BITSAT - Paper 2021

Solved Paper

Question 1

The electric potential V is given as a function of distance × (metre) by $V = (5x^2 + 10x - 4)$ volt.
Value of electric field at x = 1m is

Options:

A. $-23V / m$

B. $11V / m$

C. $6V / m$

D. $-20V / m$

Answer: D

Solution:

Solution:
$V = 5x^2 + 10x - 4$
$E = \frac{-dV}{dx} = -(10x + 10)$.
At $x = 1m$, $E = -20V / m$.

Question 2

A proton moving with a velocity $3 \times 10^5 m / s$ enters a magnetic field of 0.3 tesla at an angle of 30° with the field. The radius of curvature of its path will be (e / m for proton $= 10^8 C / kg$)

Options:

A. 2 cm

B. 0.5 cm

C. 0.02 cm

D. 1.25 cm

Answer: A

Solution:

Solution:
given that
$v = 3 \times 10^5 m / s$, $B = 0.3T$, and $e / m = 10^8 C / kg$
$F = \frac{mv^2}{r} = qvB \sin\theta$
$r = \frac{mv}{qB \sin\theta} \{\because q / m = 10^8\}$
$r = \frac{3 \times 10^5}{10^8 \times 0.3 \sin 30}$
radius of curvature of its path
$r = 2cm$

Question 3

If force (F), length (L) and time (T) are assumed to be fundamental units, then the dimensional formula of the mass will be

Options:

A. $[FL^{-1}T^2]$

B. $[FL^{-1}T^{-2}]$

C. $[FL^{-1}T^{-1}]$

D. $[FL^2T^2]$

Answer: A

Solution:

Solution:
Let $m = KF^aL^bT^c$
Substituting the dimensions of
$[F] = [MLT^{-2}]$, $[L] = [L]$ and $[T] = [T]$ and
comparing both side, we get $m = FL^{-1}T^2$

Question 4

A metal disc of radius $100\,cm$ is rotated at a constant angular speed of $60\,rad / s$ in a plane at right angles to an external field of magnetic induction $0.05\,Wb / m^2$. The emf induced between the centre and a point on the rim will be

Options:

A. 3V

B. 1.5V

C. 6V

D. 9V

Answer: B

Solution:

Solution:
Induced emf produced between the centre and a point on the disc is given by
$e = \frac{1}{2}\omega BR^2$
$\omega = 60\,\text{rad} / \text{s}, B = 0.05\,\text{Wb} / \text{m}^2$
and $R = 100\,\text{cm} = 1\text{m}$
We get $e = \frac{1}{2} \times 60 \times 0.05 \times (1)^2 = 1.5\text{V}$

Question 5

A balloon is rising vertically up with a velocity of 29ms^{-1}. A stone is dropped from it and it reaches the ground in 10 seconds. The height of the balloon when the stone was dropped from it, was $(g = 9.8\text{ms}^{-2})$

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Options:

A. 100m

B. 200m

C. 400m

D. 150m

Answer: B

Solution:

Solution:
For stone to be dropped from rising balloon of velocity $29\text{m} / \text{s}, u = -29\text{m} / \text{s}, t = 10\,\text{sec}.$
$\therefore h = -29 \times 10 + \frac{1}{2} \times 9.8 \times 100$
$= -290 + 490 = 200\text{m}.$

Question 6

An alternating voltage $V = V_0 \sin \omega t$ is applied across a circuit. As a result, a current $I = I_0 \sin\left(\omega t - \frac{\pi}{2}\right)$ flows in it. The power consumed per cycle is

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Options:

A. zero

B. $0.5V_0I_0$

C. $0.707V_0I_0$

D. $1.414V_0I_0$

Answer: A

Solution:

Solution:
The phase angle between voltage V and current I is $\frac{\pi}{2}$.

Therefore, power factor $\cos\phi = \cos\left(\frac{\pi}{2}\right) = 0$.

Hence the power consumed is zero.

