

SECTION - A

Q.1 Which of the following equations is dimensionally incorrect ?

Where t = time , h = height, s = surface tension , θ = angle, ρ = density, a, r = radius, g = acceleration due to gravity, v = volume, p = pressure, W = work done, Γ = torque, ϵ = permittivity, E electric field, J = current density, L = length.

(1) $W = \Gamma\theta$ (2) $J = \epsilon \frac{\partial E}{\partial t}$ (3) $h = \frac{2s \cos\theta}{\rho g}$ (4) $v = \frac{\pi p a^4}{8\eta L}$

Sol. 4

(1) $W = \tau\theta \rightarrow$ dimensionally correct

(2) $I_D = \epsilon \frac{d\phi}{dt}$

$\phi = E.A$

$\frac{d\phi}{dt} = A \frac{dE}{dt}$

$I_D = \epsilon A \frac{dE}{dt}$

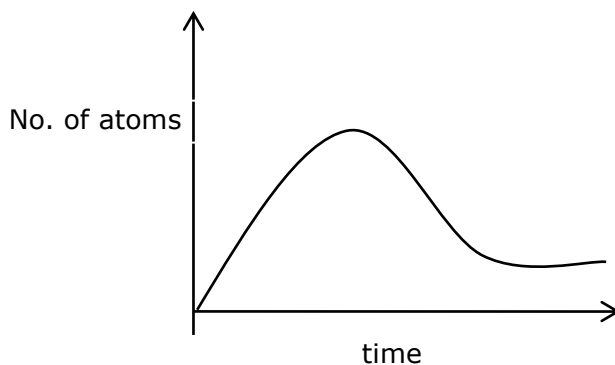
$J = \frac{I_D}{A} = \epsilon \frac{dE}{dt}$ dimensionally correct

(3) $h = \frac{2s \cos\theta}{\rho g}$ dimensionally correct

(4) $v = \frac{\pi p a^4}{8\eta L}$ dimensionally incorrect

Q.2 A sample of a radioactive nucleus A disintegrates to another radioactive nucleus B, which in turn disintegrates to some other stable nucleus C. Plot of a graph showing the variation of number of atoms of nucleus B versus time is :

(Assume that $t = 0$, there are B atoms in the sample)



(1)

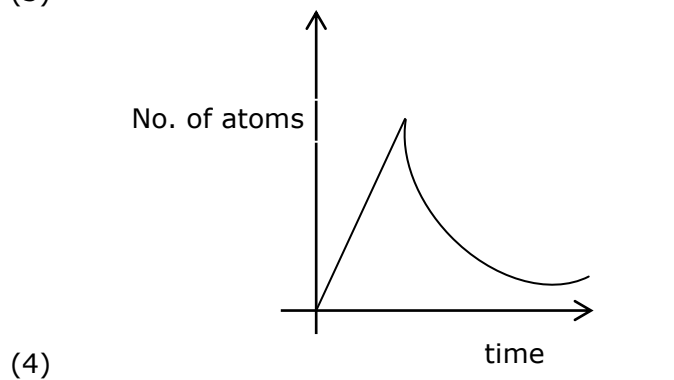
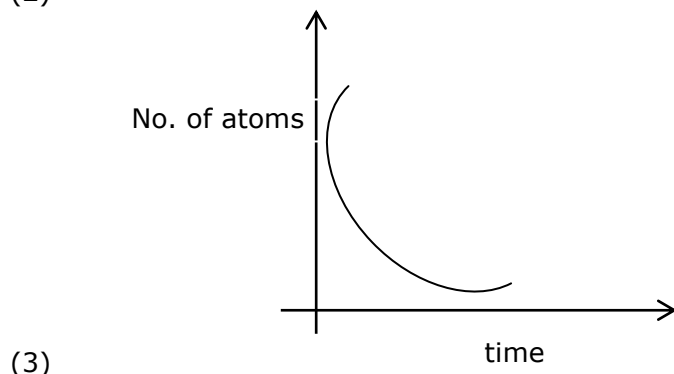
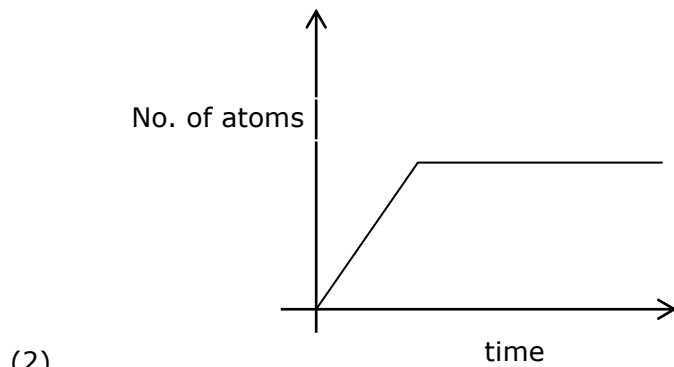


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Sol. 1

	A	→	B	→	C
$t = 0$	N_0		0		0
$t = t$	$N_0 e^{-\lambda t}$		N_B		N_C

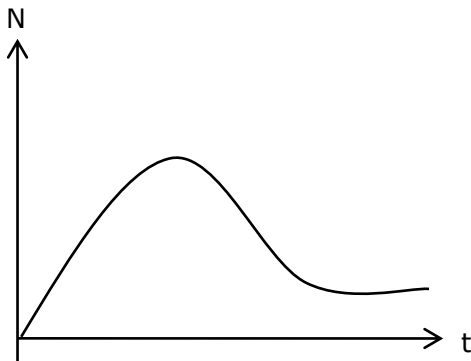


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Slope = $\frac{dN}{dt}$ = decay rate of A - decay rate of B

$$\frac{dN}{dt} = \lambda N_0 e^{-\lambda t} - \lambda N$$

Q.3 In an ac circuit, an inductor, a capacitor and a resistor are connected in series with $X_L = R = X_C$. Impedance of this circuit is :

