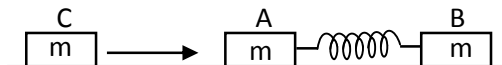


PHYSICS
JEE-MAIN (MARCH-Attempt) 17 MARCH
(Shift-2) Paper

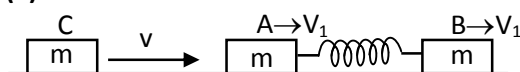
SECTION – A

1. Two identical blocks A and B each of mass m resting on the smooth horizontal floor are connected by a light spring of natural length L and spring constant K . A third block C of mass m moving with a speed v along the line joining A and B collides with A. The maximum compression in the spring is



- (1) $\sqrt{\frac{mv}{2K}}$ (2) $\sqrt{\frac{m}{2K}}$ (3) $\sqrt{\frac{mv}{K}}$ (4) $v\sqrt{\frac{m}{2K}}$

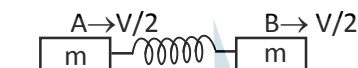
Sol. (4)



From conservation of momentum

$$mv = mv_1 + mv_1$$

$$V_1 = \frac{V}{2}$$



& from energy conservation

$$\frac{1}{2}mv^2 = \left(\frac{1}{2} \times m \left(\frac{V}{2} \right)^2 \right) \times 2 + \frac{1}{2}Kx^2$$

$$\frac{mv^2}{2} - \frac{mv^2}{4} = \frac{1}{2}Kx^2$$

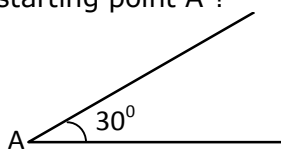
$$\frac{mv^2}{4} = \frac{1}{2}Kx^2$$

Then the maximum compression in the spring is

$$x = \sqrt{\frac{mv^2}{2K}}$$

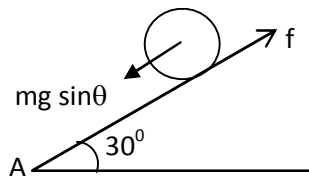
$$x = v\sqrt{\frac{m}{2K}}$$

2. A sphere of mass 2 kg radius 0.5m is rolling with an initial speed of 1 ms^{-1} goes up an inclined plane which makes an angle of 30° with the horizontal plane, without slipping. How long will the sphere take to return to the starting point A ?



- (1) 0.80 s (2) 0.60 s (3) 0.52 s (4) 0.57 s

Sol. (4)



$$a = \frac{g \sin \theta}{1 + c}$$

$$a = \frac{9.8 \sin 30^\circ}{1 + \frac{2}{5}}$$

$$a = 3.5 \text{ m/sec}^2$$

Time of ascent

$$V = u + at$$

$$0 = 1 - 3.5 t$$

$$t = \frac{1}{3.5} \text{ sec.}$$

Time of decent

$$t = \frac{1}{3.5} \text{ sec.}$$

$$\text{Total time } T = \frac{2}{3.5} = 0.57 \text{ sec.}$$

3. If one mole of the polyatomic gas is having two vibrational modes and β is the ratio of molar specific heats for polyatomic gas $\left(\beta = \frac{C_p}{C_v}\right)$ then the value of β is :

- (1) 1.35 (2) 1.02 (3) 1.25 (4) 1.2

Sol. (NTA answer is 4) our answer is (3)

Degree of freedom of polyatomic gas

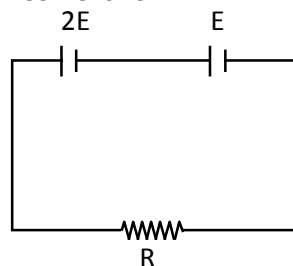
$$f = T + R + V$$

$$f = 3 + 3 + 2 = 8$$

$$\gamma = 1 + \frac{2}{f} = 1 + \frac{2}{8}$$

$$\gamma = \frac{10}{8} = \frac{5}{4} = 1.25$$

4. Two cells of emf $2E$ and E with internal resistance r_1 and r_2 respectively are connected in series to an external resistor R (see figure). The value of R , at which the potential difference across the terminals of the first cell becomes zero is



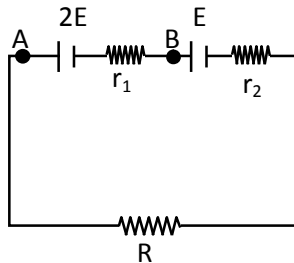
(1) $r_1 - r_2$

(2) $r_1 + r_2$

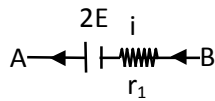
(3) $\frac{r_1}{2} + r_2$

(4) $\frac{r_1}{2} - r_2$

Sol. (4)



$$I = \frac{3E}{R + r_1 + r_2}$$



$$V_A = V_B$$

$$2E = i r_1$$

$$2E = \frac{3E}{R + r_1 + r_2} r_1$$

$$2R + 2r_1 + 2r_2 = 3r_1$$

$$R = \frac{r_1}{2} - r_2$$

5. A sound wave of frequency 245 Hz travels with the speed of 300 ms^{-1} along the positive x-axis. Each point of the wave move to and fro through a total distance of 6 cm. What will be the mathematical expression of the travelling wave ?

