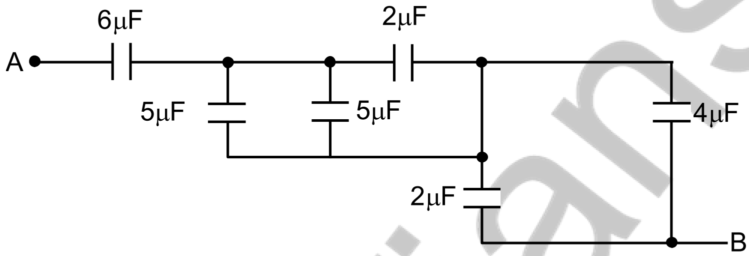
JEE Main - 2018 (CBT)
Exam Test Date 15/04/2018
Test Time: 9:30 AM - 12:30 PM
Set - II

Part - A (Physics)

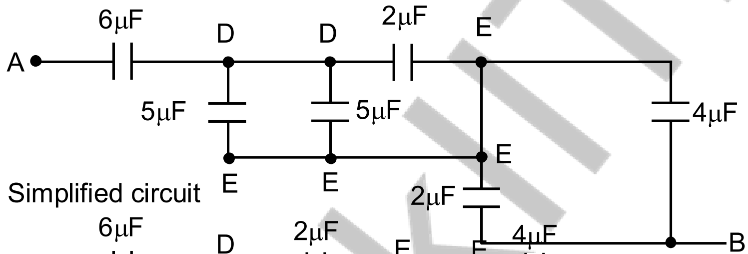
1. The equivalent capacitance between A and B in the circuit given below is :



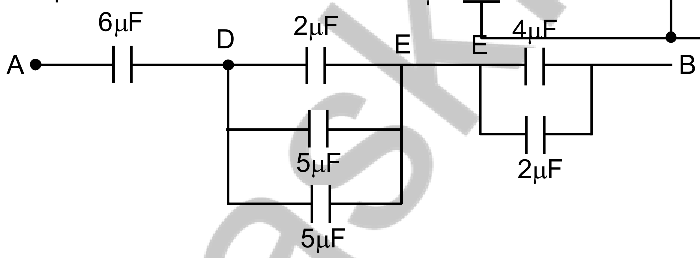
(1) 3.6μF (2) 2.4μF (3) 4.9μF (4) 5.4μF

Ans. **(2)**

Sol.

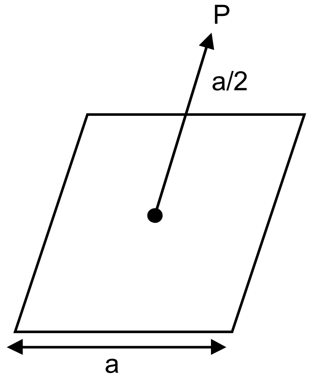


Simplified circuit



$$\frac{1}{c_{eq}} = \frac{1}{6} + \frac{1}{12} + \frac{1}{6} = \frac{5}{12} \quad \Rightarrow \quad C_{eq} = \frac{12}{5} = 2.4\mu F$$

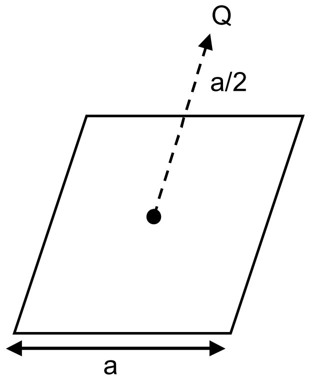
2. A charge Q is placed at a distance. The electric flux through the square the surface is a/2 above the centre of the square surface of edge a as shown in the figure.



(1) $\frac{Q}{6 \epsilon_0}$ (2) $\frac{Q}{2 \epsilon_0}$ (3) $\frac{Q}{3 \epsilon_0}$ (4) $\frac{Q}{\epsilon_0}$

Ans. **(1)**

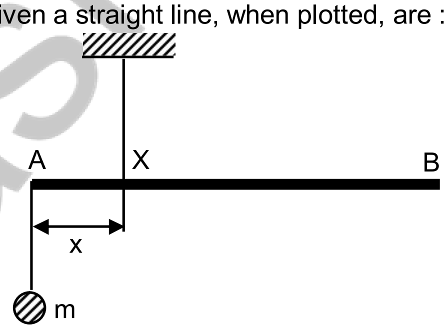
Sol.



charged particle can be Considered at centre of a cube of side a, and given surface represents its one side.