- (1) R (2) $R\sqrt{2}$ (3) Zero (4) $2R^2$

Sol. 1

$$X_L = X_C = R$$

$$Z = \sqrt{(X_L - X_C)^2 + R^2}$$

$$Z = R$$

Q.4 For an ideal gas the instantaneous change in pressure 'p' with volume 'v' given by the equation

$\frac{dp}{dv} = -ap$. If $p = p_0$ at $v = 0$ is the given boundary condition, then the maximum temperature

one mole of gas can attain is :

(Here R is the gas constant)

- (1) Infinity (2) $\frac{p_0}{a eR}$ (3) 0°C (4) $\frac{ap_0}{eR}$

Sol. 2

$$\frac{dP}{dv} = -aP$$

$$\int_{p_0}^p \frac{dP}{P} = -a \int_0^v dV$$

$$\ln P - \ln P_0 = -aV$$

$$\ln \left(\frac{P}{P_0} \right) = -aV$$

$$P = P_0 e^{-aV}$$



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By Ideal gas Equation -

$$PV = nRT$$

$$P + V \frac{dp}{dv} = nR \frac{dT}{dv} \quad (\text{at } T_{\max} \rightarrow \frac{dT}{dv} = 0)$$

$$P - aVP = 0$$

$$P = + aPV$$

$$V = \frac{1}{a}$$

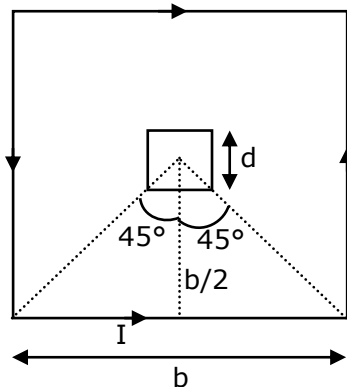
$$T = \frac{PV}{nR} = \left(\frac{1}{a}\right) \frac{P_0 e^{-a\left(\frac{1}{a}\right)}}{nR} = \frac{P_0 e^{-1}}{anR}$$

$$(n = 1 \rightarrow \text{one Mole gas}) \quad T = \frac{P_0}{aeR}$$

Q.5 A small square loop of side 'a' and one turn is placed inside a larger square loop of side b and one turn ($b \gg a$). The two loops are coplanar with their centres coinciding. If a current I is passed in the square loop of side 'b', then the coefficient of mutual inductance between the two loops is :

- (1) $\frac{\mu_0}{4\pi} 8\sqrt{2} \frac{b^2}{a}$ (2) $\frac{\mu_0}{4\pi} \frac{8\sqrt{2}}{b}$ (3) $\frac{\mu_0}{4\pi} 8\sqrt{2} \frac{a^2}{b}$ (4) $\frac{\mu_0}{4\pi} \frac{8\sqrt{2}}{a}$

Sol. 3



$$B = \frac{\mu_0 I}{4\pi R} (\sin \alpha + \sin \beta)$$

$$B = \frac{\mu_0 I}{4\pi(b/2)} (\sin 45^\circ + \sin 45^\circ) \times 4$$

$$B = \frac{2\mu_0 I}{\pi b} (\sqrt{2})$$

$$\phi = B.A$$

$$\phi = \frac{2\sqrt{2}\mu_0 I}{\pi b} a^2$$

$$\phi = \frac{8\sqrt{2}\mu_0 I a^2}{4\pi b}$$



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Q.6 Match List – I with List – II

List – I

- (a) Torque
- (b) Impulse
- (c) Tension
- (d) Surface Tension

List – II

- (i) MLT^{-1}
- (ii) MT^{-2}
- (iii) ML^2T^{-2}
- (iv) MLT^{-2}

Choose the most appropriate answer from the option given below :

- (1) (a) - (i), (b) - (iii), (c) - (iv), (d) - (ii)
- (2) (a) - (iii), (b) (i) , (c) - (iv), (d) - (ii)
- (3) (a) - (ii), (b) - (1), (c) - (iv), (d) - (iii)
- (4) (a) -(iii), (b) - (iv), (c) - (i) , (d) - (ii)

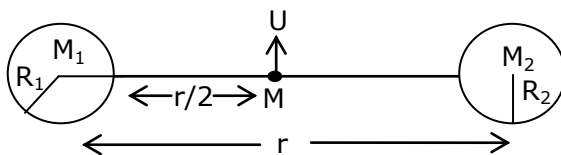
Sol. 2

- (a) Torque ($\vec{\tau}$) = $\vec{r} \times \vec{F} = L^1(M^1L^1T^{-2}) = M^1L^2T^{-2}$ (ii)
- (b) Surface Tension (T) = $\frac{F}{\ell} = \frac{M^1LT^{-2}}{L^1} = M^1L^0T^{-2}$ (iv)
- (c) Impulse ($I = \Delta P$) = $MV = M^1L^1T^{-1}$ (i)
- (d) Tension (T) = $F = M^1L^1T^{-2}$ (iii)

Q.7 The masses and radii of the earth and moon are (M_1, R_1) and (M_2, R_2) respectively. Their centres are at a distance 'r' apart. Find the minimum, escape velocity for a particle of mass 'm' to be projected from the middle of these two masses :

- (1) $v = \sqrt{\frac{4G(M_1 + M_2)}{r}}$ (2) $v = \frac{1}{2} \sqrt{\frac{2G(M_1 + M_2)}{r}}$
- (3) $v = \frac{\sqrt{2G(M_1 + M_2)}}{r}$ (4) $v = \frac{1}{2} \sqrt{\frac{4G(M_1 + M_2)}{r}}$