(1) $Y(x, t) = 0.03 \left[\sin 5.1x - (0.2 \times 10^3) t \right]$

(2) $Y(x, t) = 0.06 \left[\sin 5.1x - (1.5 \times 10^3) t \right]$

(3) $Y(x, t) = 0.06 \left[\sin 0.8x - (0.5 \times 10^3) t \right]$

(4) $Y(x, t) = 0.03 \left[\sin 5.1x - (1.5 \times 10^3) t \right]$

Sol. (4)

$$Y = A \sin (kx - \omega t)$$

$$A = \frac{6}{2} = 3 \text{ cm} = 0.03 \text{ m}$$

$$\omega = 2\pi f = 2\pi \times 245$$

$$\omega = 1.5 \times 10^3$$

$$k = \frac{\omega}{v} = \frac{1.5 \times 10^3}{300}$$

$$k = 5.1$$

$$y = 0.03 \sin (5.1x - 1.5 \times 10^3 t)$$

6. A carrier signal $C(t) = 25 \sin(2.512 \times 10^{10}t)$ is amplitude modulated by a message signal $m(t) = 5 \sin(1.57 \times 10^8 t)$ and transmitted through an antenna. What will be bandwidth of the modulated signal ?

- (1) 1987.5 MHz (2) 2.01 GHz (3) 50 MHz (4) 8 GHz

Sol. (3)

$$\beta = 2f_{m(t)}$$

$$\beta = 2 \times \frac{1.57 \times 10^8}{2\pi}$$

$$\beta = 50 \text{ MHz}$$

7. Two particles A and B of equal masses are suspended from two massless springs of spring constants K_1 and K_2 respectively. If the maximum velocities during oscillations are equal, the ratio of the amplitude of A and B is :

- (1) $\frac{K_1}{K_2}$ (2) $\sqrt{\frac{K_1}{K_2}}$ (3) $\sqrt{\frac{K_2}{K_1}}$ (4) $\frac{K_2}{K_1}$

Sol. (3)

$$\because V_{\max} = A\omega$$

$$\text{Given } \omega_1 A_1 = \omega_2 A_2$$

$$\text{We know that } \omega = \sqrt{\frac{K}{m}}$$

$$\sqrt{\frac{K_1}{m}} A_1 = \sqrt{\frac{K_2}{m}} A_2$$

$$\frac{A_1}{A_2} = \sqrt{\frac{K_2}{K_1}}$$

8. Match List I with List II

List I

(a) Phase difference between current and voltage

in a purely resistive AC circuit

(b) Phase difference between current and voltage in a pure inductive AC circuit

(c) Phase difference between current and voltage in a pure capacitive AC circuit

(d) Phase difference between current and voltage in

an LCR series circuit

Choose the most appropriate answer from the options given below :

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

List II

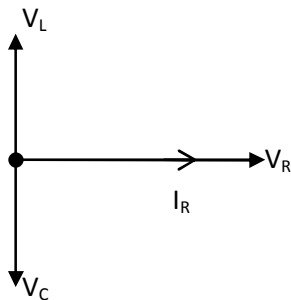
(i) $\frac{\pi}{2}$; current leads voltage

(ii) zero

(iii) $\frac{\pi}{2}$; current lags voltage

(iv) $\tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

Sol. (4)

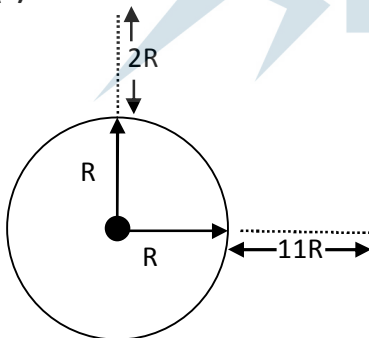


- (a) phase difference b/w current & voltage in a purely resistive AC circuit is zero
(b) phase difference b/w current & voltage in a pure inductive AC circuit is $\frac{\pi}{2}$; current lags voltage.
(c) phase different b/w current & voltage in a pure capacitive AC circuit is $\frac{\pi}{2}$; current lead voltage.
(d) phase difference b/w current & voltage in an LCR series circuit is $= \tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

9. A geostationary satellite is orbiting around an arbitrary planet 'P' at a height of $11R$ above the surface of 'P', R being the radius of 'P'. The time period of another satellite in hours at a height of $2R$ from the surface of 'P' is _____. 'P' has the time period of 24 hours.