So flux $\phi = \frac{Q}{6\varepsilon_0}$

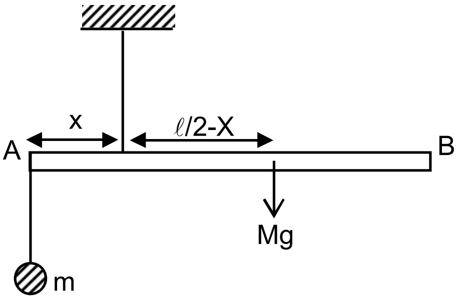
3. A uniform rod AB is suspended from a point X, at a variable distance x from A, as shown. To make the rod horizontal, a mass m is suspended from its end A. A set of (m,x) values is recorded. The appropriate variables that given a straight line, when plotted, are :



(1) m,x^2. (2) m,$\frac{1}{x^2}$ (3) m,$\frac{1}{x}$ (4) m,x

Ans. **(3)**

Sol.



Balancing torque w.r.t. point of suspension

$mg\,x = Mg\left(\frac{\ell}{2} - x\right)$

$mx = M\frac{\ell}{2} - Mx$

$m = \left(M\frac{\ell}{2}\right)\frac{1}{x} - M$

$y = \alpha\frac{1}{x} - C$ equation of a straight line

4. The energy required to remove the electron from a singly ionized Helium atom is 2.2 times the energy required to remove an electron from Helium atom. The total energy required to ionize the Helium atom completely is :

(1) 34eV (2) 20eV (3) 79eV (4) 109eV

Ans. **(3)**

Sol. Energy required to remove e^- from singly ionized helium atom = 54.4 eV

Energy required to remove e^- form helium atom = x ev given 54.4 eV = 2.2x ⇒ x = 24.73 eV

Energy required to ionize helium atom = 79.12 eV

5. A solution containing active cobalt $^{60}_{27}$Co having activity of 0.8 μCi and decay constant λ is injected in an animal's body. If 1 cm^3 of blood is drawn from the animal's body after 10 hrs of injection, the activity found was 300 decays per minute. What is the volume of blood that is flowing in the body ? (1Ci = 3.7 × 10^{10} decays per second and at t = 10 hrs $e^{-\lambda t}$ = 0.84)

(1) 4 liters (2) 6 liters (3) 5 liters (4) 7 liters

Ans. **(3)**

Sol. Let total volume of blood is v, initial activity A_0 = O.Q μci its activity at time t = A = A0$e^{-\lambda t}$ activity of x volume $A^1 = \left(\frac{A}{V}\right)x = x\left(\frac{A_0}{V}\right)e^{-\lambda t}$

$V = x\left(\frac{A_0}{A^1}\right)e^{-\lambda t}$

$V = (1cm^3)\left(\frac{8\times10^{-7}\times3.7\times10^{10}}{\frac{300}{60}}\right)(0.84)$

= 4.97 × 10^3 cm^3 = 4.97 liter

6. In a common emitter configuration with suitable bias, it is given that R_L is the load resistance and R_{BE} is small signal dynamic resistance (input side). Then, voltage gain, current gain and power gain are given, respectively, by :

β is current gain, I_B, I_C and I_E are respectively base, collector and emitter currents.

(1) $\beta\frac{R_L}{R_{BE}}, \frac{\Delta I_C}{\Delta I_B}, \beta^2\frac{R_L}{R_{BE}}$ (2) $\beta\frac{R_L}{R_{BE}}, \frac{\Delta I_E}{\Delta I_B}, \beta^2\frac{R_L}{R_{BE}}$ (3) $\beta^2\frac{R_L}{R_{BE}}, \frac{\Delta I_C}{\Delta I_B}, \beta\frac{R_L}{R_{BE}}$ (4) $\beta^2\frac{R_L}{R_{BE}}, \frac{\Delta I_C}{\Delta I_E}, \beta^2\frac{R_L}{R_{BE}}$

Ans. **(1)**

Sol. From NCERT

Current gain $\beta = \frac{\Delta I_C}{\Delta I_B}$

Voltage gain $A_v = \frac{\Delta V_{CE}}{R_{BE}\Delta I_B} = B\frac{R_L}{R_{BE}}$

Power gain $A_p = \beta Av = \beta^2\frac{R_L}{R_{BE}}$

7. A body of mass m is moving in a circular orbit of radius R about a planet of mass M. At some instant, it splits into two equal masses. The first mass moves in a circular orbit of radius $\frac{R}{2}$. and the other mass, in a circular orbit of radius $\frac{3R}{2}$. The difference between the final and initial total energies is :