Sol. 1



$$K_i + U_i = K_o_x + U_o_x$$

$$\frac{1}{2}Mv^2 - \frac{GM_1M}{(r/2)} - \frac{GM_2M}{(r/2)} = 0$$

$$\frac{v^2}{2} \frac{2GM_1}{r} + \frac{GM_2}{r}$$

$$v = \sqrt{\frac{4G}{r}(M_1 + M_2)}$$



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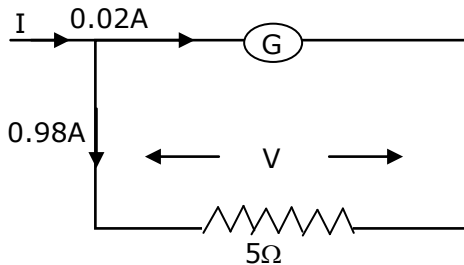
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Q.8 Consider a galvanometer shunted with 5Ω resistance and 2% of current passes through it. What is the resistance of the given galvanometer ?

- (1) 245Ω (2) 246Ω (3) 300Ω (4) 344Ω

Sol. 1



By Ohm's Law

$$V = I R$$

$$0.98 \times 5 = 0.02G$$

$$G = \frac{98 \times 5}{2} = 245\Omega$$

Q.9 A uniform heavy rod of weight 10 kg ms^{-2} , cross-sectional area 100 cm^2 and length 20 cm is hanging from a fixed support. Young modulus of the material of the rod is $2 \times 10^{11} \text{ Nm}^{-2}$. Neglecting the lateral contraction, find the elongation of rod due to its weight :

- (1) $4 \times 10^{-8} \text{ m}$ (2) $5 \times 10^{-10} \text{ m}$ (3) $5 \times 10^{-8} \text{ m}$ (4) $2 \times 10^{-9} \text{ m}$

Sol. 2

$$W = Mg = 10N$$

$$A = 100 \text{ cm}^2 = 100 \times 10^{-4} \text{ m}^2$$

$$L = 20\text{cm} = 20 \times 10^{-2} \text{ m}$$

$$Y = 2 \times 10^{11} \text{ N m}^{-2}$$

$$\text{Elongation of rod due to its own weight} = \frac{W\ell}{2Ay}$$

$$= \frac{10 \times 20 \times 10^{-2}}{2 \times 100 \times 10^{-4} \times 2 \times 10^{11}} = .5 \times 10^{-9} \text{ m}$$

$$= 5 \times 10^{-10} \text{ m}$$

Q.10 A reversible engine has efficiency of $\frac{1}{4}$. If the temperature of the sink is reduced by 58° C , its efficiency becomes double. Calculate the temperature of the sink :

- (1) 280°C (2) 382°C (3) 174°C (4) 180.4°C



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Sol. 174

Case - 1

$$n = 1 - \frac{T_L}{T_H}$$

$$\frac{1}{4} = \frac{T_H - T_L}{T_H}$$

$$T_H = 4T_H - 4T_L$$

$$T_L = \frac{3T_H}{4}$$

$$T_H = \frac{4T_L}{3}$$

Case - 2

$$2n = 1 - \frac{(T_L - 58)}{T_H}$$

$$2 \times \frac{1}{4} = \frac{T_H - T_L + 58}{T_H}$$

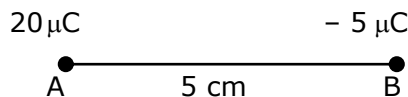
$$T_H = 2T_H - 2T_L + 116$$

$$\frac{4T_L}{3} = 2\left(\frac{4T_L}{3}\right) - 2T_L + 116$$

$$\frac{4T_L}{3} - \frac{8T_L}{3} + 2T_L = 116$$

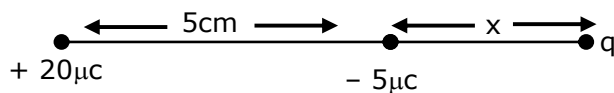
$$T_L = \frac{116 \times 3}{2} = 174^\circ\text{C}$$

Q.11 Two particles A and B having charges $20\mu\text{C}$ and $-5\mu\text{C}$ respectively are held fixed with a separation of 5 cm. At what position a third charged particle should be placed so that it does not experience a net electric force ?



- (1) At 5 cm from $20\mu\text{C}$ on the left side of system
- (2) At midpoint between two charges
- (3) At 1.25 cm from a $-5\mu\text{C}$ between two charges
- (4) At 5 cm from $-5\mu\text{C}$ on the right side

Sol. 4



$$\vec{F}_{\text{net}} = 0$$

$$\frac{K20 \times q}{(5+x)^2} = \frac{K5q}{x^2}$$

$$4x^2 = (5+x)^2$$

$$2x = 5 + x$$

$$X = 5\text{cm right of } -5\mu\text{C}$$



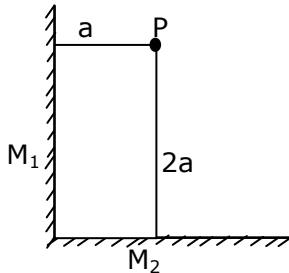
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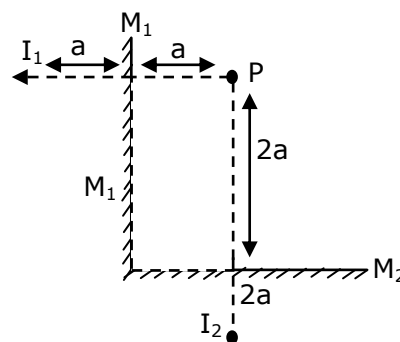