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

Sol. (2)



From Kepler's law

$$T^2 \propto R^3$$

$$\left(\frac{24}{T}\right)^2 = \left(\frac{12R}{3R}\right)^3$$

$$T = 3 \text{ sec}$$

10. The velocity of a particle is $v = v_0 + gt + Ft^2$. Its position is $x=0$ at $t=0$; then its displacement after time ($t = 1$) is :

- (1) $v_0 + \frac{g}{2} + F$ (2) $v_0 + 2g + 3F$ (3) $v_0 + g + F$ (4) $v_0 + \frac{g}{2} + \frac{F}{3}$

Sol. (4)

$$V = V_0 + gt + Ft^2$$

$$\frac{dx}{dt} = V_0 + gt + Ft^2$$

$$\int_{x=0}^x dx = \int_{t=0}^{t=1} (V_0 + gt + Ft^2) dt$$

$$x = \left[v_0 t + \frac{gt^2}{2} + \frac{Ft^3}{3} \right]_{t=0}^{t=1}$$

$$x = V_0 + \frac{g}{2} + \frac{F}{3}$$

11. A block of mass 1 kg attached to a spring is made to oscillate with an initial amplitude of 12 cm. After 2 minutes the amplitude decreases to 6 cm. Determine the value of the damping constant for this motion. (take $\ln 2 = 0.693$).

- (1) $3.3 \times 10^2 \text{ kg s}^{-1}$ (2) $5.7 \times 10^{-3} \text{ kg s}^{-1}$ (3) $1.16 \times 10^2 \text{ kg s}^{-1}$ (4) $0.69 \times 10^2 \text{ kg s}^{-1}$

Sol. (3)

$$A = A_0 e^{\frac{-b}{2m}t}$$

$$6 = 12 e^{\frac{-b}{2 \times 1} \times 120}$$

$$6 = 12 e^{-b \times 60}$$

$$\frac{1}{2} = e^{-60b}$$

$$\ln(2) = 60b$$

$$b = \frac{\ln(2)}{60} = 1.16 \times 10^2 \text{ Kg / s}$$

12. An object is located at 2 km beneath the surface of the water. If the fractional compression $\frac{\Delta V}{V}$ is 1.36%, the ratio of hydraulic stress to the corresponding hydraulic strain will be

[Given : density of water is 1000 kgm^{-3} and $g = 9.8 \text{ ms}^{-2}$]

- (1) $2.26 \times 10^9 \text{ Nm}^{-2}$ (2) $1.96 \times 10^7 \text{ Nm}^{-2}$ (3) $1.44 \times 10^7 \text{ Nm}^{-2}$ (4) $1.44 \times 10^9 \text{ Nm}^{-2}$

Sol. (4)

$$\beta = \frac{\Delta p}{\frac{\Delta V}{V}}$$

$$\beta = \frac{\rho gh}{\frac{\Delta V}{V}} = \frac{1000 \times 9.8 \times 2 \times 10^3}{\frac{1.36}{100}}$$

$$\beta = 1.44 \times 10^9 \text{ N/m}^2$$

13. Two identical photocathodes receive the light of frequencies f_1 and f_2 respectively. If the velocities of the photo-electrons coming out are v_1 and v_2 respectively, then

$$(1) v_1 + v_2 = \left[\frac{2h}{m} (f_1 + f_2) \right]^{\frac{1}{2}}$$

$$(2) v_1 - v_2 = \left[\frac{2h}{m} (f_1 - f_2) \right]^{\frac{1}{2}}$$

$$(3) v_1^2 + v_2^2 = \frac{2h}{m} [f_1 + f_2]$$

$$(4) v_1^2 - v_2^2 = \frac{2h}{m} [f_1 - f_2]$$

Sol. (4)

$$\frac{1}{2}mv_1^2 = hf_1 - \phi \text{ ----(1)}$$

$$\frac{1}{2}mv_2^2 = hf_2 - \phi \text{ ----(2)}$$

Subtracting equation (1) by equation (2)

$$\frac{1}{2}mv_1^2 - \frac{1}{2}mv_2^2 = hf_1 - hf_2$$

$$v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$$

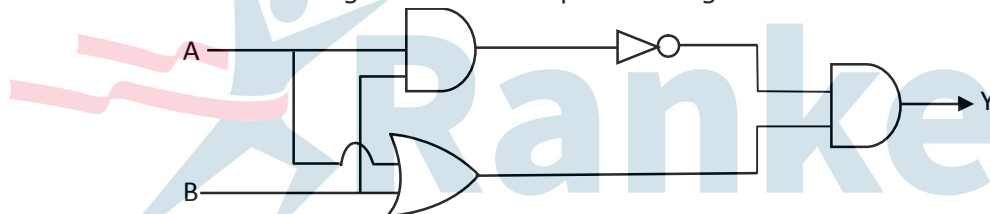
14. The atomic hydrogen emits a line spectrum consisting of various series. Which series of hydrogen atomic spectra is lying in the visible region ?

- (1) Balmer series (2) Lyman series (3) Brackett series (4) Paschen series

Sol. (1)

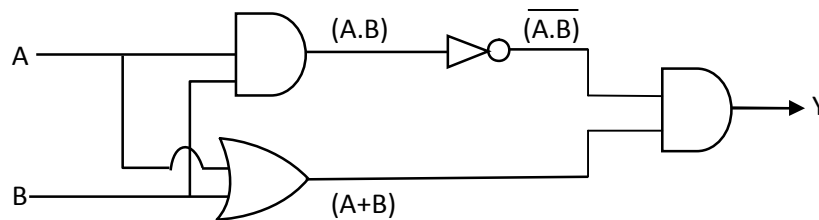
Balmer series of hydrogen atomic spectrum is lying in the visible region, when electron jumps from a higher energy level to $n = 2$ orbit.

