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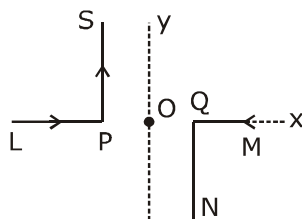
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## [PHYSICS]

1. As shown in the figure, two infinitely long, identical wires are bent by  $90^\circ$  and placed in such a way that the segments LP and QM are along the x-axis, while segments PS and QN are parallel to the y-axis. If  $OP=QQ=4\text{cm}$ , and the magnitude of the magnetic field at O is  $10^{-4}\text{T}$ , and the two wires carry equal currents (see figure), the magnitude of the current in each wire and the direction of the magnetic field at O will be ( $\mu_0 = 4\pi \times 10^{-7}\text{NA}^{-2}$ )



- (A) 20 A, perpendicular into the page      (B) 40 A, perpendicular out of the page  
(C) 20 A, perpendicular out of the page      (D) 40 A, perpendicular into the page

**Sol. A**

Magnetic field at 'O' will be done to 'PS' and 'QN' only  
i.e.  $B_0 = B_{PS} + B_{QN} \rightarrow$  Both inwards  
Let current in each wire =  $i$

$$\therefore B_0 = \frac{\mu_0 i}{4\pi d} + \frac{\mu_0 i}{4\pi d}$$

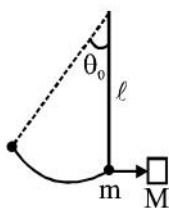
$$\text{or } 10^{-4} = \frac{\mu_0 i}{2\pi d} = \frac{2 \times 10^{-7} \times i}{4 \times 10^{-2}}$$

$$\therefore i = 20 \text{ A}$$

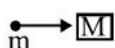
2. A simple pendulum, made of a string of length  $l$  and a bob of mass  $m$ , is released from a small angle  $\theta_0$ . It strikes a block of mass  $M$ , kept on a horizontal surface at its lowest point of oscillations, elastically. It bounces back and goes up to an angle  $\theta_1$ . Then  $M$  is given by :

- (A)  $\frac{m}{2} \left( \frac{\theta_0 - \theta_1}{\theta_0 + \theta_1} \right)$       (B)  $m \left( \frac{\theta_0 + \theta_1}{\theta_0 - \theta_1} \right)$       (C)  $\frac{m}{2} \left( \frac{\theta_0 + \theta_1}{\theta_0 - \theta_1} \right)$       (D)  $m \left( \frac{\theta_0 - \theta_1}{\theta_0 + \theta_1} \right)$

**Sol. B**



Before collision



After collision



$$v = \sqrt{2gl(1 - \cos \theta_0)} \quad v_1 = \sqrt{2gl(1 - \cos \theta_1)}$$

By momentum conservation

$$m\sqrt{2gl(1 - \cos \theta_0)} = Mv_m - m\sqrt{2gl(1 - \cos \theta)}$$

$$\Rightarrow m\sqrt{2g\ell} \left\{ \sqrt{1 - \cos\theta_0} + \sqrt{1 - \cos\theta_1} \right\} = MV_m$$

$$\text{and } e = 1 = \frac{V_m + \sqrt{2g\ell(1 - \cos\theta_1)}}{\sqrt{2g\ell(1 - \cos\theta_0)}}$$

$$\sqrt{2g\ell} \left( \sqrt{1 - \cos\theta_0} - \sqrt{1 - \cos\theta_1} \right) = V_m \quad \dots(i)$$

$$m\sqrt{2g\ell} \left( \sqrt{1 - \cos\theta_0} + \sqrt{1 - \cos\theta_1} \right) = MV_m \quad \dots(ii)$$

Dividing

$$\frac{\left( \sqrt{1 - \cos\theta_0} + \sqrt{1 - \cos\theta_1} \right)}{\left( \sqrt{1 - \cos\theta_0} - \sqrt{1 - \cos\theta_1} \right)} = \frac{M}{m}$$

By componendo divided

$$\frac{m - M}{m + M} = \frac{\sqrt{1 - \cos\theta_1}}{\sqrt{1 - \cos\theta_0}} = \frac{\sin\left(\frac{\theta_1}{2}\right)}{\sin\left(\frac{\theta_0}{2}\right)}$$

$$\Rightarrow \frac{M}{m} = \frac{\theta_0 - \theta_1}{\theta_0 + \theta_1} \Rightarrow M = \frac{\theta_0 - \theta_1}{\theta_0 + \theta_1}$$