Q.12 Two plane mirrors M_1 and M_2 are at right angle to each other shown. A point source 'P' is placed at 'a' and '2a' meter away from M_1 and M_2 respectively. The shortest distance between the images thus formed is : (Take $\sqrt{5} = 2.3$)



- (1) $2\sqrt{10} a$ (2) $2.3a$ (3) $3a$ (4) $4.6a$

Sol. 4



Distance from object of Image I_1 & I_2

$$\begin{aligned}
 &= \sqrt{(2a + 2a)^2 + (a + a)^2} = \sqrt{20 a^2} \\
 &= 2\sqrt{5}a \\
 &= 4.6a \quad (\sqrt{5} = 2.3)
 \end{aligned}$$

Q.13 A coil having N turns is wound tightly in the form of a spiral with inner and outer radii 'a' and 'b' respectively. Find the magnetic field at centre, when a current I passes through coil :

- (1) $\frac{\mu_0 I}{8} \left[\frac{a+b}{a-b} \right]$ (2) $\frac{\mu_0 I}{8} \left(\frac{a-b}{a+b} \right)$
 (3) $\frac{\mu_0 I}{4(a-b)} \left[\frac{1}{a} - \frac{1}{b} \right]$ (4) $\frac{\mu_0 IN}{2(b-a)} \log_e \left(\frac{b}{a} \right)$



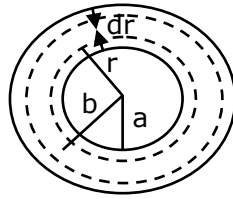
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Sol. No. of turns in thickness $(n) = \frac{N}{(b-a)} dr$



Magnetic field due to this circular coil of radius r at centre.

$$B = \int dB = \int \frac{n\mu_0 I}{2r}$$

$$B = \int \frac{N}{b-a} dr \left(\frac{\mu_0 I}{2r} \right)$$

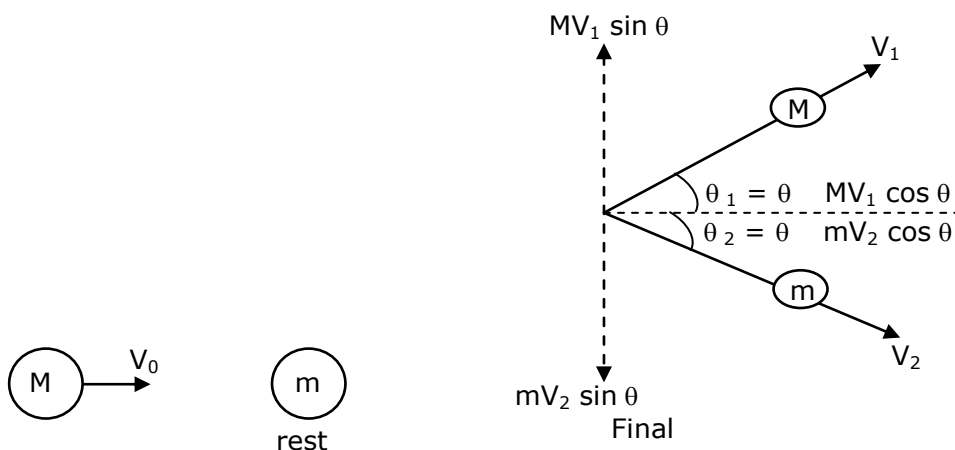
$$B = \frac{N\mu_0 I}{2(b-a)} \int_a^b \frac{dr}{r} = \frac{\mu_0 NI}{2(b-a)} \log_e \left(\frac{b}{a} \right)$$

$$B = \frac{\mu_0 NI}{2(b-a)} \log_e \left(\frac{b}{a} \right)$$

Q.14 A body of mass M moving at speed V_0 collides elastically with a mass ' m ' at rest. After the collision, the two masses at angles θ_1 and θ_2 with respect to the initial direction of motion of the body of mass M . The largest possible value of the ratio M/m , for which the angles θ_1 and θ_2 will be equal, is :

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

Sol. 4



Initial

By linear momentum conservation

In y - direction $P_i = P_f$



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$$0 = MV_1 \sin\theta - mV_2 \sin\theta$$

$$MV_1 = mV_2$$

$$V_1 = \frac{mV_2}{M} \dots\dots\dots(1)$$

In x - direction

$$P_i = MV_0$$

$$P_f = MV_1 \cos\theta + mV_2 \cos\theta$$

$$P_i = P_f$$

For elastic Collision, $e = 1$ $MV_0 = MV_1 \cos\theta + mV_2 \cos\theta \dots\dots\dots(2)$

Collision, $e = 1$

Along common normal $e = \frac{V_2 - V_1}{u_1 - u_2} = \frac{V_2 - V_1 \cos 2\theta}{V_0 \cos \theta - 0}$

$$1 = \frac{V_2 - V_1 \cos 2\theta}{V_0 \cos \theta}$$

$$V_0 \cos \theta = V_2 - V_1 \cos 2\theta$$

$$V_0 \cos \theta = V_2 - \frac{mV_2}{M} \cos 2\theta$$

$$V_0 \cos \theta = V_2 \left(1 - \frac{m}{M} \cos 2\theta\right) \dots\dots\dots(3)$$

