1 Value of force F = Asin(Bt) + Ccos(Dx) find dimension of $\frac{AB}{D}$

(1) ML^3T^{-1} (2) ML^2T^{-3} (3) ML^1T^{-3} (4) ML^2T^3

Ans. (2)

Sol. Dimension of A= MLT^{-2} , B = T^{-1}, D = L^{-1}

$$\text{Dim} = \frac{AB}{D} = \frac{MLT^{-2}T^{-1}}{L^{-1}} = ML^2T^{-3}$$

2 Force is given by $F = (5y + 20)\hat{j}$ Find work done for moving particle from y = 0 to y = 5 :

(1) 162.5 J (2) 165 J (3) 132.5 J (4) 140.5 J

Ans. (1)

Sol. $w = \int F.dy$

$$w = \int_0^5 (5y+20)dy$$

$$= \left[\frac{5y^2}{2} + 20y\right]_0^5 \Rightarrow \frac{5\times 25}{2} + 100 = 162.5 \text{ J}$$

3 A hot air balloon is ascending with constant velocity of 10 m/s. when balloon reaches a height of 75 m, a stone is dropped from balloon. what will be the height of balloon, when stone reaches earth?

(1) 125 m. (2) 135 m. (3) 140 m. (4) 145 m.

Ans. (1)

Sol. For stone

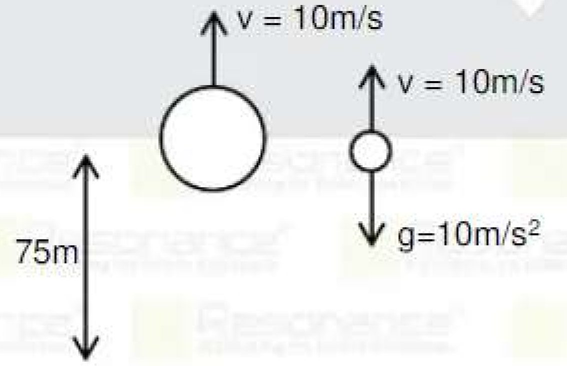
$75 = -10t + \frac{1}{2}gt^2$

$75 = -10t + 5t^2$

$t^2 - 2t - 15 = 0$

t = 5 sec.

Height of balloon



4. Relation between position and time of a particle moving along straight line is given by $t = x + 3x^2$. Find acceleration of particle at t = 10s

(1) $\frac{-5}{1331}$ (2) $\frac{6}{1331}$ (3) $\frac{-6}{1331}$ (4) $\frac{5}{1331}$

Ans. (3)

Sol. $t = x + 3x^2 \quad ...(1)$

$$1 = \frac{dx}{dt} + 6x\frac{dx}{dt} \Rightarrow v = \frac{1}{(1+6x)}$$

$$0 = \frac{d^2x}{dt^2} + 6\left(x\frac{d^2x}{dt^2} + \left(\frac{dx}{dt}\right)^2\right)$$

$$0 = a + 6xa + 6v^2$$

$$a = \frac{-6v^2}{(1+6x)} \quad ...(2)$$

$$a = -\frac{6}{(1+6x)^3}$$

From equation ....(1)

$$10 = x + 3x^2$$

$$3x^2 + x - 10 = 0$$

$$3x^2 + 6x - 5x - 10 = 0$$

$$3x(x+2) - 5(x+2)$$

$$(3x-5)(x+2) \Rightarrow x = \frac{5}{3}$$

From equation (2)

$$a = \frac{-6}{\left(1+6\times\frac{5}{3}\right)^3} = \frac{-6}{1331}$$

5. Two particle of same mass & charges Q_1 and Q_2 are moving perpendicular to an uniform magnetic field where the ratio of charges is $\frac{Q_1}{...} = 1$ and ratio of velocities is $\frac{V_1}{...} = 3$ then find the ratio of the radius $\frac{R_1}{...}$

$$a = \frac{-6}{\left(1+6\times\frac{5}{3}\right)^3} = \frac{-6}{1331}$$

5. Two particle of same mass & charges Q_1 and Q_2 are moving perpendicular to an uniform magnetic field where the ratio of charges is $\frac{Q_1}{Q_2} = \frac{1}{2}$ and ratio of velocities is $\frac{V_1}{V_2} = \frac{3}{2}$ then find the ratio of the radius $\frac{R_1}{R_2}$:

(1) 2 : 1 (2) 3 : 1 (3) 4 : 1 (4) 1 : 1

Ans. (2)