(1) $+\frac{Gm}{6R}$ (2) $-\frac{GMm}{2R}$ (3) $-\frac{GMm}{6R}$ (4) $\frac{GMm}{2R}$

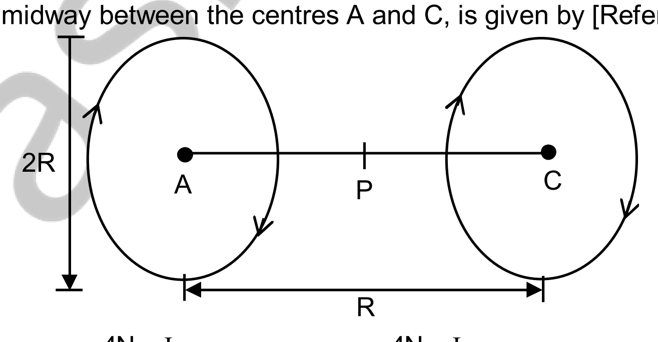
Ans. **(3)**

Sol. $E_i = -\frac{GMm}{2R}$

$$E_f = -\frac{GMm/2}{2\left(\frac{R}{2}\right)} - \frac{GMm/2}{2\left(\frac{3R}{2}\right)} = -\frac{GMm}{2R} - \frac{GMm}{6R} = -\frac{4GMm}{6R} = -\frac{2Mm}{3R}$$

$$E_f - E_i = \frac{GMm}{R}\left(-\frac{2}{3}+\frac{1}{2}\right) = -\frac{GMm}{6R}$$

8. A Helmholtz coil has a pair of loops, each with N turns and radius R. They are placed coaxially at distance R and the same current I flows through the loops in the same direction. The magnitude of magnetic field at P, midway between the centres A and C, is given by [Refer to figure given below]:



(1) $\frac{8N\mu_0 I}{5^{1/2}R}$ (2) $\frac{4N\mu_0 I}{5^{3/2}R}$ (3) $\frac{4N\mu_0 I}{5^{1/2}R}$ (4) $\frac{8N\mu_0 I}{5^{3/2}R}$

Ans. **(4)**

Sol. $B = 2\left(\dfrac{\mu_0 NIR^2}{2\left(R^2+\dfrac{R^2}{4}\right)^{3/2}}\right) = \dfrac{\mu_0 NIR^2}{\dfrac{5^{3/2}}{8}} = \dfrac{8\mu_0 NI}{5^{3/2}R}$

9. A thin uniform tube is bent into a circle of radius r in the vertical plane. Equal volumes of two immiscible liquids, whose densities are ρ_1 and ρ_2 ($\rho_1 > \rho_2$), fill half the circle. The angle θ between the radius vector passing through the common interface and the vertical is :

(1) $\theta = \tan^{-1} \dfrac{\pi}{2}\left(\dfrac{\rho_1+\rho_2}{\rho_1-\rho_2}\right)$

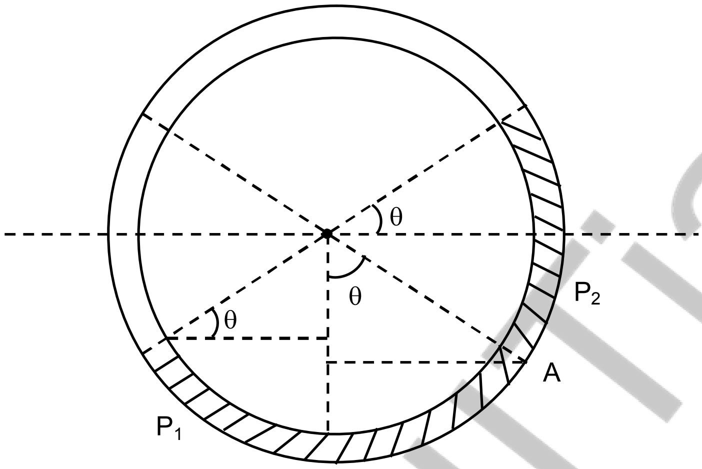
(2) $\theta = \tan^{-1}\left[\dfrac{\pi}{2}\left(\dfrac{\rho_1-\rho_2}{\rho_1+\rho_2}\right)\right]$

(3) $\theta = \tan^{-1} \dfrac{\pi}{2}\left(\dfrac{\rho_2}{\rho_1}\right)$

(4) $\theta = \tan^{-1} \pi\left(\dfrac{\rho_1}{\rho_2}\right)$

Ans. **(2)**

Sol.



equating pressure at point A

ρ_1, g R (cosθ – sinθ) = ρ_2gR(sinθ + cosθ)