15. Which one of the following will be the output of the given circuit ?



- (1) NAND Gate (2) AND Gate (3) XOR Gate (4) NOR Gate

Sol. (3)



$$y = (\overline{A.B}).(A+B)$$

$$= (\overline{A} + \overline{B}).(A+B)$$

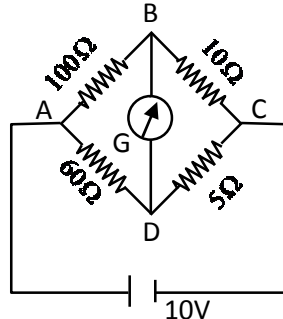
$$= \overline{A}A + \overline{A}B + A\overline{B} + \overline{B}B$$

$$= 0 + \overline{A}B + A\overline{B} + 0$$

$$y = \overline{A}B + A\overline{B}$$

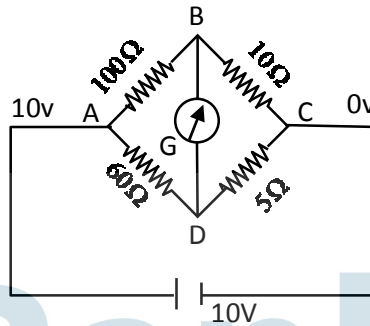
which is XOR gate

16. The four arms of a wheatstone bridge have resistances as shown in the figure. A galvanometer of $15\ \Omega$ resistance is connected across BD. Calculate the current through the galvanometer when a potential difference of 10 V is maintained across AC.



- (1) 4.87 mA (2) 4.87 μ A (3) 2.44 μ A (4) 2.44 mA

Sol. (1)



$$\frac{V_B - 10}{100} + \frac{V_B - V_D}{15} + \frac{V_B - 0}{10} = 10$$

$$\frac{V_B - 10}{20} + \frac{V_B - V_D}{3} + \frac{V_B}{2} = 0$$

$$3V_B - 30 + 20V_B - 20V_D + 30V_B = 0$$

$$53V_B - 20V_D = 30 \quad \text{--- (1)}$$

Similarly

$$\frac{V_D - 10}{60} + \frac{V_D - V_B}{15} + \frac{V_D - 0}{5} = 0$$

$$V_D - 10 + 4V_D - 4V_B + 12V_D = 0$$

$$-4V_B + 17V_D = 10 \quad \text{--- (2)}$$

after solving equation (1) & (2)

$$V_D = 0.79 \text{ volt}$$

$$V_B = 0.86 \text{ volt}$$

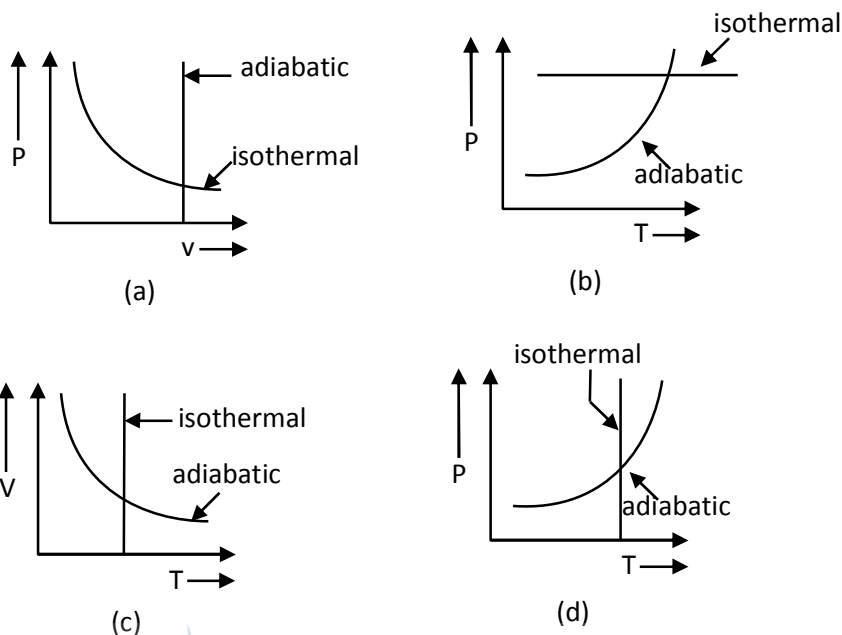
Then the current through the galvanometer

$$= \frac{V_B - V_D}{R}$$

$$= \frac{0.86 - 0.79}{15}$$

$$= 4.87 \text{ mA}$$

17. Which one is the correct option for the two different thermodynamic processes ?



- (1) (c) and (d) (2) (b) and (c) (3) (a) only (4) (c) and (a)

Sol. (1)