3. A light wave is incident normally on a glass slab of refractive index 1.5. If 4% of light gets reflected and the amplitude of the electric field of the incident light is 30V/m, then the amplitude of the electric field for the wave propagating in the glass medium will be :
- (A) 24 V/m                      (B) 10 V/m                      (C) 6 V/m                      (D) 30 V/m

Sol. A

$$P_{\text{refracted}} = \frac{96}{100} P_i$$

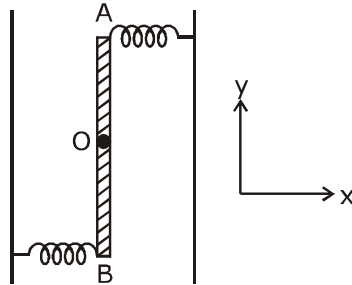
$$\Rightarrow K_2 A_t^2 = \frac{96}{100} K_1 A_i^2$$

$$\Rightarrow r_2 A_t^2 = \frac{96}{100} r_1 A_i^2$$

$$\Rightarrow A_t^2 = \frac{96}{100} \times \frac{1}{3} \times (30)^2$$

$$A_t \sqrt{\frac{64}{100}} \times (30)^2 = 24$$

4. Two light identical springs of spring constant  $k$  are attached horizontally at the two ends of a uniform horizontal rod  $AB$  of length  $l$  and mass  $m$ . The rod is pivoted at its centre 'O' and can rotate freely in horizontal plane. The other ends of the two spring are fixed to rigid supports as shown in figure. The rod is gently pushed through a small angle and released. The frequency of resulting oscillation is :



(A)  $\frac{1}{2\pi} \sqrt{\frac{3K}{m}}$

(B)  $\frac{1}{2\pi} \sqrt{\frac{K}{m}}$

(C)  $\frac{1}{2\pi} \sqrt{\frac{2K}{m}}$

(D)  $\frac{1}{2\pi} \sqrt{\frac{6K}{m}}$

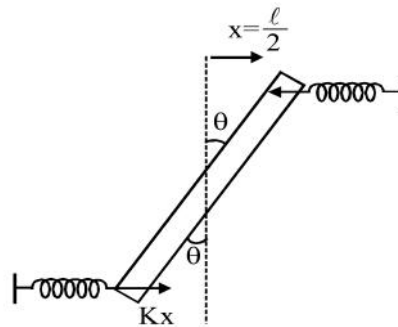
Sol. D

$$\tau = -2Kx \frac{\ell}{2} \cos \theta$$

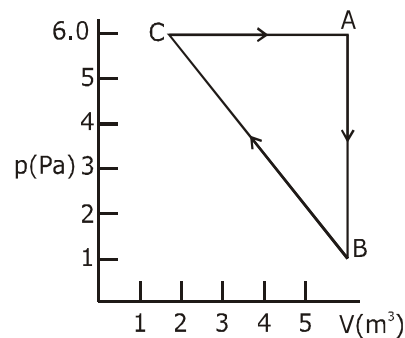
$$\Rightarrow \tau = \left( \frac{K\ell^2}{2} \right) \theta = -C\theta$$

$$\Rightarrow f = \frac{1}{2\pi} \sqrt{\frac{C}{I}} = \frac{1}{2\pi} \sqrt{\frac{K\ell^2}{\frac{M\ell^2}{12}}}$$

$$\Rightarrow f = \frac{1}{2\pi} \sqrt{\frac{6K}{M}}$$



5. For the given cyclic process CAB as shown for a gas, the work done is :



(A) 1J

(B) 5 J

(C) 30 J

(D) 10 J

Sol. **D**

Since P – V indicator diagram is given, so work done by gas is area under the cyclic diagram.

$$\therefore \Delta W = \text{Work done by gas} = \frac{1}{2} \times 4 \times 5 \text{ J} \\ = 10 \text{ J}$$

6. A travelling harmonic wave is represented by the equation  $y(x,t) = 10^{-3} \sin(50t + 2x)$ , where  $x$  and  $y$  are in meter and  $t$  is in seconds. Which of the following is a correct statement about the wave?  
 (A) The wave is propagating along the positive  $x$ -axis with speed  $25 \text{ ms}^{-1}$ .  
 (B) The wave is propagating along the negative  $x$ -axis with speed  $100 \text{ ms}^{-1}$ .  
 (C) The wave is propagating along the positive  $x$ -axis with speed  $100 \text{ ms}^{-1}$ .  
 (D) The wave is propagating along the negative  $x$ -axis with speed  $25 \text{ ms}^{-1}$ .