By Eq. (1) & (2) $MV_0 = M\left(\frac{mV_2 \cos \theta}{M}\right) + mV_2 \cos \theta$

$$MV_0 = 2m V_2 \cos \theta$$

$$V_2 = \frac{MV_0}{2m \cos \theta} \dots\dots\dots(4)$$

By Eq. (3) & (4)

$$V_0 \cos \theta = \frac{MV_0}{2m \cos \theta} \left(1 - \frac{m}{M} \cos \theta\right)$$

$$2mV_0 \cos^2 \theta = MV_0 - mV_0 \cos 2\theta$$

$$2m \cos^2 \theta + m \cos 2\theta = M$$

$$\frac{2M \cos^2 \theta}{M} + \frac{m \cos 2\theta}{m} = \frac{M}{m}$$

$$2 \cos^2 \theta + 2 \cos^2 \theta - 1 = \frac{M}{m} \quad \text{For } \frac{M}{m} \rightarrow \max$$

$$4 \cos^2 \theta - 1 = \frac{M}{m} \quad \cos \theta = 1$$

$$\frac{M}{m} = 4 - 1 = 3 \quad \theta = 0$$



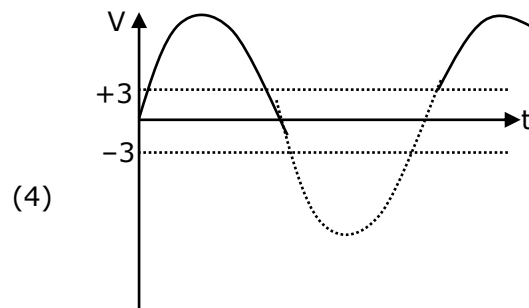
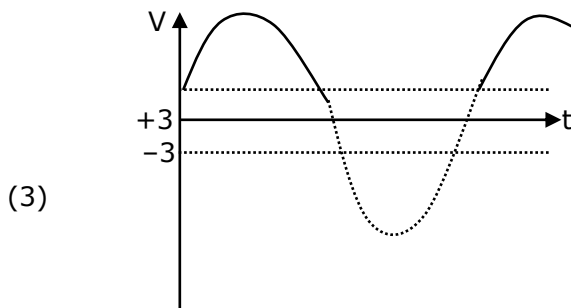
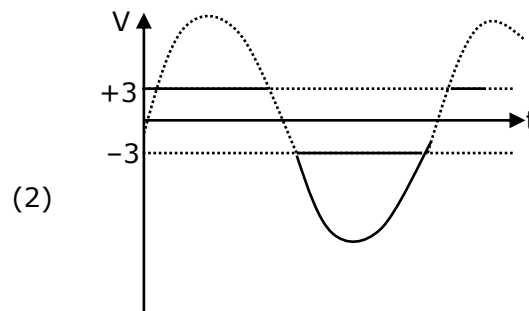
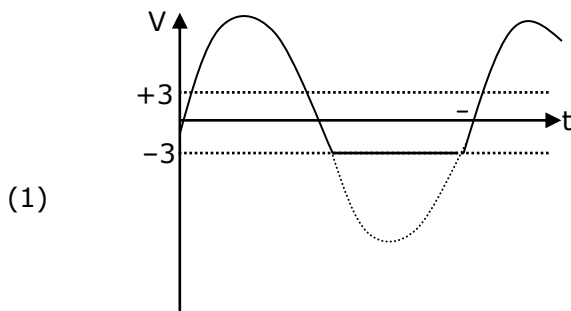
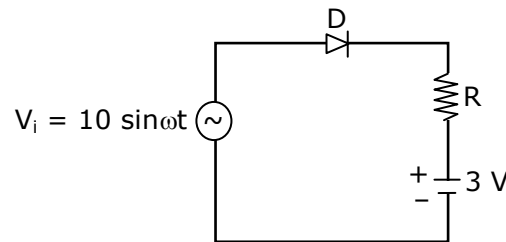
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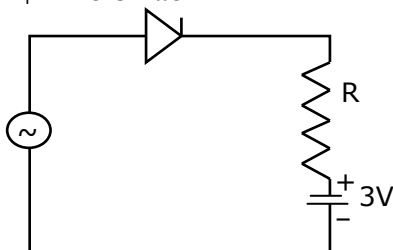
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Q.15 Choose the correct waveform that can represent the voltage across R of the following circuit, assuming the diode is ideal one :



Sol. NTA - 3
Motion - 1
 $V_i = 10 \sin \omega t$



In Forward bias current will flow in reversed bias current does no flow.

Q.16 A moving parton and electron have the same de-Broglie wavelength. If K and P denote the K.E. and momentum respectively. Then choose the correct option :

- (1) $K_p < K_e$ and $P_p < P_e$ (2) $K_p = K_e$ and $P_p = P_e$
 (3) $K_p > K_e$ and $P_p = P_e$ (4) $K_p < K_e$ and $P_p = P_e$



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Sol. 4

$$M_p > M_e$$

$$\lambda_e = \lambda_p$$

$$p = \frac{h}{\lambda}$$

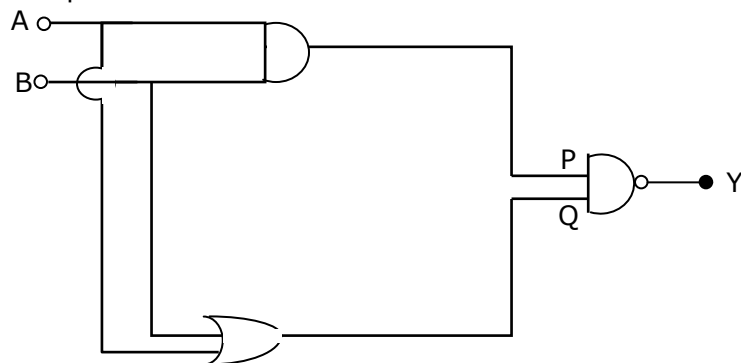
$$P_e = P_p$$

$$h = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$$

$$KE \propto \frac{1}{M}$$

$$KE_e > KE_p$$

Q.17 In the following logic circuit the sequence of the inputs A, B are (0, 0), (0, 1), (1, 0) and (1,1). The output Y for this sequence will be :