Question 7

A gun fires two bullets at 60° and 30° with horizontal. The bullets strike at some horizontal distance. The ratio of maximum height for the two bullets is in the ratio of

Options:

A. 2 : 1

B. 3 : 1

C. 4 : 1

D. 1 : 1

Answer: B

Solution:

Solution:
The bullets are fired at the same initial speed

$$\frac{H}{H'} = \frac{u^2\sin^2 60°}{2g} \times \frac{2g}{u^2\sin^2 30°} = \frac{\sin^2 60°}{\sin^2 30°}$$

$$= \frac{(\sqrt{3}/2)^2}{(1/2)^2} = \frac{3}{1}$$

Question 8

Green light of wavelength 5460Å is incident on an air-glass interface. If the refractive index of glass is 1.5, the wavelength of light in glass would be ($c = 3 \times 10^8 ms^{-1}$)

Options:

A. 3640Å

B. 5460Å

C. 4861Å

D. None of the above

Answer: A

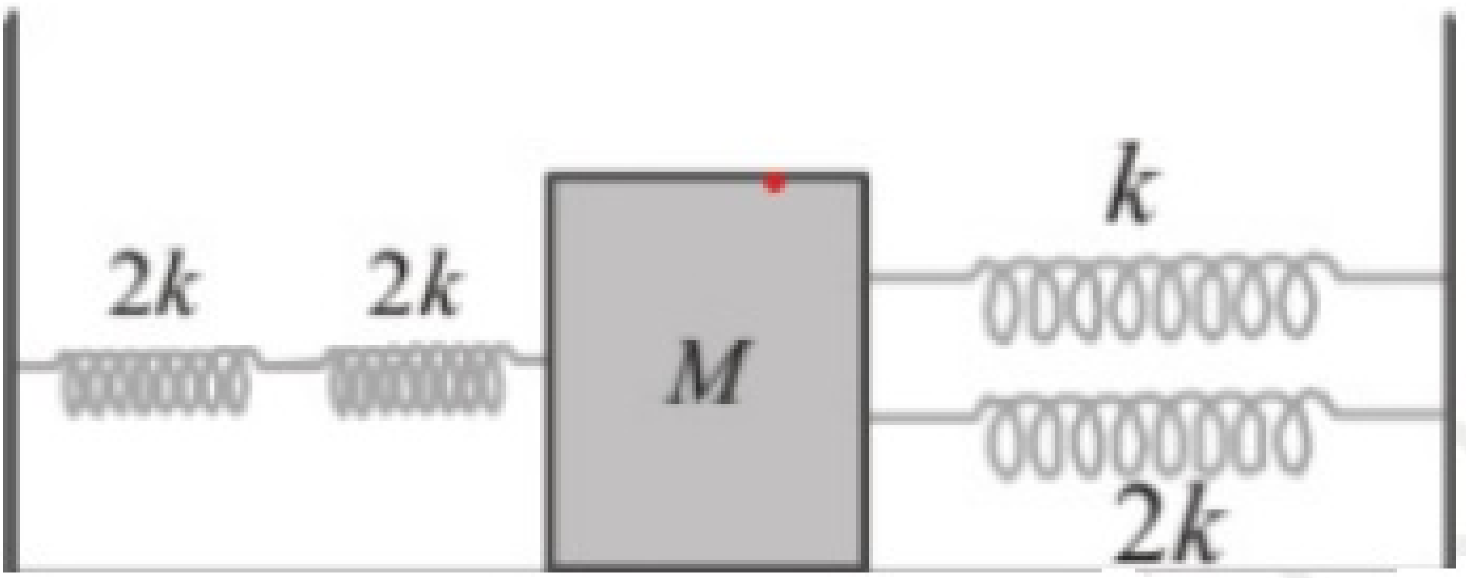
Solution:

Solution:

$a^{\lambda}g = \frac{\lambda_a}{\mu} = \frac{5460}{1.5} = 3640Å$

Question 9

Four massless springs whose force constants are 2k, 2k, k and 2k respectively are attached to a mass M kept on a frictionless plane (as shown in figure). If the mass M is displaced in the horizontal direction, then the frequency of the system



Options:

A. $\frac{1}{2\pi}\sqrt{\frac{4k}{M}}$

B. $\frac{1}{\pi}\sqrt{\frac{k}{M}}$

C. $\frac{1}{2\pi}\sqrt{\frac{k}{7M}}$

D. $\frac{1}{2\pi}\sqrt{\frac{7k}{M}}$

Answer: A

Solution:

Solution:
Two springs on the L.H.S. of mass M are in series and two springs on the R.H.S. of mass M are in parallel. These combinations of springs will be considered in parallel to mass M . Thus effective spring constant,

$K = \frac{2k \times 2k}{2k + 2k} + (k + 2k) = 4k$

$\therefore$ Frequency $v = \frac{1}{2\pi}\sqrt{\frac{K}{M}} = \frac{1}{2\pi}\sqrt{\frac{4k}{M}}$.