Sol. **D**

$y = a \sin(\omega t + kx)$   
 $\Rightarrow$  wave is moving along -ve  $x$ -axis with speed

$$v = \frac{\omega}{K} \Rightarrow v = \frac{50}{2} = 25 \text{ m/sec.}$$

7. A proton and an  $\alpha$ -particle (with their masses in the ratio of 1:4 and charges in the ratio of 1:2) are accelerated from rest through a potential difference  $V$ . If a uniform magnetic field ( $B$ ) is set up perpendicular to their velocities, the ratio of the radii  $r_p : r_\alpha$  of the circular paths described by them will be :

- (A) 1:2                      (B)  $1 : \sqrt{3}$                       (C) 1:3                      (D)  $1 : \sqrt{2}$

Sol. **D**

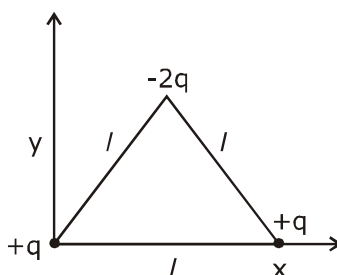
$$KE = q\Delta V$$

$$r = \frac{\sqrt{2mq\Delta V}}{qB}$$

$$r \propto \sqrt{\frac{m}{q}}$$

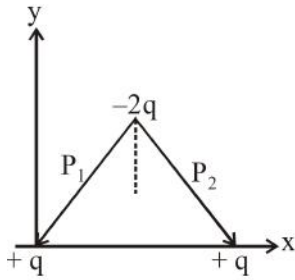
$$\frac{r_p}{r_\alpha} = \frac{1}{\sqrt{2}}$$

8. Determine the electric dipole moment of the system of three charges, placed on the vertices of an equilateral triangle, as shown in the figure.



- (A)  $ql \frac{\hat{i} + \hat{j}}{\sqrt{2}}$                       (B)  $\sqrt{3}ql \frac{\hat{j} - \hat{i}}{\sqrt{2}}$                       (C)  $-\sqrt{3}ql \hat{j}$                       (D)  $2ql \hat{j}$

Sol. C



$$|P_1| = q(d)$$

$$|P_2| = qd$$

$$|\text{Resultant}| = 2P \cos 30^\circ$$

$$2qd \left( \frac{\sqrt{3}}{2} \right) = \sqrt{3}qd$$

9. A passenger train of length 60 m travels at a speed of 80 km/hr. Another freight train of length 120m travels at a speed of 30 km/hr. The ratio of times taken by the passenger train to completely cross the freight train when : (i) they are moving in the same direction, and (ii) in the opposite directions is :

(A)  $\frac{5}{2}$

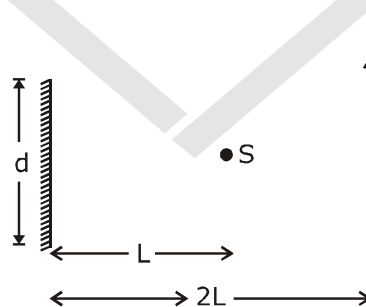
(B)  $\frac{3}{2}$

(C)  $\frac{11}{5}$

(D)  $\frac{25}{11}$

Sol. C

10. A point source of light, S is placed at a distance L in front of the centre of plane mirror of width d which is hanging vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror, at a distance 2L as shown below. The distance over which the man can see the image of the light source in the mirror is :



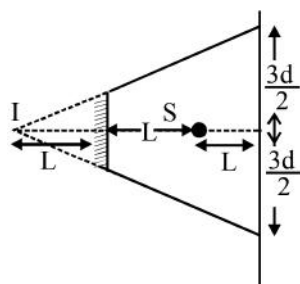
(A) d

(B) 3d

(C)  $\frac{d}{2}$

(D) 2d

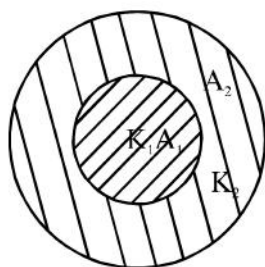
Sol. B



11. A cylinder of radius  $R$  is surrounded by a cylindrical shell of inner radius  $R$  and outer radius  $2R$ . The thermal conductivity of the material of the inner cylinder is  $K_1$  and that of the outer cylinder is  $K_2$ . Assuming no loss of heat, the effective thermal conductivity of the system for heat flowing along the length of the cylinder is :