Sol. Given

$$\frac{Q_1}{Q_2} = \frac{1}{2} \ \& \ \frac{V_1}{V_2} = \frac{3}{2}$$

$$R = \frac{mv}{qB}$$

$$\frac{R_1}{R_2} = \frac{V_1}{V_2} \times \frac{Q_2}{Q_1} = \frac{3}{2} \times \frac{2}{1} = \frac{3}{1}$$

6. A particle performing SHM with amplitude A. Find the ratio of kinetic energy and total energy when particle is at A/2

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

6. A particle performing SHM with amplitude A. Find the ratio of kinetic energy and total energy when particle is at A/2

(1) $\frac{3}{4}$ (2) $\frac{2}{3}$ (3) $\frac{4}{3}$ (4) $\frac{1}{2}$

Ans. **(1)**

Sol. $V_{A/2} = \omega\sqrt{A^2 - x^2}$

$$= \omega\sqrt{A^2 - \left(\frac{A}{2}\right)^2} = \omega\left(\frac{\sqrt{3}}{2}A\right)$$

$$= \frac{\sqrt{3}}{2}V_{max}$$

$$KE = \frac{1}{2}m\left(\frac{\sqrt{3}}{2}V_{max}\right)^2$$

$$TE = \frac{1}{2}m(V_{max})^2$$

$$\frac{KE}{TE} = \frac{3}{4} \quad \text{Ans.}$$

7. In photoelectric effect stopping potential is $3V_0$ for incident wave length λ_0 and stopping potential V_0 for incident wavelength $2\lambda_0$. Find threshold wavelength.

(1) $3\lambda_0$ (2) $2\lambda_0$ (3) $4\lambda_0$ (4) $8\lambda_0$

Ans. **(3)**

Sol. $KE = h\nu - W$

$$eV = \frac{hc}{\lambda} - W$$

For first case

$$e(3V_0) = \frac{hc}{\lambda_0} - W \quad \text{...(i)}$$

For second case

$$eV_0 = \frac{hc}{2\lambda_0} - W \quad \text{...(ii)}$$

From equation (i) and (ii)

$$W = \frac{hc}{4\lambda_0}$$

8. Efficiency of heat engine is $\eta = 1/6$. If temperature of sink is decreased by 62K, then efficiency becomes 1/3. Find temperature of source :

(1) 372K (2) 272K (3) 350K (4) 450K

Ans. **(1)**

Sol. $\eta = \left(1 - \frac{T_2}{T_1}\right)$

$$\frac{T_2}{T_1} = 1 - \eta = 1 - \frac{1}{6} \quad .....(1)$$

$$\frac{T_2 - 62}{T_1} = 1 - \frac{1}{3} \quad .....(2)$$

Equation $\frac{(1)}{(2)}$:

$$\Rightarrow \frac{T_2}{T_2 - 62} = \frac{5}{6} \times \frac{3}{2} = \frac{5}{4}$$

$\Rightarrow$ $T_2 = 5 \times 62$

From eq. (1)

$$T_1 = \frac{T_2}{1-\eta} = \frac{5 \times 62}{1 - \frac{1}{6}} = 5 \times 62 \times \frac{6}{5} = 372K$$

9. Activity of an element x becomes 1/8 of initial in 30 years. Find half-life :

(1) 10 Year. (2) 12 Year (3) 15 Year (4) 17 Year

Ans. **(1)**

Sol. $A = A_0 e^{-\lambda t}$

For half life

$A/2 = Ae^{-\lambda t_{1/2}}$

$\frac{1}{2} = e^{-\lambda t_{1/2}}$ .....(1)

9. Activity of an element x becomes 1/8 of initial in 30 years. Find half-life :

(1) 10 Year. (2) 12 Year (3) 15 Year (4) 17 Year

Ans. (1)

Sol. $A = A_0 e^{-\lambda t}$

For half life

$A/2 = Ae^{-\lambda t_{1/2}}$

$\frac{1}{2} = e^{-\lambda t_{1/2}}$ .....(1)

Given $1/8 = e^{-\lambda 30}$ .....(2)

Solving (1) and (2)

$e^{-3\lambda t_{1/2}} = e^{-\lambda 30}$

$T_{1/2} = 10$ Yrs.