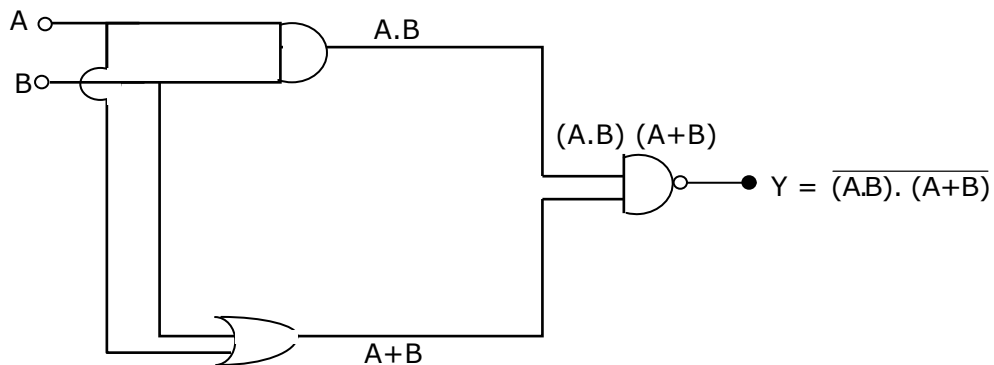
(1) 0, 1, 0, 1

(2) 1, 0, 1, 0

(3) 0, 0, 1, 1

(4) 1, 1, 1, 0

Sol. 4



By truth table

A	B	A.B	A+B	(A.B) (A+B)	$Y = \overline{(A.B) \cdot (A+B)}$
0	0	0	0	0	1
0	1	0	1	0	1
1	0	0	1	0	1
1	1	1	1	1	0



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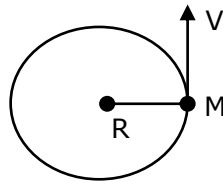
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- Q.18** Angular momentum of a single particle moving with constant speed along circular path :
- (1) change in magnitude but remains same in the direction
 - (2) is zero
 - (3) remains same in magnitude and direction
 - (4) remains same in magnitude but changes in the direction

Sol. 3



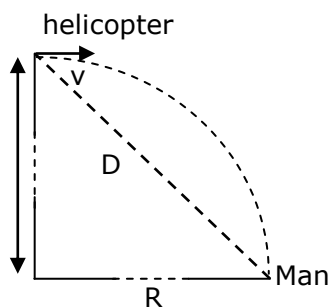
$$\vec{L} = M (\vec{R} \times \vec{V})$$

Direction and magnitude both remain same.

- Q.19** A helicopter is flying horizontally with a speed 'v' at an altitude 'h' has to drop a food packet for a man on the ground. What is the distance of helicopter from the man when the food packet dropped ?

- (1) $\sqrt{2ghv^2 + h^2}$ (2) $\sqrt{\frac{2ghv^2 + 1}{h^2}}$ (3) $\sqrt{\frac{2v^2h}{g} + h^2}$ (4) $\sqrt{\frac{2gh}{v^2} + h^2}$

Sol. 3



$$R = \sqrt{\frac{2h}{g}} \cdot v$$

$$D = \sqrt{R^2 + h^2}$$

$$= \sqrt{\left(\sqrt{\frac{2h}{g}} \cdot v\right)^2 + h^2}$$

$$R = \sqrt{\frac{2h}{g}} \cdot v$$



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$$D = \sqrt{R^2 + h^2}$$

$$= \sqrt{\left(\sqrt{\frac{2h}{g}} \cdot v\right)^2 + h^2}$$

$$D = \sqrt{\frac{2hv^2}{g} + h^2}$$

Option (3) is correct

Q.20 An object is placed at the focus of concave lens having focal length f . What is the magnification and distance of the image from the optical centre of the lens ?

- (1) 1, ∞ (2) Very high, ∞ (3) $\frac{1}{2}, \frac{f}{2}$ (4) $\frac{1}{4}, \frac{f}{4}$

Sol. 3

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Object at Focus, $u = -f$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{-f}$$

$$-\frac{2}{f} = \frac{1}{v}$$

$$v = -\frac{f}{2}$$

$$\text{Magnification } m = \frac{v}{u} = \frac{-f/2}{-f} = \frac{1}{2}$$

SECTION - B

Q.1 The electric field in an electromagnetic wave is given by

$$E = (50 \text{ NC}^{-1}) \sin \omega(t - x/c)$$

The energy contained in a cylinder of volume V is $5.5 \times 10^{-12} \text{ J}$. The value of V is _____ cm^3 .
(given $\epsilon_0 = 8.5 \times 10^{-12} \text{ C}^2\text{N}^{-1}\text{m}^{-2}$)

Sol. 500

$$E = 50 \sin \omega \left(t - \frac{x}{c} \right)$$

$$\text{Energy} \rightarrow 5.5 \times 10^{-12} \text{ J}$$

$$\text{Energy density, } \frac{U}{V} = \frac{1}{2} \epsilon_0 E_0^2$$

$$\frac{U}{V} = \frac{1}{2} \times 8.85 \times 10^{-12} \times (50)^2 = 1.1 \times 10^{-8} \text{ J/m}^3$$

$$V = \frac{5.5 \times 10^{-12}}{1.1 \times 10^{-8}}$$

$$V = 5 \times 10^{-4} \text{ m}^3$$

$$V = 500 \text{ cm}^3$$



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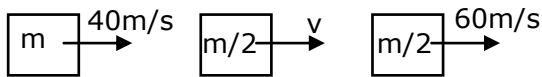
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Q.2 A block moving horizontally on a smooth surface with a speed of 40 ms^{-1} splits into two equal parts. If one of the parts moves at 60 ms^{-1} in the same direction, then the fractional change in the kinetic energy will be $x : 4$ where $x = \underline{\hspace{2cm}}$