- (A)  $K_1 + K_2$                       (B)  $\frac{2K_1 + 3K_2}{5}$                       (C)  $\frac{K_1 + K_2}{2}$                       (D)  $\frac{K_1 + 3K_2}{4}$

Sol. D



$$K_{eq} = \frac{K_1 A_1 + K_2 A_2}{A_1 + A_2}$$

$$= \frac{K_1 (\pi R^2) + K_2 (3\pi R^2)}{4\pi R^2}$$

$$= \frac{K_1 + 3K_2}{4}$$

12. The least count of the main scale of a screw gauge is 1 mm. The minimum number of divisions on its circular scale required to measure 5  $\mu\text{m}$  diameter of a wire is :

- (A) 50                      (B) 100                      (C) 500                      (D) 200

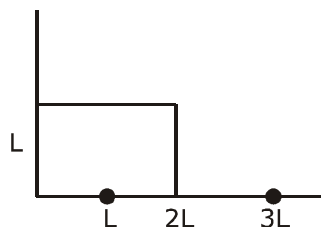
Sol. D

$$\text{Least count} = \frac{\text{Pitch}}{\text{Number of division on circular scale}}$$

$$5 \times 10^{-6} = \frac{10^{-3}}{N}$$

$$N = 200$$

13. The position vector of the centre of mass  $\vec{r}_{cm}$  of an asymmetric uniform bar of negligible area of cross-section as shown in figure is :



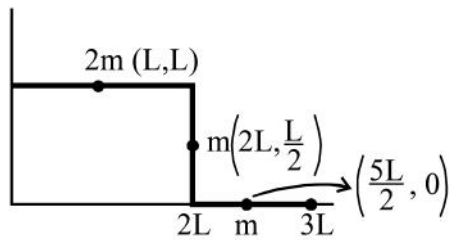
(A)  $\vec{r}_{cm} = \frac{5}{8}L\hat{x} + \frac{13}{8}L\hat{y}$

(B)  $\vec{r}_{cm} = \frac{11}{8}L\hat{x} + \frac{3}{8}L\hat{y}$

(C)  $\vec{r}_{cm} = \frac{13}{8}L\hat{x} + \frac{5}{8}L\hat{y}$

(D)  $\vec{r}_{cm} = \frac{3}{8}L\hat{x} + \frac{11}{8}L\hat{y}$

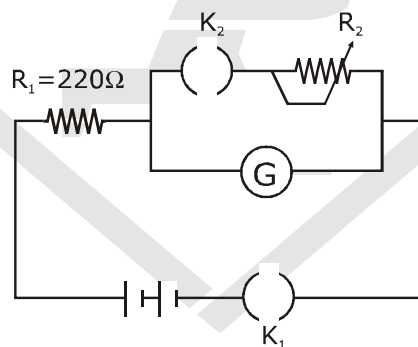
Sol. C



$$X_{cm} = \frac{2mL + 2mL + \frac{5mL}{2}}{4m} = \frac{13}{8}L$$

$$Y_{cm} = \frac{2m \times L + m \times \left(\frac{L}{2}\right) + m \times 0}{4m} = \frac{5L}{8}$$

14. The galvanometer deflection, when key  $K_1$  is closed but  $K_2$  is open, equals  $\theta_0$  (see figure). On closing  $K_2$  also and adjusting  $R_2$  to  $5\Omega$ , the deflection in galvanometer becomes  $\frac{\theta_0}{5}$ . The resistance of the galvanometer is, then, given by [Neglect the internal resistance of battery] :



- Sol. A (A)  $22\ \Omega$  (B)  $25\ \Omega$  (C)  $12\ \Omega$  (D)  $5\ \Omega$

Case I  $i_g = \frac{E}{220 + R_g} = C\theta_0 \dots(i)$

Case II

$$i_g \left( \frac{E}{220 + \frac{5R_g}{5 + R_g}} \right) \times \frac{5}{(R_g + 5)} = \frac{C\theta_0}{5} \dots(ii)$$

$$\Rightarrow \frac{5E}{225R_g + 1100} = \frac{C\theta_0}{5} \dots(ii)$$



$$\frac{E}{220 + R_g} = C\theta \quad \dots(i)$$

$$\Rightarrow \frac{225R_g + 1100}{1100 + 5R_g} = 5$$

$$\Rightarrow 5500 + 25R_g = 225R_g + 1100$$

$$200R_g = 4400$$

$$R_g = 22\Omega$$

15. An ideal battery of 4 V and resistance R are connected in series in the primary circuit of a potentiometer of length 1m and resistance 5Ω. The value of R, to give a potential difference of 5 mV across 10 cm of potentiometer wire, is :