10. If De-Broglie wavelengths of photon and electron are equal, what will be the ratio of kinetic energy of electron and energy of photon? Given that velocity of electron is v and velocity of light is c :

(1) $\frac{2v}{c}$ (2) $\frac{v}{2c}$ (3) $\frac{3v}{c}$ (4) $\frac{c}{3v}$

Ans. (2)

Sol. De-Broglie wavelength is given by $\lambda = \frac{h}{p}$

$KE_{pn} = mc^2 = pc$ ...(1)

$KE_e = \frac{1}{2}mv^2 = \frac{pv}{2}$ ...(2)

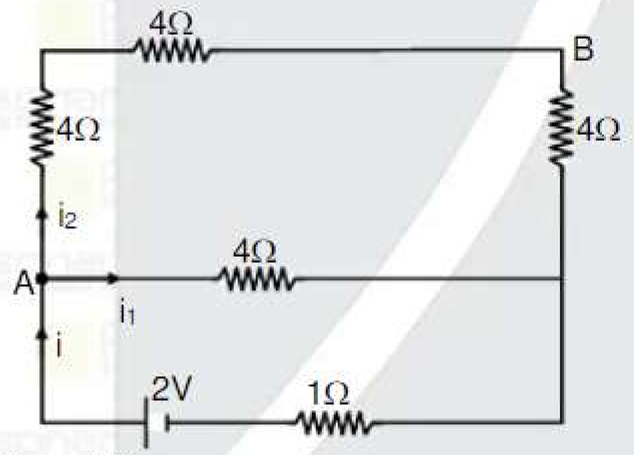
$\frac{KE_e}{KE_{pn}} = \frac{pv/2}{pc} = \frac{v}{2c}$

11. A square loop of total resistance 16Ω. If a battery of 2V and 1Ω internal resistance is connected across one of its side then find potential difference across its diagonal :

(1) 1V (2) 2V (3) 3V (4) 4V

Ans. (1)

Sol.



$V_{AB} = ??$

$R_{eq} = \frac{12 \times 4}{12 + 4} = 3$

11. A square loop of total resistance 16Ω. If a battery of 2V and 1Ω internal resistance is connected across one of its side then find potential difference across its diagonal :

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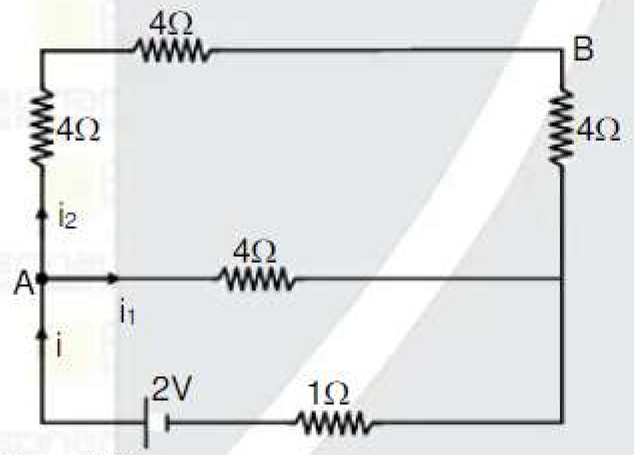

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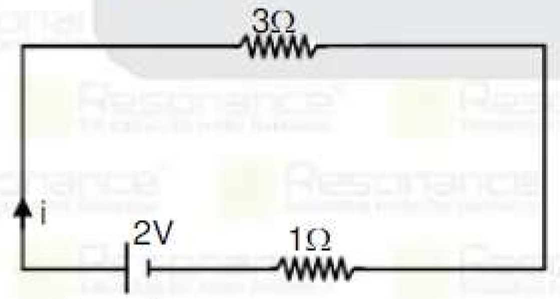


$$i = \frac{2}{3+1} = \frac{1}{2}\,A$$

$$i_2 = \frac{r_2}{r_2 + r_1} i = \frac{1}{3+1} \times \frac{1}{2} = \frac{1}{8}$$

$$V_{AB} = \frac{1}{8} \times 8 = 1V$$

12. $\vec{A}$ and $\vec{B}$ are two vectors such that $|\vec{A}| = 2$ and $|\vec{B}| = 5$. If $|\vec{A}\times\vec{B}| = 8$, then $|\vec{A}.\vec{B}| = ?$

(1) 2 (2) 6 (3) 7 (4) 9

Ans. (2)

Sol. $|\vec{A}\times\vec{B}| = |\vec{A}||\vec{B}|\sin\theta$

$\Rightarrow 10\sin\theta = 8$

$\sin\theta = \frac{4}{5}$

Now $|\vec{A}.\vec{B}| = |\vec{A}||\vec{B}|\cos\theta = 10\times\frac{3}{5} = 6$

13. Find significant figure for the value 0.00346.

(1) 5 (2) 4 (3) 3 (4) 2

Ans. (3)

Sol. There are 3 non zero digit after the decimal point so significant number is 3.

0.00346

14. For a prism, if angle of minimum deviation is equal to angle of prism. If refractive index of prism material is μ. Then angle of prism should be?

