 m/s
    (d) 3×10^9 m/s

17. The binding energy per nucleon of α-particle is
    (a) 6.00 MeV
    (b) 7.00 MeV
    (c) 8.00 MeV
    (d) 9.00 MeV

Paragraph for Questions numbers 18 to 20

2.8 grams of an ideal gas is taken in a container of volume 100 liters at temperature T_1 = 288 K and pressure P = 1.5×10^3 Pa. The gas in the tube is heated isobarically to a temperature T_2. Standing waves of frequency 5 kHz is produced in tube. The separation between the nodes at temperature T_1 and T_2 are 3 cm and 4 cm respectively. Then,

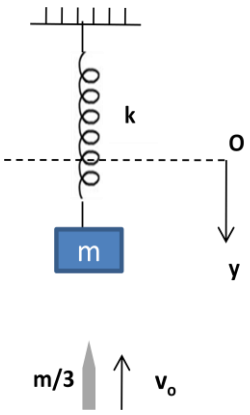
18. The final temperature T_2 is
    (a) 288 K
    (b) 375 K
    (c) 427 K
    (d) 512 K

19. Value of ratio of specific heats γ is
    (a) 1.68
    (b) 1.44
    (c) 1. 29
    (d) 1.13

20. Amount of heat supplied is
    (a) 318.26 J
    (b) 576.68 J
    (c) 483.19 J
    (d) 288.34 J

Paragraph for Questions numbers 21 to 23

A block of mass m is suspended from one end of light spring as shown in the figure. The origin O is considered at distance equal to natural length of string from ceiling and vertical downward direction as +ve Y axis. When the system is in equilibrium a bullet of mass m/3 moving in vertical upward direction with velocity v_0 strikes the block and embeds into it. As a result the block (with the bullet embedded into it) moves up and starts oscillating. Then answer the following questions:



21. Mark the correct statement(s)

(a) The block-bullet system performs SHM about $y = \frac{Mg}{k}$

(b) The block-bullet system performs oscillatory motion but not SHM about $y = \frac{Mg}{k}$

(c) The block-bullet system performs SHM about $y = \frac{4Mg}{3k}$

(d) The block-bullet system performs oscillatory motion but not SHM about $y = \frac{4Mg}{3k}$

22. The amplitude of oscillation would be

(a) $\sqrt{\left(\frac{4mg}{3k}\right)^2+\left(\frac{mv_0^2}{12k}\right)^2}$

(b) $\sqrt{\left(\frac{mg}{3k}\right)^2+\left(\frac{mv_0^2}{12k}\right)^2}$

(c) $\sqrt{\left(\frac{mg}{k}\right)^2+\left(\frac{mv_0^2}{6k}\right)^2}$

(d) $\sqrt{\left(\frac{4mg}{3k}\right)^2+\left(\frac{mv_0^2}{6k}\right)^2}$

23. The time taken by block-bullet system to move from $y=\frac{Mg}{k}$ (initial equilibrium position) to y = 0 is

(a) $\sqrt{\frac{4m}{3k}}\left[\cos^{-1}\left(\frac{mg}{3kA}\right)-\cos^{-1}\left(\frac{4mg}{3kA}\right)\right]$

(b) $\sqrt{\frac{3m}{4k}}\left[\cos^{-1}\left(\frac{mg}{3kA}\right)-\cos^{-1}\left(\frac{4mg}{3kA}\right)\right]$

(c) $\sqrt{\frac{4m}{3k}}\left[\sin^{-1}\left(\frac{mg}{3kA}\right)-\sin^{-1}\left(\frac{4mg}{3kA}\right)\right]$

(d) $\sqrt{\frac{3m}{4k}}\left[\sin^{-1}\left(\frac{mg}{3kA}\right)-\sin^{-1}\left(\frac{4mg}{3kA}\right)\right]$