Sol. 1



$$P_i = P_f$$

$$m \times 40 = \frac{m}{2} \times v + \frac{m}{2} \times 60$$

$$40 = \frac{v}{2} + 30$$

$$\Rightarrow v = 20$$

$$(\text{K.E.})_i = \frac{1}{2} m \times (40)^2 = 800m$$

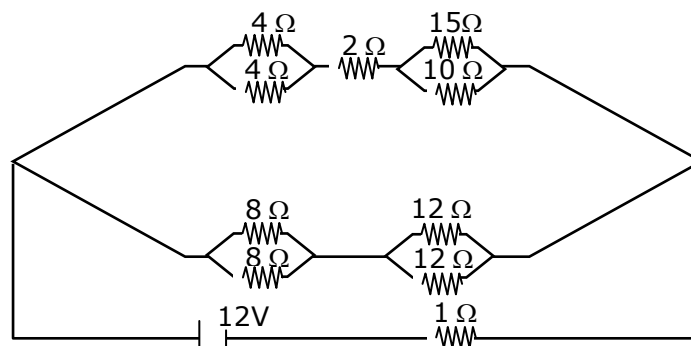
$$(\text{K.E.})_f = \frac{1}{2} \frac{m}{2} \cdot (20)^2 + \frac{1}{2} \cdot \frac{m}{2} (60)^2 = 1000m$$

$$|\Delta \text{K.E.}| = |1000m - 800m| = 200m$$

$$\frac{\Delta \text{K.E.}}{(\text{K.E.})_i} = \frac{200m}{800m} = \frac{1}{4} = \frac{x}{4}$$

$$x = 1$$

Q.3 The voltage drop across 15Ω resistance in the given figure will be _____ V.



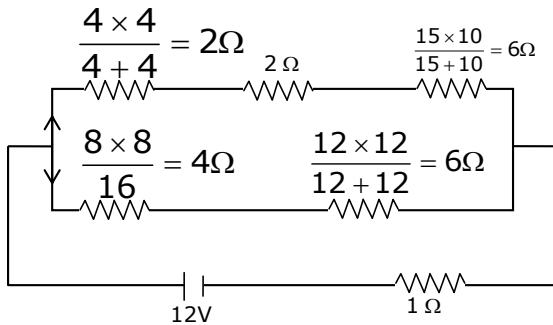
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Sol. 6

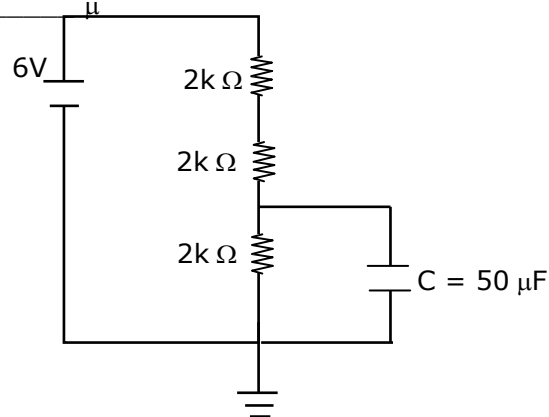


$$R = \frac{10 \times 10}{10 + 10} = 5 \Omega$$

$$I = \frac{V}{R_{eq}} = \frac{12}{6 + 1} = 2A$$

$$V_{15\Omega} = 6 \times 1 = 6V$$

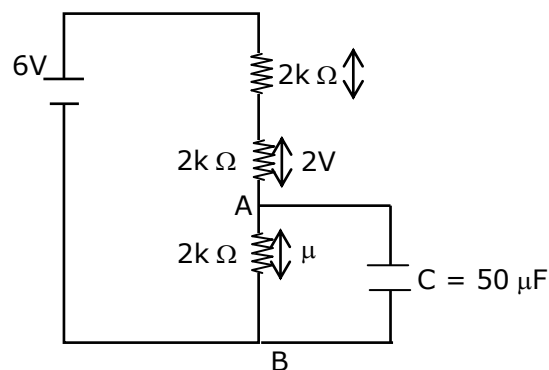
Q.4 A capacitor of $50 \mu F$ is connected in a circuit as shown in figure. The charge on the upper plate of the capacitor is



Sol. 100

In steady State Current is zero across capacitor p.d. across capacitor is

$$I = \frac{V}{R} = 10^{-3} A$$



$$V_{AB} = IR = 10^{-3} \times 2 \times 10^3 = 2V$$

$$Q = CV = 50 \times 2 = 100 \mu C$$



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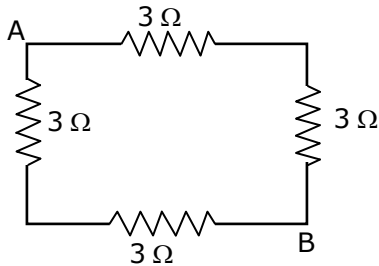
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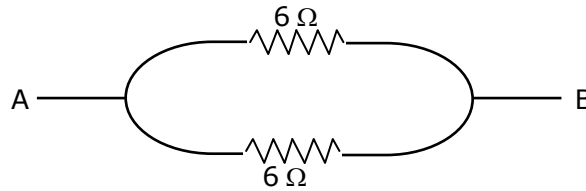


Q.5 A square shaped wire with resistance of each side 3Ω is bent to form a complete circle. The resistance between two diametrically opposite points of the circle in unit of Ω will be

Sol. 3



$$R_{eq} = \frac{6 \times 6}{6 + 6} = 3\Omega$$



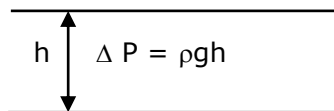
$$R_{AB} = \frac{6 \times 6}{6 + 6} = 3\Omega$$