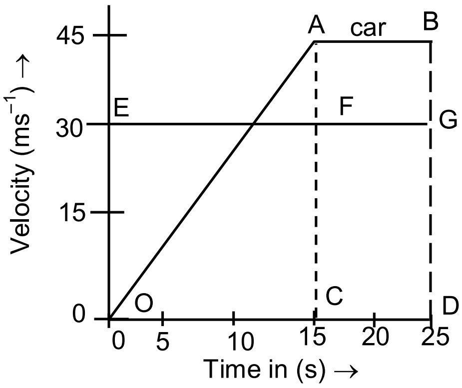
$\dfrac{\rho_1}{\rho_2} = \dfrac{\sin\theta+\cos\theta}{\cos\theta-\sin\theta} = \dfrac{\tan\theta+1}{1-\tan\theta}$

$\rho_1 - \rho_1\tan\theta = \rho_2 + \rho_2\tan\theta$

$(\rho_1+\rho_2)\tan\theta = \rho_1 - \rho_2$

$\theta = \tan^{-1}\left(\dfrac{\rho_1-\rho_2}{\rho_1+\rho_2}\right)$

10. The velocity-time graphs of a car and a scooter are shown in the figure. (i) The difference between the distance travelled by the car and the scooter in 15 s and (ii) the time at which the car will catch up with the scooter are, respectively.



(3) 225.5 m and 10 s (4) 112.5 m and 15 s

Ans. **(1)**

Sol. Distance travelled by car in 15 sec = $\frac{1}{2}(45)\ (15) = \frac{675}{2}\text{m}$, Distance traveled by scooter in 15 seconds = 30 × 15 = 450

Let car catches scooter in time t;

$\frac{675}{2} + 45(t-15) = 30t$

337.5 + 45t – 675 = 30t ⇒ 15t = 337.5 ⇒ t = 22.5 sec

11. A monochromatic beam of light has a frequency $v = \frac{3}{2\pi} \times 10^{12}\text{Hz}$ and is propagating along the direction $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$. It is polarized along the $\hat{k}$ direction. The acceptable form the magnetic field is :

(1) $\frac{E_0}{C}\left(\frac{\hat{i}-\hat{j}}{\sqrt{2}}\right)$

$\cos\left[10^4\frac{(\hat{i}-\hat{j})}{\sqrt{2}}.\vec{r} - (3\times10^{12})t\right]$

(2) $\frac{E_0}{C}\hat{k}$

$\cos\left[10^4\frac{(\hat{i}+\hat{j})}{\sqrt{2}}.\vec{r} + (3\times10^{12})t\right]$

(3) $\frac{E_0}{C}\frac{(\hat{i}-\hat{j})}{\sqrt{2}}$

$\cos\left[10^4\frac{(\hat{i}+\hat{j})}{\sqrt{2}}.\vec{r} + (3\times10^{12})t\right]$

(4) $\frac{E_0}{C}\frac{(\hat{i}+\hat{j}+\hat{k})}{\sqrt{3}}$

$\cos\left[10^4\frac{(\hat{i}+\hat{j})}{\sqrt{2}}.\vec{r} + (3\times10^{12})t\right]$

Ans. **(3)**

Sol. $\hat{E} \times \hat{B}$ should give direction of wave propagation

$\Rightarrow \hat{K} \times \hat{B} \parallel \frac{\hat{i}+\hat{j}}{\sqrt{2}}$

option – 1 $\quad \hat{K} \times \left(\frac{\hat{i}+\hat{j}}{\sqrt{2}}\right) = \frac{\hat{j}-(-\hat{i})}{\sqrt{2}} = \frac{\hat{i}+\hat{j}}{\sqrt{2}} \parallel \frac{\hat{i}+\hat{j}}{\sqrt{2}}$

option -2 and 4 does not satisfy this.

wave propagation vector $\hat{K}$ should be along $\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

So correct option is 3.