(1) $2\sin^{-1}\left(\frac{\mu}{2}\right)$ (2) $2\cos^{-1}\left(\frac{\mu}{2}\right)$ (3) $3\cos^{-1}\left(\frac{\mu}{2}\right)$ (4) $3\sin^{-1}\left(\frac{\mu}{2}\right)$

Ans. (2)

Sol. $\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

$\mu = \frac{\sin A}{\sin A/2}$

15. A photon of wavelength 500 nm falls on a metal surface of work function 1.3eV. An electron releases from metal moved in a perpendicular magnetic field. In a circular path of radius 30 cm. Then the magnitude of magnetic field will be ?

(1) 12.2 μT (2) 10.2 μT (3) 8.2 μT (4) 6.2 μT

Ans. **(1)**

Sol. $\frac{hc}{\lambda} = \phi + KE_{max}$

$\frac{1240}{500} = 1.3 + KE_{max}$

$KE_{max} = 1.18$ eV

Now $R = \frac{mv}{qB} = \frac{\sqrt{2mKE}}{qB}$

$B = \frac{\sqrt{2mKE}}{qR}$

$B = \frac{\sqrt{2\times 9.1\times 10^{-31}\times 1.18\times 1.6\times 10^{-19}}}{1.6\times 10^{-19}\times 30\times 10^{-2}}$

$B = 0.122 \times 10^{-4}$

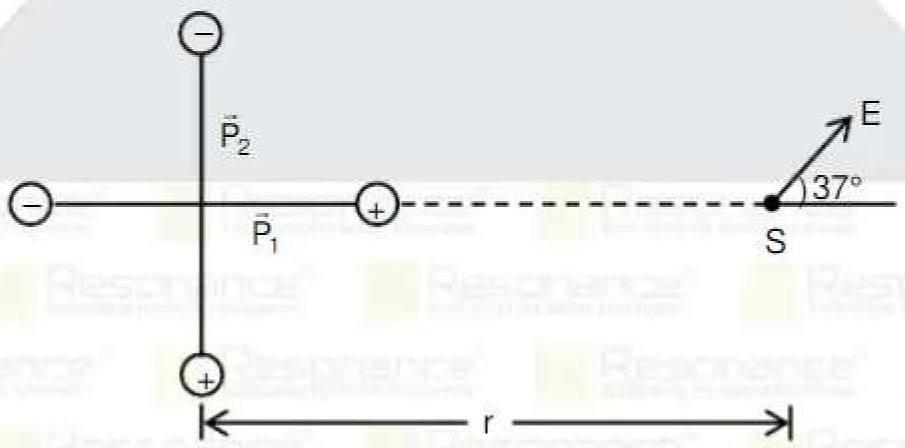
$B = 12.2 \times 10^{-6}$

i.e., $B = 12.2\ \mu T$

16. Two electric dipole $\vec{P}_1$ and $\vec{P}_2$ are kept as shown in figure. Net electric field at point S is E makes an angle 37° with $\vec{P}_1$ then find the ratio of $|\vec{P}_1|$ and $|\vec{P}_2|$.

i.e., B = 12.2 μT

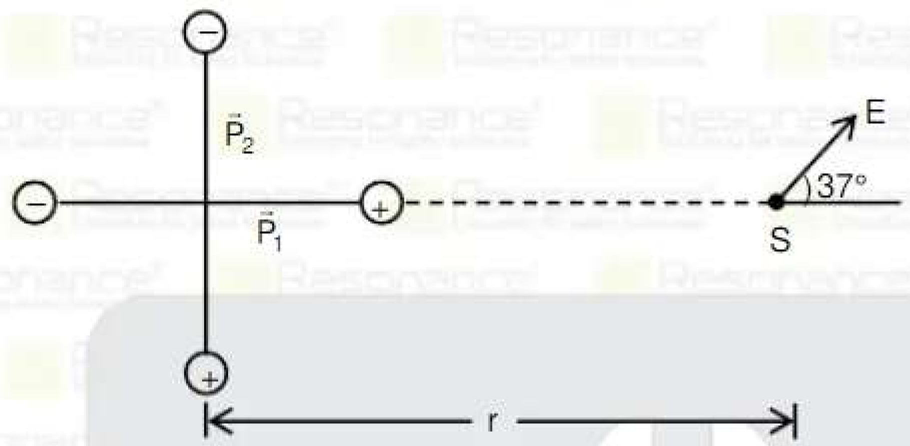
16. Two electric dipole $\vec{P}_1$ and $\vec{P}_2$ are kept as shown in figure. Net electric field at point S is E makes an angle 37° with $\vec{P}_1$ then find the ratio of $|\vec{P}_1|$ and $|\vec{P}_2|$.



(1) $\frac{3}{2}$ (2) $\frac{1}{2}$ (3) $\frac{2}{3}$ (4) $\frac{3}{4}$

Ans. (3)

Sol.