(A) 395 Ω                      (B) 480 Ω                      (C) 495 Ω                      (D) 490 Ω

Sol. A

Let current flowing in the wire is i.

$$\therefore i = \left( \frac{4}{R + 5} \right) A$$

if resistance of 10m length of wire is x

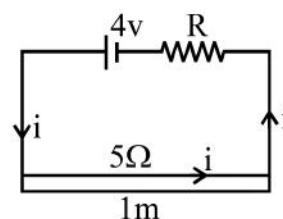
$$\text{then } x = 0.5\Omega = 5 \times \frac{0.1}{1} \Omega$$

$$\therefore \Delta V = \text{P.d. on wire} = i \cdot x$$

$$5 \times 10^{-3} = \left( \frac{4}{R + 5} \right) \cdot (0.5)$$

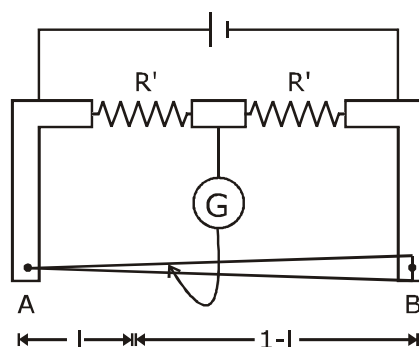
$$\therefore \frac{4}{R + 5} = 10^{-2} \text{ or } R + 5 = 400\Omega$$

$$\therefore R = 395\Omega$$



16. In a meter bridge, the wire of length 1m has a non-uniform cross-section such that, the variation  $\frac{dR}{dl}$

of its resistance R with length  $l$  is  $\frac{dR}{dl} \propto \frac{1}{\sqrt{l}}$ . Two equal resistances are connected as shown in the figure. The galvanometer has zero deflection when the jockey is at point P. What is the length AP?



(A) 0.35 m                      (B) 0.25 m                      (C) 0.3 m                      (D) 0.2 m

Sol. B

For the given wire :  $dR = C \frac{dl}{\sqrt{l}}$ , where C = constant.

Let resistance of part AP is  $R_1$  and PB is  $R_2$

$$\therefore \frac{R_1}{R_2} = \frac{R_1}{R_2} \text{ or } R_1 = R_2 \text{ By balanced}$$

WSB concept.

$$\text{Now } \int dR = c \int \frac{d\ell}{\sqrt{\ell}}$$

$$\therefore R_1 = C \int_0^{\ell} \ell^{-1/2} d\ell = C \cdot 2 \cdot \sqrt{\ell}$$

$$R_2 = C \int_0^{\ell} \ell^{-1/2} d\ell = C \cdot (2 - 2\sqrt{\ell})$$

Putting  $R_1 = R_2$

$$C_2 \sqrt{\ell} = C(2 - 2\sqrt{\ell})$$

$$\therefore 2\sqrt{\ell} = 1$$

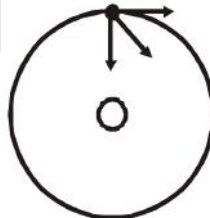
$$\sqrt{\ell} = \frac{1}{2}$$

$$\text{i.e. } \ell = \frac{1}{4} \text{ m} \Rightarrow 0.25 \text{ m}$$

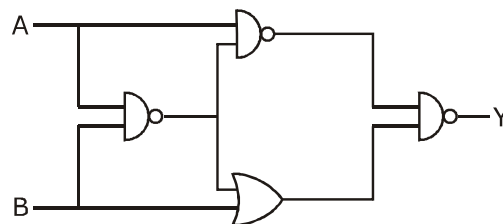
- 17.** A satellite of mass  $M$  is in a circular orbit of radius  $R$  about the centre of the earth. A meteorite of the same mass, falling towards the earth, collides with the satellite completely inelastically. The speeds of the satellite and the meteorite are the same, just before the collision. The subsequent motion of the combined body will be :  
 (A) in circular orbit of a different radius (B) such that it escapes to infinity  
 (C) in the same circular orbit of radius  $R$  (D) in an elliptical orbit

**Sol. D**

$$\begin{aligned} & m\hat{i} + m\hat{j} \\ &= 2m\hat{v}^{-1} \\ \vec{v} &= \frac{1}{\sqrt{2}} \times \sqrt{\frac{GM}{R}} \end{aligned}$$