Isothermal process means constant temperature which is only possible in graph (c) & (d) for adiabatic process

$$pv^\gamma = \text{constant} \dots\dots(1)$$

$$\therefore PV = nRT$$

$$p \propto \frac{T}{v}$$

$$\text{So } \frac{T}{v} v^\gamma = \text{constant}$$

$$Tv^{\gamma-1} = \text{constant} \dots\dots(2)$$

Similarly,

$$v \propto \frac{T}{p}$$

$$P \left(\frac{T}{P} \right)^\gamma = \text{constant}$$

$$P^{1-\gamma} T^\gamma = \text{constant} \dots\dots(3)$$

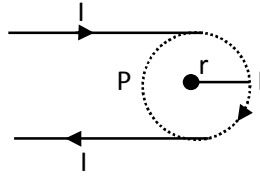
\therefore differentiating equation (3) w.r.to temp.

$$(P)^{1-\gamma} \gamma (T)^{\gamma-1} dT + (T)^\gamma (1-\gamma) (P)^{1-\gamma-1} dP = 0$$

$$\frac{dP}{dT} = - \frac{(1-\gamma) T^\gamma P^{-\gamma}}{\gamma (P)^{1-\gamma} (T)^{\gamma-1}} = \frac{(\gamma-1) T}{\gamma P}$$

It gives (+ve) slope.

18. A hairpin like shape as shown in figure is made by bending a long current carrying wire. What is the magnitude of a magnetic field at point P which lies on the centre of the semicircle ?



- (1) $\frac{\mu_0 I}{4\pi r}(2 - \pi)$ (2) $\frac{\mu_0 I}{4\pi r}(2 + \pi)$ (3) $\frac{\mu_0 I}{2\pi r}(2 + \pi)$ (4) $\frac{\mu_0 I}{2\pi r}(2 - \pi)$

Sol. (2)

$$B = \frac{\mu_0 I}{4\pi r} + \frac{\mu_0 I}{4\pi r} + \frac{\mu_0 I}{4r}$$

$$= \frac{\mu_0 I}{2\pi r} + \frac{\mu_0 I}{4r}$$

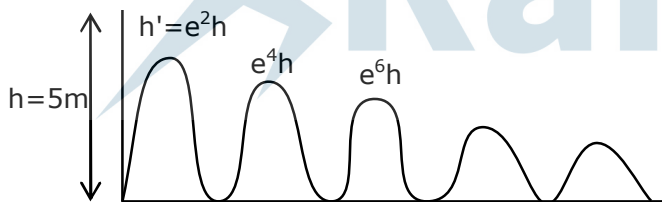
$$B = \frac{\mu_0 I}{4\pi r}(2 + \pi)$$

19. A rubber ball is released from a height of 5 m above the floor. It bounces back repeatedly, always rising to $\frac{81}{100}$ of the height through which it falls. Find the average speed of the ball.

(Take $g=10 \text{ ms}^{-2}$)

- (1) 2.50 ms^{-1} (2) 3.50 ms^{-1} (3) 3.0 ms^{-1} (4) 2.0 ms^{-1}

Sol. (1)



$$\text{Total distance } d = h + 2e^2 h + 2e^4 h + 2e^6 h + 2e^8 h + \dots$$

$$d = h + 2e^2 h (1 + e^2 + e^4 + e^6 + \dots)$$

$$d = h + 2e^2 h \left(\frac{1}{1 - e^2} \right)$$

$$d = \frac{(1 - e^2)h + 2e^2 h}{1 - e^2} = \frac{h(1 + e^2)}{1 - e^2}$$

$$\text{Total time} = T + 2eT + 2e^2 T + 2e^3 T + \dots$$

$$\text{Total time} = T + 2eT (1 + e + e^2 + e^3 + \dots)$$

$$= T + 2e.T \left(\frac{1}{1 - e} \right)$$

$$\text{Total time} = \frac{T(1 + e)}{1 - e}$$

Average speed of the ball

$$V_{\text{avg}} = \frac{h \left(\frac{1+e^2}{1-e^2} \right)}{T \left(\frac{1+e}{1-e} \right)}$$

$$= \frac{5 \left(\frac{1+e^2}{(1+e)(1-e)} \frac{(1-e)}{(1+e)} \right)}{1}$$

$$V_{\text{avg}} = \frac{5(1+e^2)}{(1+e)^2}$$

$$\therefore h^1 = e^2 h$$

$$\frac{81}{100} = e^2$$

$$e = \frac{9}{10} = 0.9$$

$$V_{\text{avg}} = \frac{5 \left(1 + \frac{81}{100} \right)}{(1+0.9)^2}$$

$$= 2.50 \text{ m/sec.}$$

20. What happens to the inductive reactance and the current in a purely inductive circuit if the frequency is halved ?

- (1) Both , including reactance and current will be doubled
- (2) Both, inductive reactance and current will be halved
- (3) Inductive reactance will be halved and current will be doubled
- (4) Inductive reactance will be doubled and current will be halved.