Question 10

Suppose the law of gravitational attraction suddenly changes and becomes an inverse cube law i.e. $F \propto \frac{1}{r^3}$, but still remaining a central force. Then

Options:

A. Kepler's law of area still holds

B. Kepler's law of period still holds

C. Kepler's law of area and period still holds

D. neither the law of area, nor the law of period still holds

Answer: A

Solution:

Solution:
According to kepler's law of area

$\frac{dA}{dt} = \frac{L}{2m}$

For central forces, torque = 0

$\therefore L =$ constant

$\therefore \frac{dA}{dt} =$ constant

Question 11

Three specimens A, B, C of same radioactive element has activities 1 microcurie, 1 rutherford and 1 becquerel respectively. Which specimen has maximum mass?

Options:

A. A

B. B

C. C

D. all have equal masses

Answer: B

Solution:

Solution:
1 becquerel $= 1\,\text{dis / s}$
1 rutherford $= 10^6\,\text{dis / s}$
1 curie $= 3.7 \times 10^{10}\,\text{dis / s}$

Question 12

A solenoid is 2m long and 3 cm in diameter. It has 5 layers of winding of 1000 turns each and carries a current of 5A. What is the magnetic field at its centre ? Use the standard value of μ_0.

Options:

A. $1.57 \times 10^{-4}\text{T}$

B. $2.57 \times 10^{-3}\text{T}$

C. $1.57 \times 10^{-2}\text{T}$

D. $3.57 \times 10^{-6}\text{T}$

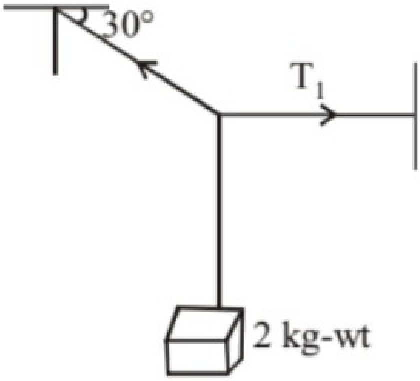
Answer: C

Solution:

Solution:
Length of solenoid, $l = 2\text{m}$
Total number of turns, $N = 5 \times 1000 = 5000$
Number of turns per unit length,
$n = \frac{N}{l} = \frac{5000}{2} = 2500\text{m}^{-1}$
Current, $I = 5\text{A}$
Now, $B = \mu_0 nI = 4\pi \times 10^{-7} \times 2500 \times 5\text{T}$
$= 1.57 \times 10^{-2}\text{T}$

Question 13

A body of weight 2 kg is suspended as shown in the figure. The tension T_1 in the horizontal string (in kg wt) is



Options:

A. $\frac{2}{\sqrt{3}}$

B. $\frac{\sqrt{3}}{2}$

C. $2\sqrt{3}$

D. 2

Answer: C

Solution:

Solution:
The tension in the above string can be divided into two components where the component opposite to weight will balance the weight while the component of this tension opposite to T_1 will be equal to T_1.
$T \sin\theta = 2\text{kgwt}$
$T \cos\theta = T_1$
The first equation gives
$T = 4\text{kgwt}$
So T_1 will be,
$T_1 = 2\sqrt{3}\text{kgwt}$

Question 14

A wire of a certain material is stretched slowly by ten per cent. Its new resistance and specific resistance become respectively:

Options:

A. 1.2 times, 1.3 times

B. 1.21 times, same

C. both remain the same

D. 1.1 times, 1.1 times

Answer: B

Solution:

Solution:
Let we have a wire of length l, cross-sectional area A, and Resistivity ρ
Then Resistance of wire is
$R = \rho \frac{l}{A} - (1)$
The volume of cylindrical wire is the product of its length and cross-sectional area.
$V = I . A$
If length is increased by 10 percent, the new length I' is
$I' = | + 10\% \text{ of } I = 1.1 \mid -(2)$
After stretching the cross-sectional area will also change, as volume remains constant. Let the new cross-sectional area be A'
$V = I . A = I' A' \ldots (3)$
Putting (2) in (3) we have
$I \cdot A = 1.1I \cdot A'$
$A' = \frac{A}{1.1} \ldots . (4)$
So, the Resistance of this stretched wire is
$R' = \rho \frac{l'}{A'} \cdots \quad (5)$
Putting (2) and (4) in (5)
$R' = \rho \left(\frac{1.1l}{A / 1.1} \right)$
$\Rightarrow R' = \rho \left(\frac{1.1 \times 1.1l}{A} \right)$
$\Rightarrow R' = \rho \left(\frac{1.21l}{A} \right)$
$\Rightarrow R' = 1.21 \left(\rho \frac{l}{A} \right) - (6)$
Comparing $Eq(6)$ and $Eq(1)$ We get $R' = 1.21R$
So, the resistance increases 1.21 times.

Question 15

The significant result deduced from the Rutherford's scattering experiment is that

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Options:

A. whole of the positive charge is concentrated at the centre of atom

B. there are neutrons inside the nucleus

C. α - particles are helium nuclei

D. electrons are embedded in the atom

Answer: A

Solution:

Solution:
The significant result deduced from the Rutherford's scatter ing is that whole of the positive charge is concentrated at the centre of atom i.e. nucleus.

Question 16

A ball of mass 0.2 kg is thrown vertically upwards by applying a force by hand. If the hand moves 0.2m while applying the force and the ball goes

upto 2m height further, find the magnitude of the force. (Consider $g = 10m / s^2$).

Options:

A. 4N

B. 16N

C. 20N

D. 22N

Answer: D

Solution:

Solution:
Let the velocity of the ball just when it leaves the hand is u then applying, $v^2 - u^2 = 2as$ for upward journey
$\Rightarrow -u^2 = 2(-10) \times 2$
$\Rightarrow u^2 = 40$
Again applying $v^2 - u^2 = 2as$ for the upward journey of the ball, when the ball is in the hands of the thrower,
$v^2 - u^2 = 2as$
$\Rightarrow 40 - 0 = 2(a)0.2$
$\Rightarrow a = 100m / s^2$
$\therefore F = ma = 0.2 \times 100 = 20N$
$\Rightarrow N - mg = 20$
$\Rightarrow N = 20 + 2 = 22N$

Question 17

A zener diode of voltage $V_Z(= 6V)$ is used to maintain a constant voltage across a load resistance $R_L(= 1000\Omega)$ by using a series resistance $R_s(= 100\Omega)$. If the e.m.f. of source is E (= 9V), what is the power being dissipated in Zener diode ?

Options:

A. 0.144 watt

B. 0.324 watt

C. 0.244 watt

D. 0.544 watt

Answer: A

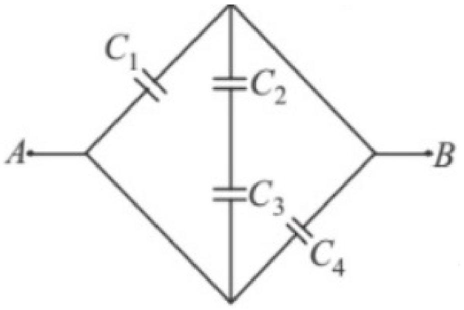
Solution:

Solution:
Here, $E = 9V$; $V_z = 6$; $R_L = 1000\Omega$
and $R_s = 100\Omega$,

Potential drop across series resistor
$V = E - V_Z = 9 - 6 = 3V$
Current through series resistance R_S is
$I = \frac{V}{R} = \frac{3}{100} = 0.03A$
Current through load resistance R_L is
$I_L = \frac{V_Z}{R_L} = \frac{6}{1000} = 0.006A$
Current through Zener diode is
$I_Z = I - I_L = 0.03 - 0.006 = 0.024$ amp.
Power dissipated in Zener diode is
$P_Z = V_Z I_Z = 6 \times 0.024 = 0.144$ Watt

Question 18

In a given network the equivalent capacitance between A and B is $C_1 = C_4 = 1\mu F$, $C_2 = C_3 = 2\mu F$.