Electric field due to $\vec{P}_1$ at axis point S

$$E_{axis} = \frac{2KP_1}{r^3}$$

$$\Rightarrow \quad E\cos 37° = \frac{2KP_1}{r^3} \quad \ldots(1)$$

Electric field due to $\vec{P}_2$ at perpendicular bisector at point S.

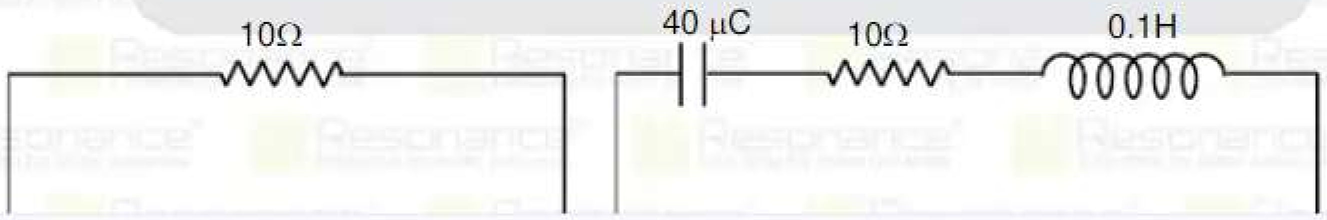
$$E_{\perp} = \frac{KP_2}{r^3}$$

$$\Rightarrow \quad E\sin 37° = \frac{KP_2}{r^3} \quad \ldots.(2)$$

$$\therefore \quad \frac{\frac{2KP_1}{r^3}}{\frac{KP_2}{r^3}} = \frac{E\cos 37°}{E\sin 37°}$$

$$\Rightarrow \quad \frac{2P_1}{P_2} = \frac{4}{3} \Rightarrow \frac{P_1}{P_2} = \frac{2}{3}$$

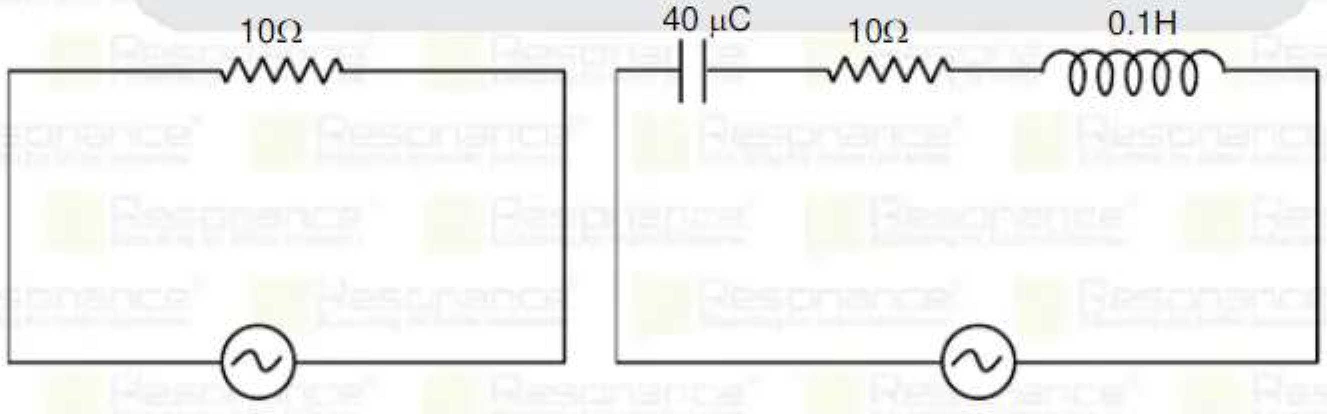
17. Power in both the given circuit are same then find angular frequency of AC source.



$\frac{KP_2}{r^3}$ Esin37°

$\Rightarrow \frac{2P_1}{P_2} = \frac{4}{3} \Rightarrow \frac{P_1}{P_2} = \frac{2}{3}$

17. Power in both the given circuit are same then find angular frequency of AC source.



(1) 200 (2) 300 (3) 400 (4) 500

Ans. (4)

Sol. $P_1 = P_2$

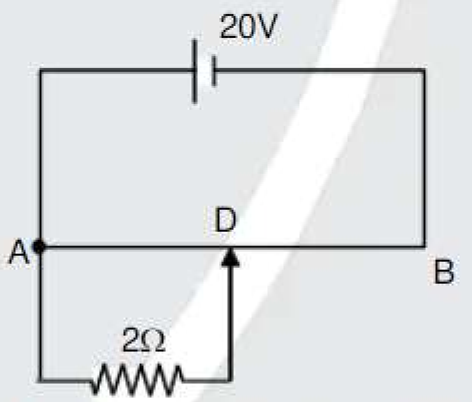
$\left(\frac{V^2}{\ }\right) = \left(\frac{V^2}{\ }\right) \Rightarrow R = Z$