Sol. (3)

$$X_L = \omega L$$

$$X'_L = \left(\frac{X_L}{2} \right)$$

$$\therefore I = \frac{V}{X_L}$$

$$\& I' = \frac{2V}{X_L} = 2I$$

SECTION – B

1. The electric field intensity produced by the radiation coming from a 100 W bulb at a distance of 3 m is E. The electric field intensity produced by the radiation coming from 60 W at the same distance is

$$\sqrt{\frac{x}{5}} E . \text{ Where the value of } x = \underline{\hspace{2cm}}$$

Sol. (3)

$$I = \frac{1}{2} C \epsilon_0 E^2$$

$$E^2 \propto I$$

$$I = \frac{\text{Power}}{\text{Area}}$$

$$E^2 \propto \frac{P}{A}$$

$$E \propto \sqrt{P}$$

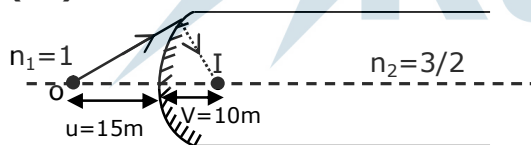
$$\frac{E'}{E} = \sqrt{\frac{60}{100}}$$

$$E' = \sqrt{\frac{3}{5}} E$$

So the value of $x = 3$

2. The image of an object placed in air formed by convex refracting surface is at a distance of 10 m behind the surface. The image is real and is at $\frac{2^{\text{nd}}}{3}$ of the distance of the object from the surface. The wavelength of light inside the surface is $\frac{2}{3}$ times the wavelength in air. The radius of the curved surface is $\frac{x}{13}$ m. The value of 'x' is _____

Sol. (30)



$$\frac{n_2}{v} - \frac{n_1}{u} = \left(\frac{n_2 - n_1}{R} \right)$$

$$\frac{\frac{3}{2}}{10} - \frac{1}{(-15)} = \left(\frac{\frac{3}{2} - 1}{R} \right)$$

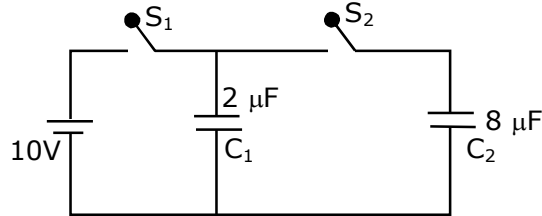
$$\frac{3}{20} + \frac{1}{15} = \frac{1}{2R}$$

$$R = \frac{150}{65}$$

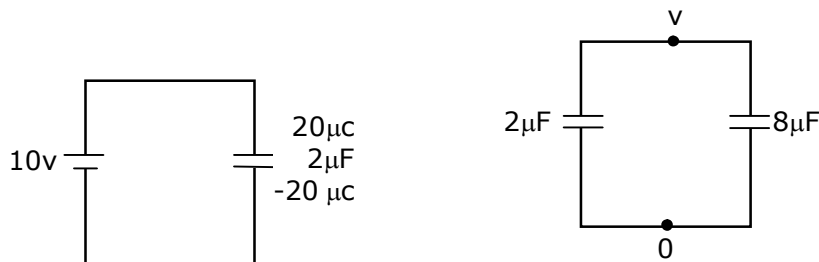
$$R = \frac{30}{13} \text{ m}$$

Then the value of $x = 30$

3. A $2\mu\text{F}$ capacitor C_1 is first charged to a potential difference of 10V using a battery. Then the battery is removed and the capacitor is connected to an uncharged capacitor C_2 of $8\mu\text{F}$. The charge in C_2 on equilibrium condition is _____ μC . (Round off to the Nearest Integer)



Sol. (16)



When battery is removed & the capacitor is connected

$$2V + 8v = 20$$

$$10V = 20$$

$$V = 2 \text{ volt}$$

$$\therefore Q = CV$$

$$Q = 8 \times 2 = 16\mu\text{C}$$

4. A particle of mass m moves in a circular orbit in a central potential field $U(r) = U_0 r^4$. If Bohr's quantization conditions are applied, radii of possible orbital r_n vary with n^α , where α is _____

Sol. (3)

$$\vec{F} = -\frac{dU}{dr}$$

$$= -\frac{d}{dr}(U_0 r^4)$$

$$\vec{F} = -4U_0 r^3$$

$$\therefore \frac{mv^2}{r} = 4U_0 r^3$$

$$mv^2 = 4U_0 r^4$$

$$\text{Then } v \propto r^2$$

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

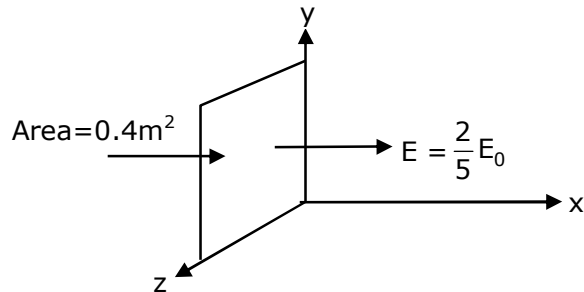
$$\text{Then } r^3 \propto n$$

$$r \propto (n)^{\frac{1}{3}}$$

So the value of $\alpha = 3$

5. The electric field in a region is given by $\vec{E} = \frac{2}{5}E_0\hat{i} + \frac{3}{5}E_0\hat{j}$ with $E_0 = 4.0 \times 10^3 \frac{N}{C}$. The flux of this field through a rectangular surface are 0.4 m^2 parallel to Y-Z plane is _____ Nm^2C^{-1} .