12. Take the mean distance of the moon and the sun from the earth to be 0.4×10^6 km and 150×10^6 km respectively. Their masses are 8×10^{22} kg and 2×10^{30} kg respectively. The radius of the earth is 6400km. Let ΔF_1 be the difference in the forces exerted by the moon at the nearest and farthest point on the earth and ΔF_2 be the difference in the force exerted by the sun at the nearest and farthest points on the earth. Then, the number closest to $\frac{\Delta F_1}{\Delta F_2}$ is :

(1) 6 (2) 10^{-2} (3) 2 (4) 0.6

Ans. **(3)**

Sol. $F_1 = \frac{GM_e m}{r_1^2} \qquad F_2 = \frac{GM_e M_s}{r_2^2}$

$\Delta F_1 = -\frac{2GM_e m}{r_1^3}\Delta r_1 \qquad \Delta F_2 = -\frac{2GM_e M_s}{r_2^3}\Delta r_2$

$$\frac{\Delta F_1}{\Delta F_2} = \frac{m\Delta r_1}{r_1^3}\frac{r_2^3}{M_s \Delta r_2} = \left(\frac{m}{M_s}\right)\left(\frac{r_2^3}{r_1^3}\right)\left(\frac{\Delta r_1}{\Delta r_2}\right)$$

using $\quad \Delta r_1 = \Delta r_2 = 2R_{earth}$

$m = 8 \times 10^{22}$ kg

$M_s = 2 \times 10^{30}$ kg

$r_1 = 0.4 \times 10^6$ km

$r_2 = 150 \times 10^6$ km

we get $\frac{\Delta F_1}{\Delta F_2} = 2$

13. A planoconvex lens becomes an optical system of 28cm focal length when its plane surface is silvered and illuminated from left to right as shown in fig-A

If the same lens is instead silvered on the curved surface and illuminated from other side as in fig. B, it acts like an optical system of focal length 10 cm. The refractive index of the material of lens is:

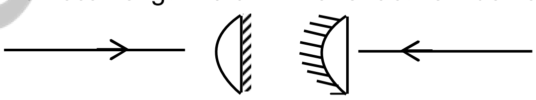
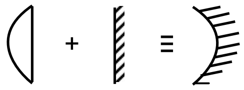


Fig .A Fig .B

(1) 1.55 (2) 1.50 (3) 1.75 (4)1.51

Ans. **(1)**

Sol. Case-1

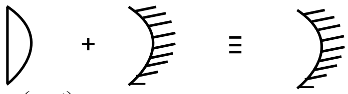


$\frac{1}{f_1} = \left(\frac{\mu - 1}{R}\right)$ $f = -28$

$P = 2P_1 + P_2$

$$\frac{1}{28} = 2\left(\frac{\mu - 1}{R}\right)$$

Case-2



$\frac{1}{f_1} = \left(\frac{\mu - 1}{R}\right)$ $f_2 = -\frac{R}{2}$ $f = -10\text{cm}$

$$P = 2P_1 + P_2 \Rightarrow \frac{1}{10} = 2\left(\frac{\mu - 1}{2}\right) + \frac{2}{R}$$

$$\frac{1}{10} = \frac{1}{28} + \frac{2}{R}$$

$$\frac{2}{R} = \frac{1}{10} - \frac{2}{28} = \frac{18}{280}$$

$$R = \frac{280}{9}\text{ cm}$$

$$\frac{1}{28} = 2\left(\frac{\mu - 1}{280}\right)9$$

$$\mu - 1 = \frac{5}{9}$$

$$\mu = 1 + \frac{5}{9} = \frac{14}{9} = 1.55$$

14. One mole of an ideal monatomic gas is compressed isothermally in a rigid vessel to double its pressure at room temperature, 27°C. The done on the gas will be :

(1) 300R (2) 300R In 2 (3) 300 In 6 (4) 300R In 7

Ans. **(2)**

Sol. Work done on gas = $nRT\ \ell n\left(\frac{p_f}{p_i}\right) = R(300)\ \ell n(2) = 300R\ell n2$

15. An automobile, travelling at 40 km/h, can be stopped at a distance of 40 m by applying brakes. If the same automobile is travelling at 80 km/h, the minimum stopping distance, in metres, is (assume no skidding) :

(1) 150m (2) 100m (3) 75m (4) 160m

Ans. **(4)**

Sol. $S = \frac{u^2}{2a}$

$$\frac{S_1}{S_2} = \frac{u_1^2}{u_2^2} \Rightarrow S_2 = \left(\frac{u_2}{u_1}\right)^2 S_1 = (2)^2(40) = 160\text{ m}$$

16. A carnot's engine works as a refrigerator between 250K and 300K. It receives 500 cal heat from the reservoir at the lower temperature. The amount of work done in each cycle to operate the refrigerator is

(1) 772 J (2) 420 J (3) 2100 J (4) 2520 J

Ans. **(2)**

Sol. Efficiency = $1 - \frac{T_2}{T_1} = \frac{W}{Q_2 + W}$

$\Rightarrow \quad 1 - \frac{250}{300} = \frac{W}{Q_2 + W}$

$W = \frac{Q_2}{5} = \frac{500 \times 4.2}{5} J = 420J$

17. In a screw gauge, 5 complete rotations of the screw cause it to move a linear distance of 0.25 cm. There are 100 circular scale divisions. The thickness of a wire measured by this screw gauge gives a reading of 4 main scale divisions and 30 circular scale divisions. Assuming negligible zero error, the thickness of the wire is :