$\omega^2 (0.1) = \frac{\ldots}{40\times10^{-6}}$

$\omega^2 = \frac{1}{4}\times10^6$

$\omega = 500$

18. For the given circuit, find the potential drop across 2Ω resistance ?

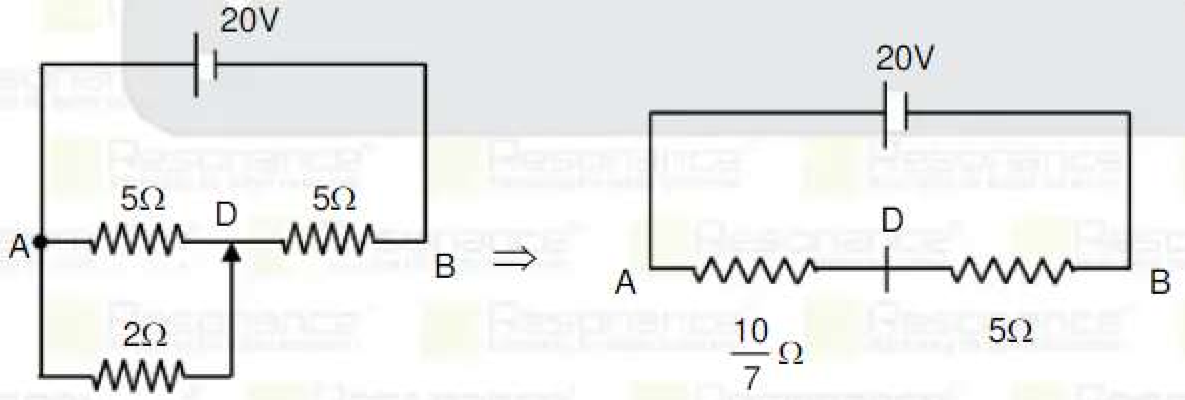


The wire AB is of length 10 cm, and its resistance is 1Ω/cm. Point D is mid-point of wire AB.

(1) 2.44 V (2) 4.44 V (3) 3.44 V (4) 10.44V

Ans. **(2)**

Sol.



$$V_{2\Omega} = \frac{20}{\frac{10}{7}+5}\times\frac{10}{7}$$

$$V_{2\Omega} = 4.44\text{ V}$$

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19. Mass of a planet is double the mass of earth. Both the planet have same mass density. A body has weight W on surface of earth, then weight of the same body on surface of planet ?

(1) $2^{2/3}$ W (2) $2^{1/3}$ W (3) W (4) $3^{1/2}$ W

Ans. **(2)**

Sol. $2M_E = M_P$

$$2\rho \times \frac{4}{3}R_E^3 = \rho \times \frac{4}{3}\pi R_P^3 \text{ (same density)}$$

$R_P = 2^{1/3} R_E$

$$g_P = \frac{GM_P}{R_P^2} \text{ (acceleration due to gravity)}$$

$$g_P = \frac{G2M_E}{(2^{1/3}R_E)^2} = \frac{G2M_E}{2^{2/3}R_E^2}$$

$g_P = 2^{1/3} g_e$

weight on planet = $2^{1/3}$ weight on earth

$W_P = 2^{1/3}$ W

20. A force $\vec{F} = 40\hat{i} + 10\hat{j}$ is applied on a stationary object of mass 5kg. What will be the position of object after 10s, if initially object was at origin ?

(1) (200, 100) (2) (400, 400) (3) (400, 100) (4) (100, 100)

Ans. **(3)**

Sol. $\vec{a} = 8\hat{i} + 2\hat{j}$

$$\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$$

$$\vec{s} = \frac{1}{2}(8\hat{i} + 2\hat{j}) \times 100$$

$$\vec{s} = 400\hat{i} + 100\hat{j}$$

21. An AC Source with V_{max} = 200 V and f =50 Hz connected across 10Ω resistance. Find the time in which

$\omega t = \frac{\pi}{4}$

thus $t = \frac{\pi/4}{100\pi} = \frac{1}{400}$ s

22. A Disc of mass 2 kg and radius 2m is rotating with angular velocity $\omega = 600$ rpm. If this disc stops under the action of a constant Torque in 10 sec then if Torque is $n\pi$ then 'n' is.