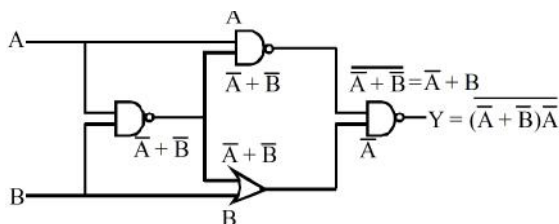


- 18.** The output of the given logic circuit is :



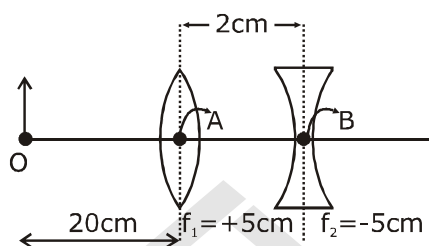
- (A)  $A\bar{B} + \bar{A}B$  (B)  $\bar{A}\bar{B}$  (C)  $AB + \bar{A}\bar{B}$  (D)  $A\bar{B}$

**Sol. D**



$$\begin{aligned}
 Y &= \overline{(\overline{A + B})\overline{A}} \\
 &= \overline{\overline{A} + \overline{AB}} \\
 &= A(\overline{AB}) \\
 &= A(A + \overline{B}) \\
 &= A + A\overline{B} = A\overline{B}
 \end{aligned}$$

19. What is the position and nature of image formed by lens combination shown in figure? ( $f_1, f_2$  are focal lengths)



- (A) 40 cm from point B at right ; real      (B)  $\frac{20}{3}$  cm from point B at right ; real  
 (C) 70 cm from point B at right ; real      (D) 70 cm from point B at left ; virtual

Sol.

**C**

For first lens

$$\frac{1}{v} - \frac{1}{-20} = \frac{1}{5}$$

$$v = \frac{20}{3}$$

For second lens

$$v = \frac{20}{3} - 2 = \frac{14}{3}$$

$$\frac{1}{V} - \frac{1}{14} = \frac{1}{-5}$$

$$V = 70\text{cm}$$

20. Let the moment of inertia of a hollow cylinder of length 30 cm (inner radius 10 cm and outer radius 20 cm), about its axis be I. The radius of a thin cylinder of the same mass such that its moment of inertia about its axis is also I is :

- (A) 12 cm      (B) 14 cm      (C) 18 cm      (D) 16 cm

Sol.

**D**

21. A person standing on an open ground hears the sound of a jet aeroplane, coming from north at an angle  $60^\circ$  with ground level. But he finds the aeroplane right vertically above his position. If  $v$  is the speed of sound, speed of the plane is :

- (A)  $\frac{2v}{\sqrt{3}}$       (B)  $\frac{\sqrt{3}}{2}v$       (C)  $v$       (D)  $\frac{v}{2}$

**Sol. D**

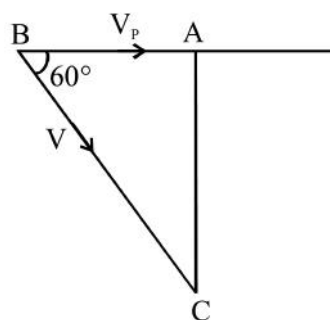
$$AB = V_p \times t$$

$$BC = V_t$$

$$\cos 60^\circ = \frac{AB}{BC}$$

$$\frac{1}{2} = \frac{V_p \times t}{Vt}$$

$$V_p = \frac{V}{2}$$



22. A particle of mass  $m$  moves in a circular orbit in a central potential field  $U(r) = \frac{1}{2}kr^2$ . If Bohr's quantization conditions are applied, radii of possible orbits and energy levels vary with quantum number  $n$  as :

(A)  $r_n \propto \sqrt{n}$ ,  $E_n \propto n$     (B)  $r_n \propto n$ ,  $E_n \propto n$     (C)  $r_n \propto \sqrt{n}$ ,  $E_n \propto \frac{1}{n}$     (D)  $r_n \propto n^2$ ,  $E_n \propto \frac{1}{n^2}$

**Sol. A**

$$F = \frac{dV}{dr} = kr = \frac{mv^2}{r}$$

$$mvr = \frac{nh}{2\pi}$$

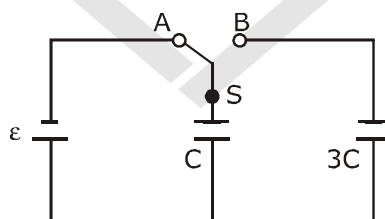
$$r^2 \propto n$$

$$r^2 \propto \sqrt{n}$$

$$E = \frac{1}{2}kr^2 + \frac{1}{2}mv^2 \propto r^2$$

$$\propto n$$

23. In the figure shown, after the switch 'S' is turned from position 'A' to position 'B', the energy dissipated in the circuit in terms of capacitance 'C' and total charge 'Q' is :



