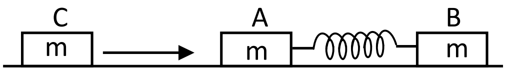
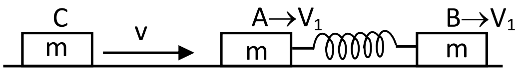
SECTION – A

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) $\sqrt{\dfrac{mv}{2K}}$ (2) $\sqrt{\dfrac{m}{2K}}$ (3) $\sqrt{\dfrac{mv}{K}}$ (4) $v\sqrt{\dfrac{m}{2K}}$

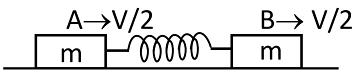
Sol. **(4)**



From conservation of momentum

$mv = mv_1 + mv_1$

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



& from energy conservation

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

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

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

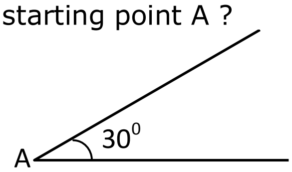
Then the maximum compression in the spring is

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

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

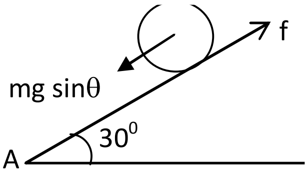
-

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 30^0 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)**



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

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

a = 3.5 m/sec^2

Time of accent

V = u + at

0 = 1 −3.5 t

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

Time of decent

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

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

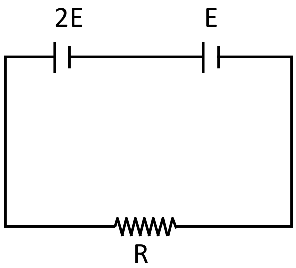
f = T + R + V

f = 3 + 3 + 2 = 8

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

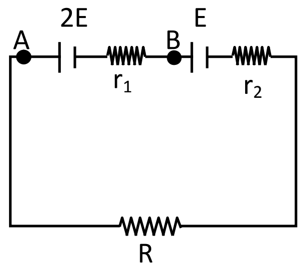
$\gamma = \frac{10}{8} = \frac{5}{4} = 1.25$

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

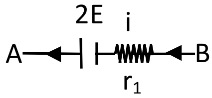


(1) $r_1 - r_2$ (2) $r_1 + r_2$ (3) $\frac{r_1}{2} + r_2$ (4) $\frac{r_1}{2} - r_2$

Sol. **(4)**



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



$V_A = V_B$

$2\,E = i\,r_1$

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

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

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

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

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

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

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

Sol. **(4)**

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

$A = \frac{6}{2} = 3\text{cm} = 0.03$ 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 $(2.512\times10^{10}t)$ is amplitude modulated by a message signal m(t)=5 sin $(1.57\times10^{8}t)$ and transmitted through an antenna. What will be bandwith of the modulated signal ?

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

Sol. **(3)**

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

$$\beta = 2\times\frac{1.57\times10^{8}}{2\pi}$$

β = 50 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 osciliations 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)**

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

Given $\omega_1 A_1 = \omega_2 A_2$

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

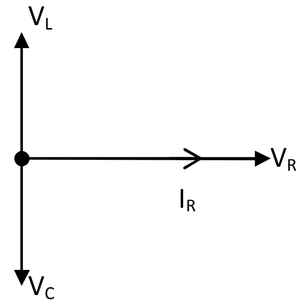
List I	**List II**
(a) Phase difference between current and voltage in a purely resistive AC circuit	(i) $\frac{\pi}{2}$; current leads voltage
(b) Phase difference between current and voltage in a pure inductive AC circuit	(ii) zero
(c) Phase difference between current and voltage in a pure capacitive AC circuit	(iii) $\frac{\pi}{2}$; current lags voltage
(d) Phase difference between current and voltage in an LCR series circuit	(iv) $\tan^{-1}\left(\frac{X_C - X_L}{R}\right)$

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)

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.

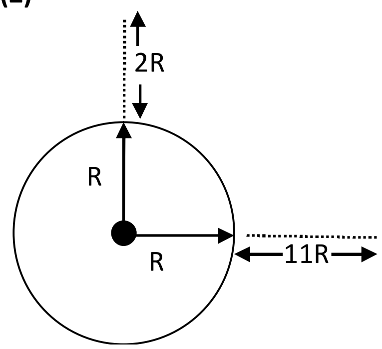
(c) phase different b/w current & voltage in a pure capacitive AC circuit is $\frac{\pi}{2}$; current lead voltage.

(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 arbitary 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 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)**

$V = V_0 + gt + Ft^2$

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

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

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

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

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 In 2 = 0.693).