(1) 7 (2) 6 (3) 8 (4) 4

Ans. (3)

Sol. $\omega = \frac{600 \times 2\pi}{60} = 20\pi$ rad/s

$\omega_f = \omega_i + \alpha_t$

$0 = 20\pi - \alpha(10)$

$\alpha = 2\pi$ rad/s^2

$\tau = I \times \alpha$

$= \frac{mR^2}{2} \times 2\pi = \frac{2 \times 4}{2} \times 2\pi = 8\pi$

$\eta = 8$

23. For two vector $\vec{X}$ and $\vec{Y}$, $|\vec{X}| = |\vec{Y}|$ and $|\vec{X} - \vec{Y}| = n|\vec{X} + \vec{Y}|$. Then find angle between $\vec{X}$ and $\vec{Y}$?

(1) $\cos^{-1}\frac{1-n^2}{1+n^2}$ (2) $\cos^{-1}\frac{1+n^2}{1-n^2}$ (3) $\cos^{-1}\frac{2-n^2}{2+n^2}$ (4) $\cos^{-1}\frac{2+n^2}{2-n^2}$

Ans. (1)

Sol. $|\vec{X} - \vec{Y}| = n|\vec{X} + \vec{Y}|$

$$|\vec{X}|^2 + |\vec{Y}|^2 - 2|\vec{X}||\vec{Y}|\cos\theta = n^2\left[|\vec{X}|^2 + |\vec{Y}|^2 + 2|\vec{X}||\vec{Y}|\cos\theta\right]$$

As $|\vec{X}| = |\vec{Y}|$

$$2|\vec{X}|^2 - 2|\vec{X}|^2\cos\theta = 2n^2|\vec{X}|^2 + 2n^2|\vec{X}|^2\cos\theta$$

$$1 - \cos\theta = n^2 + n^2\cos\theta$$

$$\cos\theta = \frac{1-n^2}{1+n^2}$$

$$\theta = \cos^{-1}\frac{1-n^2}{1+n^2}$$

24 Find energy required to break an Aluminium nucleus into its constituent nucleons.

(m_n = 1.00867 u, m_p = 1.00783 u, m_{Al} = 26.98154 u)

(1) 225 MeV (2) 230 MeV (3) 235 MeV (4) 245 MeV

Ans. (1)

Sol. Binding Energy = ΔmC^2

$\Delta m = [13 \times 1.00783 + 14 \times 1.00867 - 26.98154]$

$= [13.10179 + 14.12138 - 26.98154] = 0.24163$

$\therefore$ B.E = 0.24163 C^2 × 931 MeV/C^2

= 224.95 MeV ≈ 225 MeV.

25. A Cell of Voltage 'V_0' is connected across a capacitor of capacitance 'C'. Now the space between the

26. Pure S_i at room temperature has equal electron (n_e) and hole (n_h) concentration of 1.5×10^{16} m^{-3}. Doping by indium increases n_h to 3×10^{22} m^{-3}. Calculate n_e in the doped S_i.

(1) 7.5×10^9 m^{-3} (2) 6.5×10^9 m^{-3} (3) 7.5×10^8 m^{-3} (4) 7.5×10^7 m^{-3}

Ans. (1)

Sol. For a doped semi-conductor in thermal equilibrium

$$n_e n_h = n_i^2$$

$$\Rightarrow \quad n_e = \frac{n_i^2}{n_h} = \frac{(1.5\times10^{16})^2}{3\times10^{22}} = 7.5 \times 10^9 \text{ m}^{-3}$$

27. A particle starts from rest and moves with a variable acceleration $a = \alpha t + \beta t^2$, where α and β are positive constants. Find the distance covered by particle in t = 1sec to t = 2sec ?

(1) $\frac{11}{6}\alpha + \frac{15}{12}\beta$ (2) $\frac{7}{6}\alpha + \frac{17}{12}\beta$ (3) $\frac{7}{6}\alpha + \frac{15}{12}\beta$ (4) $\frac{1}{3}\alpha + \frac{15}{12}\beta$

Ans. **(3)**

Sol. $$\int_0^v dv = \int_0^t a\,dt$$

$$v = \frac{\alpha t^2}{2} + \frac{\beta t^3}{3}$$

Now

$$\int_0^s ds = \int_1^2 v\,dt$$

$$s = \left[\frac{\alpha t^3}{6} + \frac{\beta t^4}{12}\right]_1^2 \Rightarrow s = \frac{7}{6}\alpha + \frac{15}{12}\beta$$

28. A carrier frequency of 1 MHz and peak value of 10 v is amplitude modulated with a signal frequency of 10 KHz with peak value of 0.5 v. Find modulation index.