(A)  $\frac{3 Q^2}{4 C}$

(B)  $\frac{1 Q^2}{8 C}$

(C)  $\frac{3 Q^2}{8 C}$

(D)  $\frac{5 Q^2}{8 C}$

**Sol. C**

$$V_i = \frac{1}{2}CE^2$$

$$V_f = \frac{(CE)^2}{2 \times 4C} = \frac{1}{2} \frac{CE^2}{4}$$

$$\Delta E = \frac{1}{2}CE^2 \times \frac{3}{4} = \frac{3}{8}CE^2$$

24. A 100 V carrier wave is made to vary between 160 V and 40 V by a modulating signal. What is the modulation index?  
 (A) 0.4 (B) 0.6 (C) 0.3 (D) 0.5

Sol. B

$$\begin{array}{l|l} E_m + E_c = 160 & \mu = \frac{E_m}{E_c} = \frac{60}{100} \\ E_m + 100 = 160 & \\ E_m = 60 & \mu = 0.6 \end{array}$$

25. A particle A of mass 'm' and charge 'q' is accelerated by a potential difference of 50V. Another particle B of mass '4m' and charge 'q' is accelerated by a potential difference of 2500V. The ratio of de-Broglie wavelengths  $\frac{\lambda_A}{\lambda_B}$  is close to :  
 (A) 10.00 (B) 4.47 (C) 0.07 (D) 14.14

Sol. D

K.E. acquired by charge = K = qV

$$\lambda = \frac{h}{q} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mqV}}$$

$$\frac{\lambda_A}{\lambda_B} = \frac{\sqrt{2m_B q_B V_B}}{\sqrt{2m_A q_A V_A}} = \sqrt{\frac{4m.q.2500}{m.q.50}} = 2\sqrt{50}$$

$$= 2 \times 7.07 = 14.14$$

26. An ideal gas occupies a volume of 2m<sup>3</sup> at a pressure of 3×10<sup>6</sup> Pa. The energy of the gas is :  
 (A) 9×10<sup>6</sup>J (B) 6×10<sup>4</sup> J (C) 10<sup>8</sup> J (D) 3×10<sup>2</sup> J

Sol. A

$$\begin{aligned} \text{Energy} &= \frac{1}{2} nRT = \frac{f}{2} PV \\ &= \frac{f}{2} (3 \times 10^6)(2) \\ &= f \times 3 \times 10^6 \end{aligned}$$

Considering gas is monoatomic i.e. f = 3

$$E_r = 9 \times 10^6 \text{ J}$$

Option-(D)

27. Two electric bulbs, rated at (25 W, 220 V) and (100 W, 220V), are connected in series across a 220 V voltage source. If the 25 W and 100 W bulbs draw powers P<sub>1</sub> and P<sub>2</sub> respectively, then :  
 (A) P<sub>1</sub>=16W, P<sub>2</sub>=4W (B) P<sub>1</sub>=16W, P<sub>2</sub>=9W (C) P<sub>1</sub>=4W, P<sub>2</sub>=16W (D) P<sub>1</sub>=9W, P<sub>2</sub>=16W

Sol. A

$$R_1 = \frac{220^2}{25}$$

$$R_2 = \frac{220^2}{100}$$

$$L = \frac{220}{R_1 + R_2}$$

$$P_1 = i^2 R_1$$

$$P_2 = i^2 (R_2 = 4w)$$

$$= \frac{220^2}{\left(\frac{220^2}{25} + \frac{220^2}{100}\right)} \times \frac{220^2}{25}$$

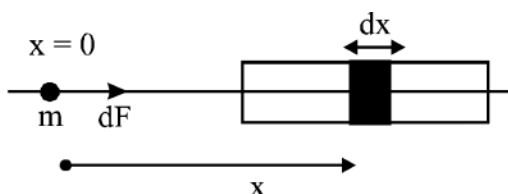
$$= \frac{400}{25} = 16W$$

28. A straight rod of length  $L$  extends from  $x=a$  to  $x=L+a$ . The gravitational force it exerts on a point mass ' $m$ ' at  $x=0$ , if the mass per unit length of the rod is  $A + Bx^2$ , is given by :