(1) 0.4300 cm (2) 0.3150 cm (3) 0.0430 cm (4) 0.2150 cm

Ans. **(4)**

Sol. Least Count = $\frac{0.25}{5 \times 100}$ cm = 5×10^{-4} cm

Reading = 4×0.05cm + $30 \times 5 \times 10^{-4}$ cm

= (0.2 + 0.0150) cm = 0.2150 cm

18. The number of amplitude modulated broadcast stations that can be accommodated in a 300 kHz band width for the highest modulating frequency 15 kHz will be :

(1) 15 (2) 20 (3) 8 (4) 10

Ans. **(4)**

Sol. If modulating frequency is 15 KHz then band width of one channel = 30 kHz

No of channels accommodate = $\frac{300kHz}{30kHz} = 10$

19. An ideal capacitor of capacitance 0.2 μF is charged to a potential difference of 10 V. The charging battery is then disconnected. The capacitor is then connected to an ideal inductor of self inductance 0.5 mH. The current at a time when the potential difference across the capacitor is 5V is :

(1) 0.15 A (2) 0.17 A (3) 0.34 A (4) 0.25 A

Ans. **(2)**

Sol. Using energy conservation

$\frac{1}{2} \times 0.2 \times 10^{-6} \times 10^2 + 0 = \frac{1}{2} \times 0.2 \times 10^{-6} \times 5^2 + \frac{1}{2} \times 0.5 \times 10^{-3} I^2$

$I = \sqrt{3} \times 10^{-1} A = 0.17A$

20. Light of wavelength 550 nm falls normally on a slit of width 22.0×10^{-5} cm. The angular position of the second minima from the central maximum will be (in radians) :

(1) $\frac{\pi}{4}$ (2) $\frac{\pi}{8}$ (3) $\frac{\pi}{12}$ (4) $\frac{\pi}{6}$

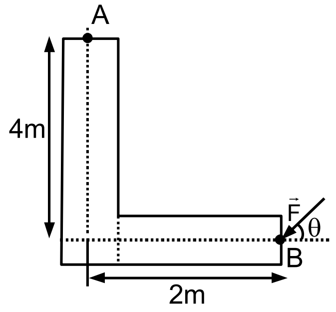
Ans. **(2)**

Sol. If angular position of 2[nd] maxima from central maxima is θ then

$$\sin\theta = \frac{3\lambda}{2a} = \frac{3\times 550\times 10^{-9}}{2\times 22\times 10^{-7}}$$

$$\theta \simeq \frac{\pi}{8} \text{ rad}$$

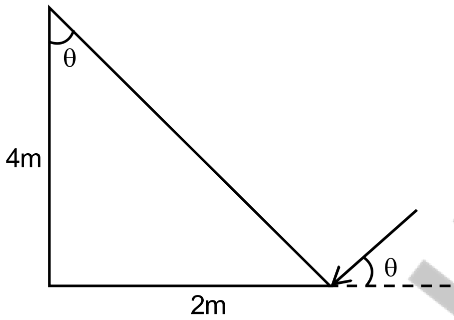
21. A force of 40 N acts on a point B at the end of an L-shaped object as shown in the figure. The angle θ that will produce maximum moment of the force about point A is given by :



(1) $\tan\theta = 4$ (2) $\tan\theta = \frac{1}{4}$ (3) $\tan\theta = \frac{1}{2}$ (4) $\tan\theta = 2$

Ans. **(3)**

Sol. Moment of force will be maximum when line of action of force is perpendicular to line AB.



$$\tan\theta = \frac{2}{4} = \frac{1}{2}$$

22. A tuning fork vibrates with frequency 256 Hz and gives one beat per second with the third normal mode of vibration of an open pipe. What is the length of the pipe ? (Speed of sound in air is 340 ms^{-1})

(1) 220 cm (2) 200 cm (3) 190 cm (4) 180 cm

Ans. **(2)**

Sol. Organ pipe will have frequency either 255 or 257 Hz

Using 255Hz

$$255 = \frac{3V}{2\ell} \qquad \ell = \frac{3\times 340}{2\times 255}\text{m}$$

ℓ = 200 cm.