(1) 0.02 (2) 0.03 (3) 0.04 (4) 0.05

Ans. (4)

Sol. $A_{max.} = 10 + 0.5 = 10.5$

$A_{min} = 10 - 0.5 = 9.5$

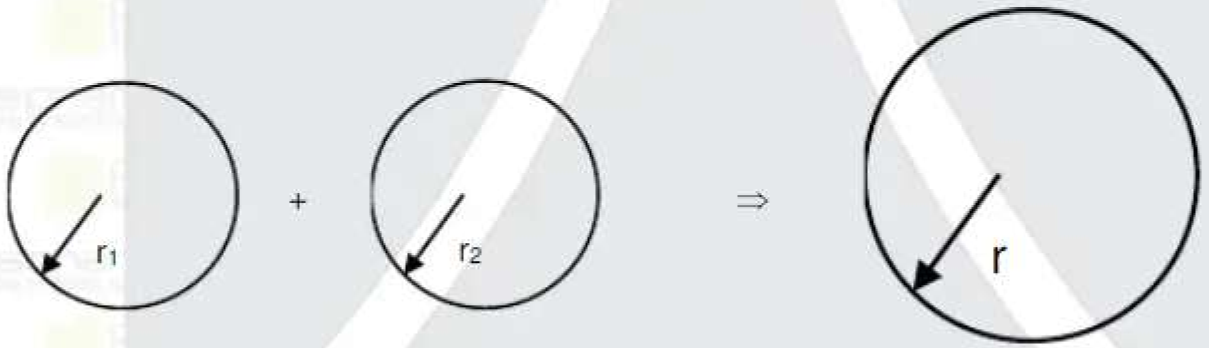
$$m_a = \frac{A_{max.} - A_{min.}}{A_{max.} + A_{min.}} = \frac{10.5 - 9.5}{10.5 + 9.5} = 0.05$$

29. Two soap bubbles of radius r_1 and r_2 in vacuum are combined isothermally to form a new bubble. Find the radius of this new bubble ?

(1) $\sqrt{r_1^2 + r_2^2}$ (2) $\sqrt{r_1^2 - r_2^2}$ (3) $\sqrt{\frac{r_1 r_2}{r_1 + r_2}}$ (4) $\sqrt{\frac{r_1 r_2}{r_1 - r_2}}$

Ans. (1)

Sol.



By surface energy conservation

$\sigma A_1 + \sigma A_2 = \sigma A$

$\sigma[2 \times 4\pi r_1^2] + \sigma [2 \times 4\pi r_2^2] = \sigma [2 \times 4\pi r^2]$

$r_1^2 + r_2^2 = r^2$

$r = \sqrt{r_1^2 + r_2^2}$

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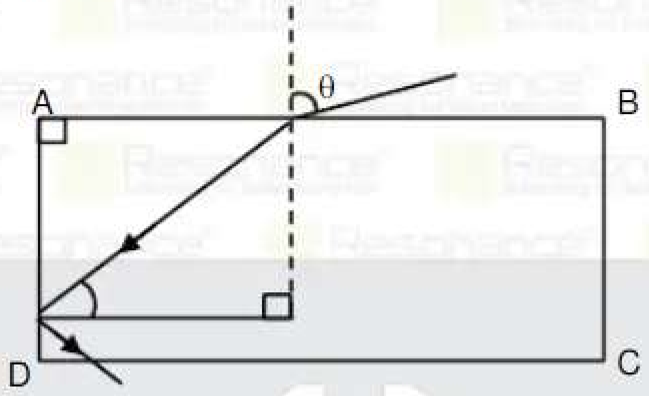
resonance.ac.in/answer-key-solutions/JEE-Main/2021/jeemain.aspx?uid=517265790&key=OwcO0sFle3fuBR0mW1TX

30. A ray is incident on a slab of refractive index $\frac{5}{4}$ at an angle θ as shown in figure. Find maximum angle θ. So that TIR occur at surface AD.



(1) $\sin^{-1}\frac{\sqrt{5}}{3}$ (2) $\sin^{-1}\frac{\sqrt{3}}{2}$ (3) $\sin^{-1}\frac{3}{4}$ (4) $\sin^{-1}\frac{\sqrt{5}}{4}$

Ans. **(3)**

Sol. $1 \times \sin\theta = \frac{5}{4}\sin(90 - C)$

$\sin\theta = \frac{5}{4}\cos C$

but $\sin C = \frac{1}{\mu} = \frac{4}{5}$

$\cos C = \frac{3}{5}$

$\sin\theta = \frac{5}{4} \times \frac{3}{5} = \frac{3}{4}$

For T.I.R. $\sin\theta < \frac{3}{4}$

$\theta = \sin^{-1}\frac{3}{4}$