(A)  $Gm \left[ A \left( \frac{1}{a+L} - \frac{1}{a} \right) - BL \right]$       (B)  $Gm \left[ A \left( \frac{1}{a} - \frac{1}{a+L} \right) - BL \right]$

(C)  $Gm \left[ A \left( \frac{1}{a+L} - \frac{1}{a} \right) + BL \right]$       (D)  $Gm \left[ A \left( \frac{1}{a} - \frac{1}{a+L} \right) + BL \right]$

Sol. D



$$dm = (A + Bx^2)dx$$

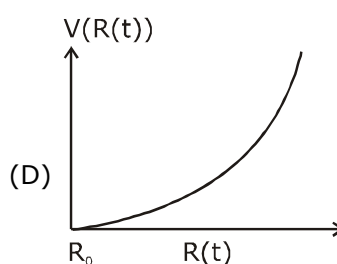
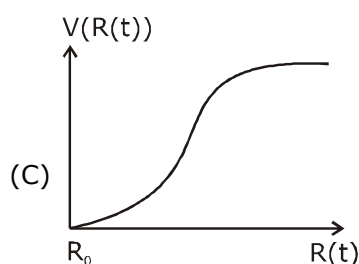
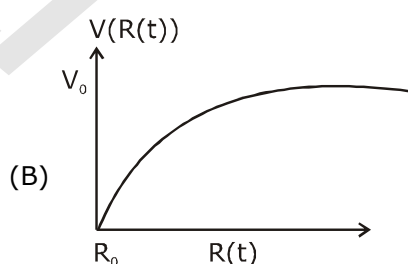
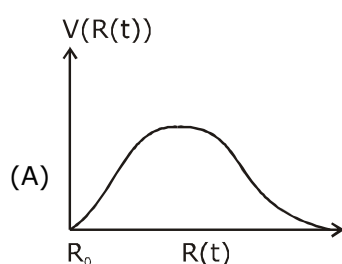
$$dF = \frac{GMdm}{x^2}$$

$$= F = \int_a^{a+L} \frac{GM}{x^2} (A + Bx^2) dx$$

$$= GM \left[ -\frac{A}{x} + Bx \right]_a^{a+L}$$

$$= GM \left[ A \left( \frac{1}{a} - \frac{1}{a+L} \right) + BL \right]$$

29. There is a uniform spherically symmetric surface charge density at a distance  $R_0$  from the origin. The charge distribution is initially at rest and starts expanding because of mutual repulsion. The figure that represents best the speed  $V(R(t))$  of the distribution as a function of its instantaneous radius  $R(t)$  is :



Sol. B

At any instant 't'  
Total energy of charge distribution is constant

$$\text{i.e. } \frac{1}{2} mV^2 + \frac{KQ^2}{2R} = 0 + \frac{KQ^2}{2R_0}$$

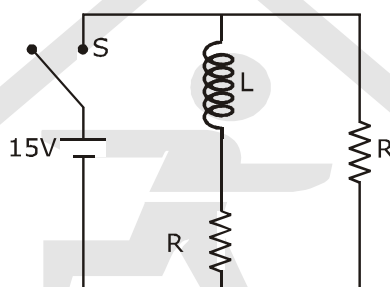
$$\therefore \frac{1}{2} mV^2 = \frac{KQ_0^2}{2R_0} - \frac{KQ^2}{2R}$$

$$\therefore V = \sqrt{\frac{2 KQ^2}{m} \cdot \left( \frac{1}{R_0} - \frac{1}{R} \right)}$$

$$\therefore V = \sqrt{\frac{KQ^2}{m} \cdot \left( \frac{1}{R_0} - \frac{1}{R} \right)} = C \sqrt{\frac{1}{R_0} - \frac{1}{R}}$$

Also the slope of v-s curve will go on decreasing  
∴ Graph is correctly shown by option (B)

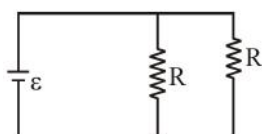
30. In the figure shown, a circuit contains two identical resistors, with resistance  $R=5\Omega$  and an inductance with  $L = 2\text{mH}$ . An ideal battery of  $15\text{ V}$  is connected in the circuit. What will be the current through the battery long after the switch is closed?



- (A) 6 A                      (B) 5.5 A                      (C) 3 A                      (D) 7.5A

Sol. A

Ideal inductor will behave like zero resistance long time after switch is closed



$$I = \frac{2\epsilon}{R} = \frac{2 \times 15}{5} = 6\text{A}$$