23. A body of mass M and charge q is connected to a spring of spring constant k. It is oscillating along x-direction about its equilibrium position, taken to be at x = 0, with an amplitude A. An electric field E is applied along the x-direction. Which of the following statements is **correct**?

(1) The total energy of the system is $\frac{1}{2}m\omega^2A^2 + \frac{1}{2}\frac{q^2E^2}{k}$.

(2) The new equilibrium position is at a distance $\frac{2qE}{k}$ from x = 0.

(3) The new equilibrium position is at a distance $\frac{qE}{2k}$ from x = 0.

(4) The total energy of the system is $\frac{1}{2}m\omega^2A^2 - \frac{1}{2}\frac{q^2E^2}{k}$.

Ans. **(1)**

Sol. Equilibrium position will shift to point where resultant force = 0

$kx_{eq} = qE \Rightarrow x_{eq} = \frac{qE}{k}$

Energy $\frac{1}{2}m\omega^2\left[A^2 + \left(\frac{qE}{k}\right)^2\right] = \frac{1}{2}m\omega^2A^2 + \frac{1}{2}\frac{q^2E^2}{k}$

24. A given object takes n times more time to slide down a 45° rough inclined plane as it takes to slide down a perfectly smooth 45° incline. The coefficients of kinetic friction between the object and the incline is :

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

Ans. **(2)**

Sol. Time taken to slide along smooth surface

$s = \frac{1}{2}g\sin 45° t_1^2$

$t_1 = \sqrt{\frac{2\sqrt{2}s}{g}}$

Time taken to slide along rough surface

$S = \frac{1}{2}(g\sin 45° - \mu g\cos 45°)t_2^2$

$t_2 = \sqrt{\frac{2\sqrt{2}s}{g(1-\mu)}}$

$t_2 = nt_1$

$\frac{2\sqrt{2}s}{g(1-\mu)} = n^2 \times \frac{2\sqrt{2}s}{g} \Rightarrow 1 - \mu = \frac{1}{n^2} \Rightarrow \quad \mu = 1 - \frac{1}{n^2}$

25. The relative error in the determination of the surface area of a sphere is α. Then the relative error in the determination of its volume is :

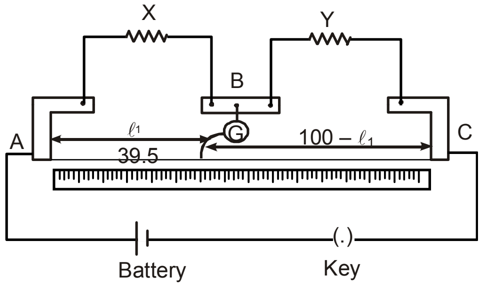
(1) $\frac{3}{2}\alpha$ (2) $\frac{2}{3}\alpha$ (3) α (4) $\frac{5}{2}\alpha$

Ans. **(1)**

Sol. $\frac{\Delta s}{s} = 2 \times \frac{\Delta r}{r}$ $\frac{\Delta v}{v} = 3 \times \frac{\Delta r}{r}$

$\frac{\Delta v}{v} = \frac{3}{2}\alpha$

26. In a meter bridge as shown in the figure it is given that resistance Y = 12.5 Ω and that the balance is obtained at a distance 39.5 cm from end A (by Jockey J). After interchanging the resistances X and Y a new balance point is found at a distance l_2 from end A. What are the values of X and l_2?



(1) 19.15 Ω and 39.5 cm
(2) 8.16 Ω and 60.5 cm
(3) 8.16 Ω and 39.5 cm
(4) 19.15 Ω and 60.5 cm

Ans. **(2)**

Sol. For a balanced meter bridge

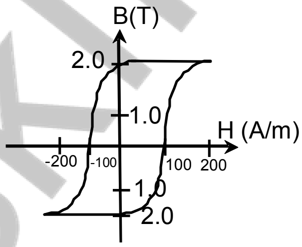
y × 39.5 = x × (100 – 39.5)

$x = \frac{12.5 \times 39.5}{60.5} = 8.16\Omega$

when x & y are interchanged ℓ_1 and $(100 - \ell_1)$ will also interchange

ℓ_2 = 60.5 cm.