Sol. (640)



From gauss law

$$\phi = \oint \vec{E} \cdot d\vec{A}$$

$$= \frac{2}{5}E_0 \times (0.4)$$

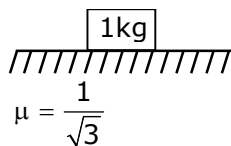
$$= \frac{2}{5} \times 4 \times 10^3 \times 0.4$$

$$\phi = 640 \text{ Nm}^2 \text{ c}^{-1}$$

6. A body of mass 1 kg rests on a horizontal floor with which it has a coefficient of static friction $\frac{1}{\sqrt{3}}$. It is desired to make the body move by applying the minimum possible force F N. The value of F will be _____. (Round off to the Nearest Integer)

[Take $g = 10 \text{ ms}^{-2}$]

Sol. (5)



Minimum possible force \Rightarrow

$$F = \frac{\mu mg}{\sqrt{1 + \mu^2}}$$

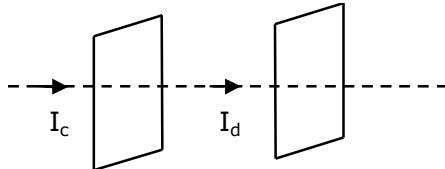
$$F_{\min} = \frac{\frac{1}{\sqrt{3}} \times 1 \times 10}{\sqrt{1 + \frac{1}{3}}}$$

$$F_{\min} = 5\text{N}$$

7. Seawater at a frequency $f = 9 \times 10^2$ Hz, has permittivity $\epsilon = 80\epsilon_0$ and resistivity $\rho = 0.25 \Omega\text{m}$. Imagine a parallel plate capacitor is immersed in seawater and is driven by an alternating voltage source $V(t) = V_0 \sin(2\pi ft)$. Then the conduction current density becomes 10^x times the displacement current density after time $t = \frac{1}{800}$ s. The value of x is _____.

(Given : $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2\text{C}^{-2}$)

Sol.7 (6)



Given $f = 9 \times 10^2 \text{ Hz}$

$\epsilon = \epsilon_0 \epsilon_r$

$\epsilon = 80 \epsilon_0$

So $\epsilon_r = 80$

$\rho = 0.25 \Omega\text{m}$

$V(t) = V_0 \sin(2\pi ft)$

$I_d = \frac{dq}{dt} = \frac{cdv}{dt}$

$I_d = \frac{\epsilon_0 \epsilon_r A}{d} \frac{d}{dt} (v_0 \sin(2\pi ft))$

$I_d = \frac{\epsilon_0 \epsilon_r A}{d} V_0 (2\pi f) \cos(2\pi ft) \dots\dots(1)$

& $I_c = \frac{V}{R}$

$I_c = \frac{V_0 \sin(2\pi ft)}{\rho \frac{d}{A}} = \frac{Av_0 \sin(2\pi ft)}{\rho d} \dots(2)$

divide equation (1) and (2)

$\frac{I_d}{I_c} = \epsilon_0 \epsilon_r 2\pi f(\rho) \cot(2\pi ft)$

$\frac{I_d}{I_c} = \frac{1}{4\pi \times 9 \times 10^9} \times 80 \times 2\pi \times 9 \times 10^2 \times (0.25) \times \cot(2\pi \times 9 \times 10^2 \times \frac{1}{800})$

$= \frac{10^3}{10^9} \left(\cot\left(\frac{9\pi}{4}\right) \right)$

$= \frac{10^3}{10^9}$

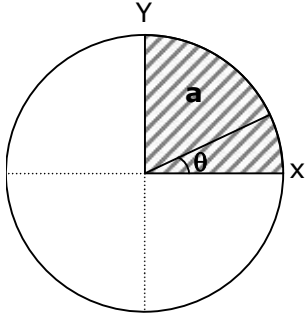
$\frac{I_d}{I_c} = \frac{1}{10^6}$

$I_c = 10^6 I_d$

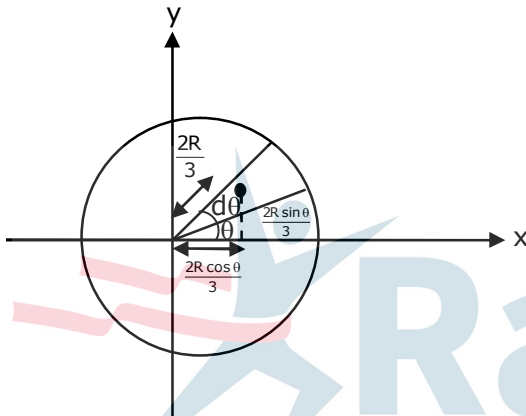
So $x = 6$

8. The disc of mass M with uniform surface mass density σ is shown in the figure. The centre of mass of the quarter disc (the shaded area) is at the position $\frac{x a}{3 \pi}, \frac{x a}{3 \pi}$.