Options:

A. 3μF

B. 6μF

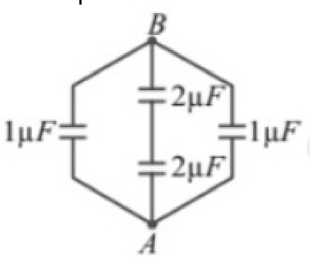
C. 4.5μF

D. 2.5μF

Answer: A

Solution:

Solution:
The equivalent circuit is shown in figure.



$C_{AB} = 1 + \frac{2 \times 2}{2 + 2} + 1$
$C_{AB} = 3\mu F$.

Question 19

In a simple pendulum of length I the bob is pulled aside from its equilibrium position through an angle θ and then released. The bob passes through the equilibrium position with speed

Options:

A. $\sqrt{2gl\,(1+\cos\theta)}$

B. $\sqrt{2gl\ \sin\theta}$

C. $\sqrt{2gl}$

D. $\sqrt{2gl\,(1-\cos\theta)}$

Answer: D

Solution:

Solution:
If l is length of pendulum and θ be angular amplitude then from principle of conservation of energy
(Initial total energy) $0 + mgh = \frac{1}{2}mv^2 + 0$ (Final total energy)
$\Rightarrow v = \sqrt{2gh} = \sqrt{2gl\,(1-\cos\theta)}$

Question 20

A moving coil galvanometer has resistance of 10Ω and full scale deflection of 0.01A. It can be converted into voltmeter of 10V full scale by connecting into resistance of

Options:

A. 9.90Ω in series

B. 10Ω in series

C. 990Ω in series

D. 0.10Ω

Answer: C

Solution:

Solution:
Let G be resistance of galvanometer and i_g the current through it. Let V is maximum potential difference, then from Ohm's law

$i_g = \dfrac{V}{G+R}$
$\Rightarrow R = \dfrac{V}{i_g} - G$
Given, $G = 10\Omega$, $i_g = 0.01A$
$V = 10$ volt

$\therefore R = \frac{10}{0.01} - 10 = 990\Omega$

Thus, on connecting a resistance R of 990Ω in series with the galvanometer, the galvanometer will become a voltmeter of range zero to $10V$.

For the voltmeter, a high resistance is series with the galvanometer and so the resistance of a voltmeter is very high compared to that of galvanometer.

Question 21

The frequency of whistle of an engine appears to be $(4 / 5)^{th}$ of initial frequency when it crosses a stationary observer. If the velocity of sound is $330m / s$, then the speed of engine will be

Options:

A. $30m / s$

B. $36.6m / s$

C. $40m / s$

D. $330m / s$

Answer: B

Solution:

Solution:

$n' = \frac{nv}{v - v_s}$ ....(1)

$n" = \frac{nv}{v + v_s}$ ....(2)

From (1) and (2), $\frac{n'}{n"} = \frac{v + v_s}{v - v_s}$ ....(3)

According to question, $\frac{n'}{n'} = \frac{5}{4}$

$v_s = ?v = 330m / s$ ....(4)

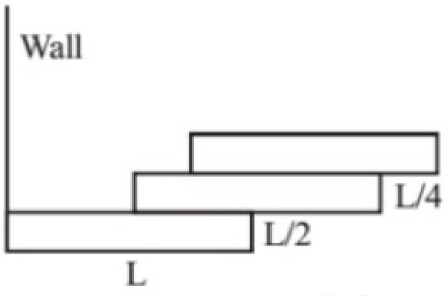
From eq. (3) and (4)

$\frac{5}{4} = \left[\frac{330 + v_s}{330 - v_s}\right] \Rightarrow 9v_s = 330$

$\therefore v_s = 36.6m / s$

Question 22

Three bricks each of length L and mass M are arranged as shown from the wall. The distance of the centre of mass of the system from the wall is



Options:

A. $\frac{L}{4}$

B. $\frac{L}{2}$

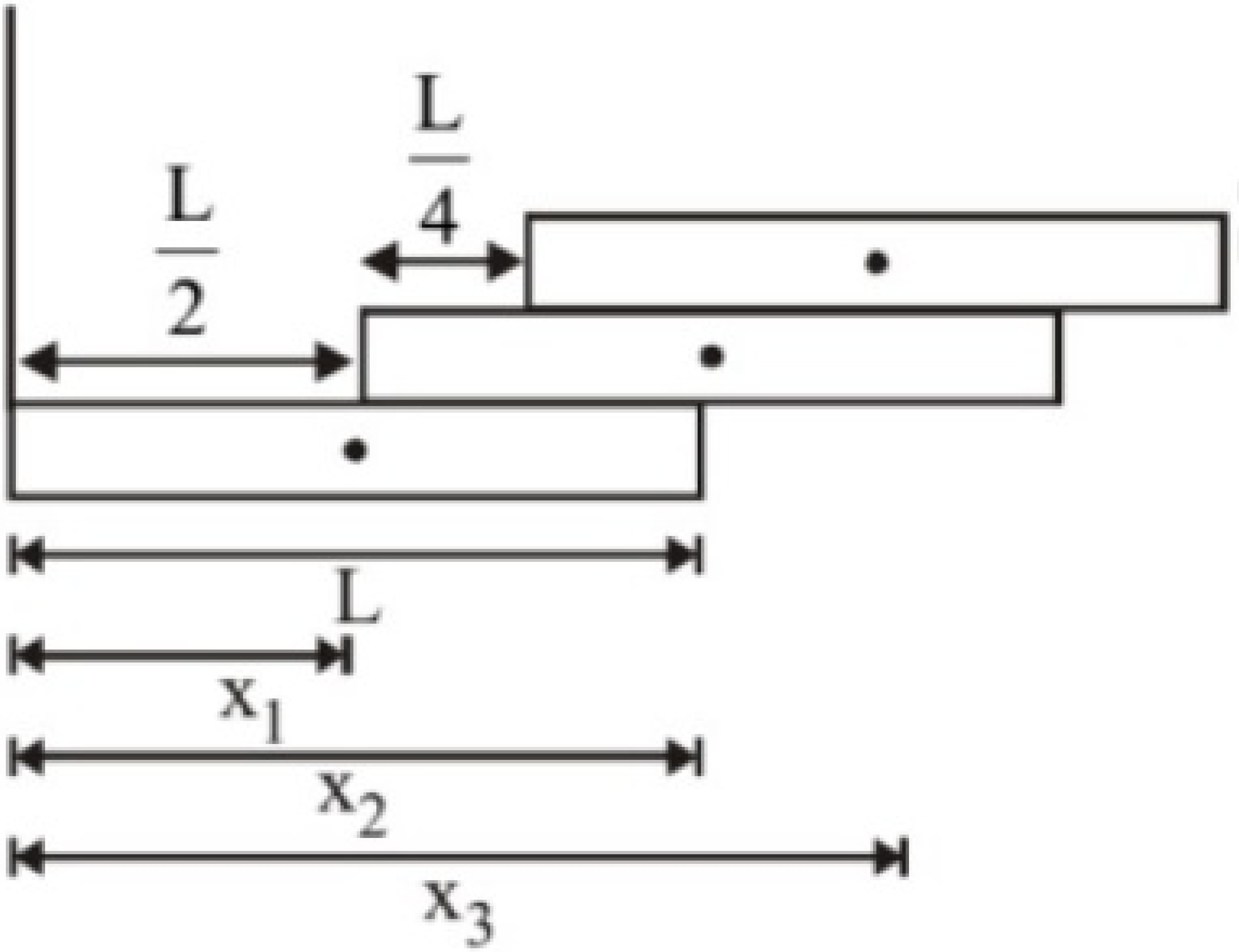
C. $\left(\frac{3}{2}\right)L$

D. $\left(\frac{11}{12}\right)L$

Answer: D

Solution:

Solution:



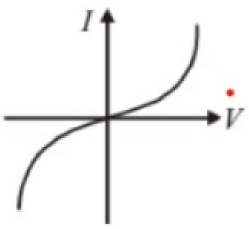
$x_1 = \frac{L}{2}, x_2 = L, x_3 = \frac{5L}{4}$

$\therefore x_{CM} = \frac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$

$= \frac{M \times \frac{L}{2} + M \times L + M \times \frac{5L}{4}}{M + M + M} = \frac{11L}{12}$

Question 23

The I − V characteristics shown in figure represents



Options:

A. ohmic conductors

B. non-ohmic conductors

C. insulators

D. superconductors

Answer: B

Solution:

Solution:
The figure is showing I − V characteristics of non ohmic or non linear conductors.