27. The B-H curve for a ferromagnet is shown in the figure. The ferromagnet is placed inside a long solenoid with 1000 turns/cm. The current that should be passed in the solenoid to demagnetise the ferromagnet completely is :



(1) 2 mA
(2) 20 μA
(3) 1 mA
(4) 40 μA

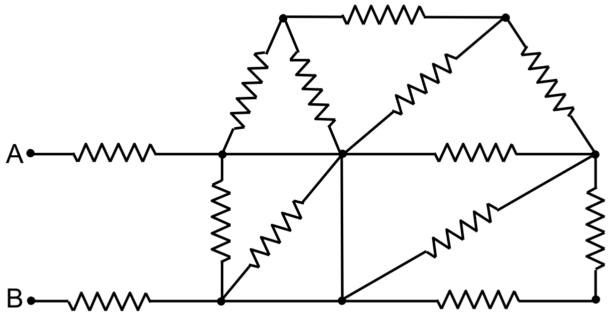
Ans. **(3)**

Sol. Coercivity of Ferro magnet H = 100 A/m

nI = 100

$I = \frac{100}{10^5} = 1mA$

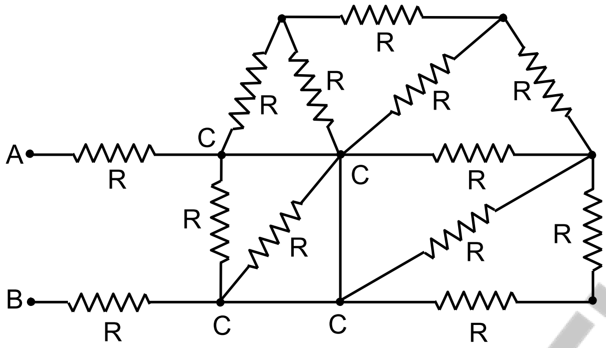
28. In the given circuit all resistances are of value of R ohm each. The equivalent resistance between A and B is :



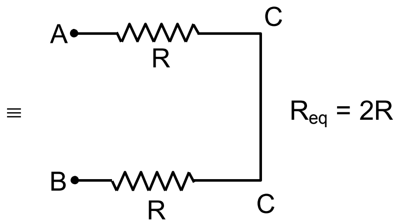
(1) $\frac{5R}{2}$ (2) 3R (3) $\frac{5R}{3}$ (4) 2R

Ans. **(4)**

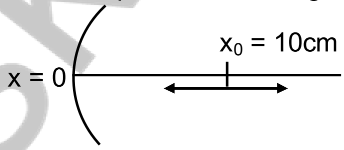
Sol.



$\equiv$



29. A particle is oscillating on the x-axis with an amplitude 2cm about the point x_0 = 10cm with a frequency ω. A concave mirror of focal length 5cm is placed at the origin (see figure).



Identify the correct statements?

(A) The image executes periodic motion

(B) The image executes non-periodic motion

(C) The turning points of the image are asymmetric w.r.t. the image of the point at x = 10 cm.

(D) The distance between the turning points of the oscillation of the image is $\frac{100}{21}$ cm.

(1) (B, C) (2) (A, C, D) (3) (A, D) (4) (B, D)

Ans. **(2)**

Sol. When object is at 8 cm

$$V_1 = \frac{f \times u}{u - f} = -\frac{40}{3}\text{cm}$$

When object is at 12 cm

$$V_2 = -\frac{60}{7}\text{cm}$$

Separation = $|V_1 - V_2| = \frac{100}{21}$ cm

So A, C and D are correct

30. Two electrons are moving with non-relativistic speeds perpendicular to each other. If corresponding de Broglie wavelengths are λ_1 and λ_2 their de Broglie wavelength in the frame of reference attached to their centre of mass is :

(1) $\frac{1}{\lambda_{CM}} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$ (2) $\lambda_{CM} = \frac{2\lambda_1\lambda_2}{\sqrt{\lambda_1^2 + \lambda_2^2}}$ (3) $\lambda_{CM} = \lambda_1 = \lambda_2$ (4) $\lambda_{CM} = \left(\frac{\lambda_1 + \lambda_2}{2}\right)$

Ans. **(2)**

Sol. Momentum of each electron $\frac{h}{\lambda_1}\hat{i}$ & $\frac{h}{\lambda_2}\hat{j}$

Velocity of centre of mass

$$V_{cm} = \frac{h}{2m\lambda_1}\hat{i} + \frac{h}{2m\lambda_2}\hat{j}$$

Velocity of 1st particle about centre of mass

$$V_{1cm} = \frac{h}{2m\lambda_1}\hat{i} - \frac{h}{2m\lambda_2}\hat{j}$$

$$\lambda_{cm} = \frac{h}{\sqrt{\frac{h^2}{4\lambda_1^2} + \frac{h^2}{4\lambda_2^2}}} = \frac{2\lambda_1\lambda_2}{\sqrt{\lambda_1^2 + \lambda_2^2}}$$