x is ____ (Round off to the Nearest Integer)
[a is an area as shown in the figure]



Sol. (4)



$$dm = \sigma \frac{1}{2} R \times R d\theta$$

$$dm = \frac{\sigma R^2 d\theta}{2}$$

$$x_{cm} = \frac{\int x dm}{\int dm} = \frac{\int_0^{\pi/2} \frac{\sigma R^2}{2} d\theta \left(\frac{2R}{3} \cos \theta \right)}{\int_0^{\pi/2} \frac{\sigma R^2}{2} d\theta}$$

$$= \frac{2R}{3} \frac{\int_0^{\pi/2} \cos \theta d\theta}{\int_0^{\pi/2} d\theta}$$

$$= \frac{2R}{3} \left(\frac{2}{\pi} \right)$$

$$= \frac{4R}{3\pi}$$

So the value of $x = 4$

9. Suppose you have taken a dilute solution of oleic acid in such a way that its concentration becomes 0.01 cm^3 of oleic acid per cm^3 of the solution. Then you make a thin film of this solution (monomolecular thickness) of area 4 cm^2 by considering 100 spherical drops of radius $\left(\frac{3}{40\pi}\right)^{\frac{1}{3}} \times 10^{-3} \text{ cm}$. Then the thickness of oleic acid layer will be $x \times 10^{-14} \text{ m}$.

Where x is _____.

Sol. (NTA answer is 25) our answer is (0.25)

$$Ax \times \frac{10^{-2}}{10^{-6}} = 100 \times \frac{4}{3} \pi r^3$$

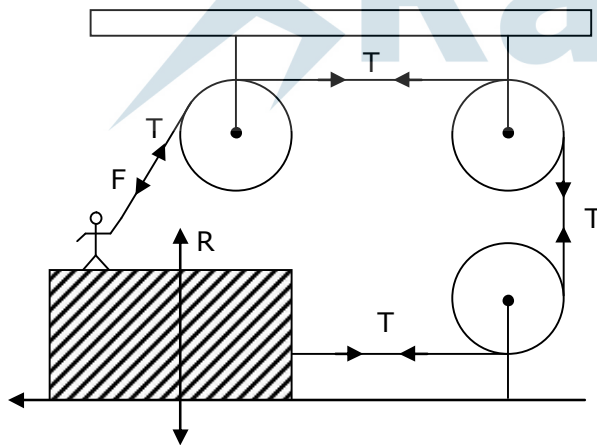
$$4 \times 10^{-4} x \times \frac{10^{-2}}{10^{-6}} = 100 \times \frac{4}{3} \pi \frac{3}{40\pi} \times 10^{-9} \times 10^{-6}$$

$$4x = 10^{-14}$$

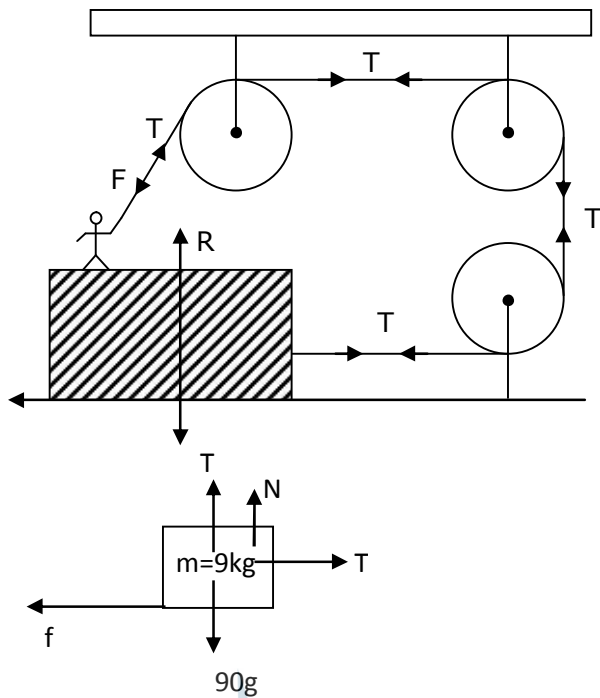
$$x = \frac{1}{4} \times 10^{-14} = 0.25 \times 10^{-14} \text{ m}$$

10. A boy of mass 4 kg is standing on a piece of wood having mass 5 kg . If the coefficient of friction between the wood and the floor is 0.5 , the maximum force that the boy can exert on the rope so that the piece of wood does not move from its place is _____ N. (Round off to the Nearest Integer)

[Take $g = 10 \text{ ms}^{-2}$]



Sol. (30)



$$\begin{aligned} \therefore f &= T \\ \mu N &= T \\ \mu(90-T) &= T \\ 0.5(90-T) &= T \\ 90 - T &= 2T \\ 3T &= 90 \\ T &= 30 \text{ N} \end{aligned}$$

 Rankers