Question 24

The angle of dip at a place is 37° and the earth's magnetic field is 6×10^{-5}T. The earth's magnetic field at this place is $\left(\tan 37° = \frac{3}{4}\right)$

Options:

A. 7×10^{-5}T

B. 6×10^{-5}T

C. 5×10^{-5}T

D. 10^{-4}T

Answer: D

Solution:

Solution:

$\tan\theta = \frac{V}{H} = \frac{3}{4}\left[\because \tan 37° = \frac{3}{4}\right]$

$\therefore V = \frac{3}{4}H$

$V = 6 \times 10^{-5}T$

$H = \frac{4}{3} \times 6 \times 10^{-5}T = 8 \times 10^{-5}T$

$\therefore B_{total} = \sqrt{V^2 + H^2} = \sqrt{(36 + 64)} \times 10^{-5}$

$= 10 \times 10^{-5} = 10^{-4}T.$

Question 25

A round disc of moment of inertia I_2 about its axis perpendicular to its plane and passing through its centre is placed over another disc of moment of inertia I_1 rotating with an angular velocity ω about the same axis. The final angular velocity of the combination of discs is

Options:

A. $\frac{(I_1 + I_2)\omega}{I_1}$

B. $\frac{I_2\omega}{I_1 + I_2}$

C. ω

D. $\frac{I_1\omega}{I_1 + I_2}$

Answer: D

Solution:

Solution:
Angular momentum will be conserved
i.e., $I_1\omega = I_1\omega' + I_2\omega'$
$\Rightarrow \omega' = I_1\omega I_1 + I_2$

Question 26

For an RLC circuit driven with voltage of amplitude V_m and frequency $\omega_0 = \frac{1}{\sqrt{LC}}$ the current exhibits resonance the quality factor, Q is given by

Options:

A. $\frac{\omega_0}{L}$

B. $\frac{\omega_0 L}{R}$

C. $\frac{R}{\omega_0 C}$

D. $\frac{CR}{\omega_0}$

Answer: B

Solution:

Solution:

Question 27

The two ends of a rod of length L and a uniform cross-sectional area A are kept at two temperatures T_1 and $T_2 (T_1 > T_2)$. The rate of heat transfer, $\frac{dQ}{dt}$ through the rod in a steady state is given by:

Options:

A. $\frac{k(T_1 - T_2)}{LA}$

B. $kLA(T_1 - T_2)$

C. $\frac{kA(T_1 - T_2)}{L}$

D. $\frac{kL(T_1 - T_2)}{A}$

Answer: C

Solution:

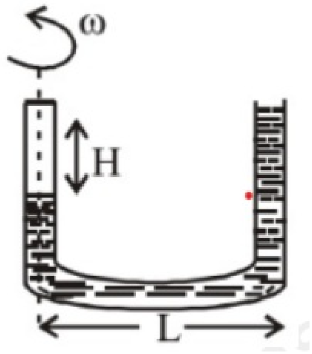
Solution:

$\frac{dQ}{dt} = \frac{kA(T_1 - T_2)}{L}$

[$(T_1 - T_2)$ is the temperature difference]

Question 28

A U - shaped tube contains a liquid of density rho and it is rotated about the left dotted line as shown in the figure.
Find the difference in the levels of liquid column.



Options:

A. $\frac{\omega^2 L^2}{2g}$

B. $\frac{\omega^2 L^2}{2\sqrt{2}g}$

C. $\frac{2\omega^2 L^2}{g}$

D. $\frac{2\sqrt{2}\omega^2 L^2}{g}$

Answer: A

Solution:

Solution:

Question 29

Monochromatic light of wavelength 667 nm is produced by a helium neon laser. The power emitted is 9 mW. The number of photons arriving per sec on the average at a target irradiated by this beam is:

Options:

A. 3×10^{16}

B. 9×10^{15}

C. 3×10^{19}

D. 9×10^{17}

Answer: A

Solution:

Solution:
$\lambda = 667 \times 10^{-9}\mathrm{m}$, $P = 9 \times 10^{-3}\mathrm{W}$
$P = \frac{Nhc}{\lambda}$, $N =$ No. of photons emitted/sec.

$$N = \frac{9 \times 10^{-3} \times 667 \times 10^{-9}}{6.6 \times 10^{-34} \times 3 \times 10^{8}} = 3 \times 10^{16} \text{ / sec}$$