Q.6 When a rubber ball is taken to a depth of _____ m in deep sea, its volume decreases by 0.5%

(The bulk modulus of rubber = $9.8 \times 10^8 \text{ Nm}^{-2}$
Density of sea water = 10^3 kgm^{-3} $g = 9.8 \text{ m/s}^2$)

Sol. 500

$$\text{given } -\frac{\Delta v}{v} = 0.5\% = \frac{0.5}{100}$$



$$\text{bulk modulus } (\beta) = -\frac{\Delta p}{\frac{\Delta v}{v}}$$

$$\beta = \frac{\rho gh}{\left(-\frac{\Delta v}{v}\right)} = \frac{10^3 \times 9.8 \times h}{\frac{0.5}{100}}$$

$$h = \frac{9.8 \times 10^8 \times 0.5}{9.8 \times 10^3 \times 100}$$

$$h = 500 \text{ M}$$

Q.7 If the sum of the heights of transmitting and receiving antennas in the line of sight of communication is fixed at 160 m, the the maximum range of LOS communication is _____ km.

(Take radius of Earth = 6400 km)



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Sol. 64

$$h_T + h_2 = 160 \text{ cm}$$

$$\text{LOS} = \sqrt{2R_e h_T} + \sqrt{2R_e h_2}$$

$$\text{LOS} = \sqrt{2R_e} (h_r + (160 - h_r))^{\frac{1}{2}}$$

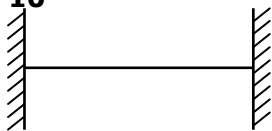
$$h_T = h_r = 60$$

$$\text{LOS} = \sqrt{2R} (\sqrt{0.8} + \sqrt{0.80})$$

$$= 2 \sqrt{2 \times 6400 \times 10^3 \times .80} = 64 \text{ KM}$$

Q.8 A wire having a linear mass density $9.0 \times 10^{-4} \text{ kg/m}$ is stretched between two rigid supports with a tension of 900 N. The wire resonates at a frequency of 500 Hz. The next higher frequency at which the same wire resonates is 550 Hz. The length of the wire is _____ m.

Sol. 10



$$f_0, 2f_0, 3f_0$$

$$m = 9 \times 10^{-4} \text{ kg/m}$$

$$T = 900 \text{ N}$$

$$V = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{900}{9 \times 10^{-4}}} = 1000 \text{ m/s}$$

$$f_n = \frac{nV}{2l} = 500$$

$$f_{n+1} = \frac{(n+1)V}{2l} = 550$$

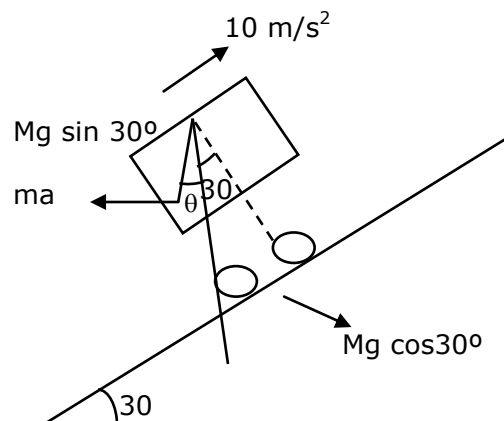
$$\Delta f = f_{n+1} - f_n = f_0 = 550 - 500 = 50 \text{ Hz}$$

$$\text{Fundamental frequency, } f_0 = \frac{1}{2l} \sqrt{\frac{T}{\mu}} = \frac{V}{2l}$$

$$l = \frac{V}{2f_0} = \frac{1000}{2 \times 50} = 10 \text{ m}$$

Q.9 A car is moving on a plane inclined at 30° to the horizontal with an acceleration of 10 ms^{-2} parallel to the plane upward. A bob is suspended by a string from the roof of the car. The angle in degree which the string makes with the vertical is _____.

Sol. 30



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$$\tan(\theta + 30^\circ) = \frac{Mg \sin 30^\circ + Ma}{Mg \cos 30^\circ} = \frac{5 + 10}{5\sqrt{3}} = \frac{1 + 2}{\sqrt{3}} = \sqrt{3}$$

$$\frac{\tan \theta + \tan 30^\circ}{1 - \tan 30^\circ \tan \theta} = \sqrt{3}$$

$$\tan \theta + \frac{1}{\sqrt{3}} = \sqrt{3} - \frac{\sqrt{3}}{\sqrt{3}} \tan \theta$$

$$2 \tan \theta = \sqrt{3} - \frac{1}{\sqrt{3}} = \frac{2}{\sqrt{3}}$$

$$\tan \theta = \frac{1}{\sqrt{3}}$$

$$\theta = 30^\circ$$

- Q.10** A particle of mass 1 kg is hanging from a spring of force constant 100 Nm^{-1} . The mass is pulled slightly downward and released so that it executes free simple harmonic motion with time period T . The time when the kinetic energy and potential energy of the system will become equal, is $\frac{T}{x}$. The value of x is _____.

Sol. 8

$$K E = P E$$

$$\frac{1}{2} k A^2 - \frac{1}{2} k x^2 = \frac{1}{2} k x^2$$

$$A^2 = 2x^2$$

$$x = \pm \frac{A}{\sqrt{2}}$$

$$x = A \sin \omega t$$

$$\frac{A}{\sqrt{2}} = A \sin \frac{2\pi}{T} t$$

$$\frac{2\pi}{T} t = \frac{\pi}{4}$$

$$T = \frac{T}{8} \text{ sec}$$

$$x = 8 \text{ sec}$$



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