(1) 3.3×10^2 kg s^{-1} (2) 5.7×10^{-3} kg s^{-1} (3) 1.16×10^2 kg s^{-1} (4) 0.69×10^2 kg s^{-1}

Sol. **(3)**

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

$6 = 12e^{\frac{-b}{2\times1}\times120}$

$6 = 12\ e^{-b\times60}$

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

$\ln(2) = 60b$

$$b = \frac{\ln(2)}{60} = 1.16\times10^2 Kg/s$$

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 ms^{-2}]

(1) 2.26×10^9 Nm^{-2} (2) 1.96×10^7 Nm^{-2} (3) 1.44×10^7 Nm^{-2} (4) 1.44×10^9 Nm^{-2}

Sol. **(4)**

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

$$\beta = \frac{\rho gh}{\frac{\Delta V}{V}} = \frac{1000\times9.8\times2\times10^3}{\frac{1.36}{100}}$$

$\beta = 1.44\times10^9$ 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) $v_1^2+v_2^2 = \frac{2h}{m}\left[f_1+f_2\right]$

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

Sol. **(4)**

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

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

Subtracting equation (1) by equation (2)

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

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

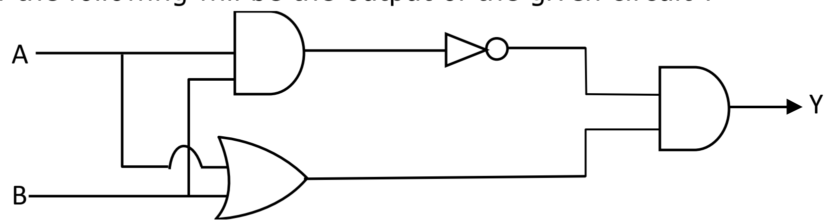
14. The atomic hydrogen emits a line spectrum consisting of various series. Which series of hydrogen atomic spectra is lying in the visible region ?

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

Sol. **(1)**

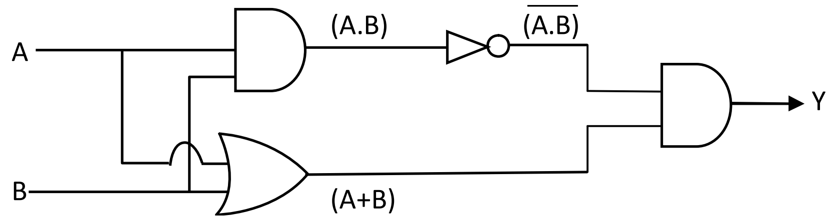
Balmer series of hydrogen atomic spectrum is lying in the visible region, when electron jumps from a higher energy level to n = 2 orbit.

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

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

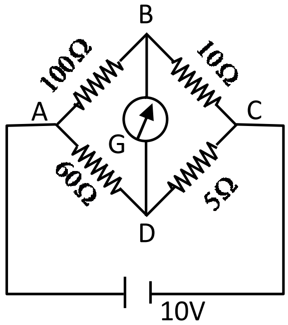
= $\overline{A}\ A + \overline{A}B + A\overline{B} + \overline{B}B$

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

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

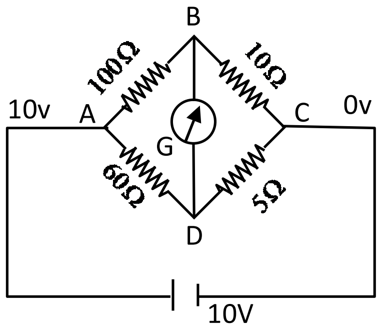
which is XOR gate

16. The four arms of a wheatstone bridge have resistances as shown in the figure. A galvanometer of 15 Ω 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 μA (3) 2.44 μA (4) 2.44 mA

Sol. **(1)**



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

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

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

$53V_B - 20V_D = 30$ ____(1)

Similarly

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

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

$-4V_B + 17V_D = 10$ _____(2)

after solving equation (1) & (2)

$V_D = 0.79$ volt

$V_B = 0.86$ volt

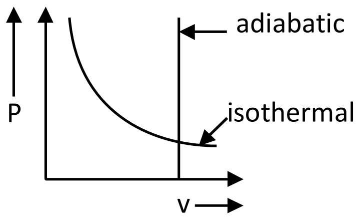
Then the current through the galvanometer

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

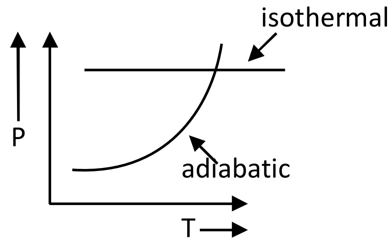
$$= \frac{0.86 - 0.79}{15}$$

= 4.87 mA

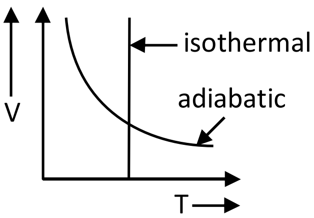
17. Which one is the correct option for the two different thermodynamic processes ?



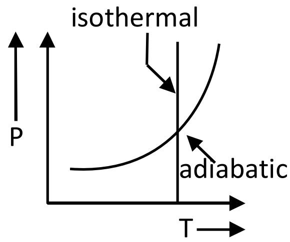
(a)



(b)



(c)



(d)

(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^{γ} = constant ……(1)

$\because$ PV = nRT

$p \ \alpha \dfrac{T}{v}$

So $\dfrac{T}{v} v^{\gamma}$ = constant

Tv^{r-1} = constant ….(2)

Similarly,

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

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

$P^{1-r}\ T^{r}$ = constant ….(3)

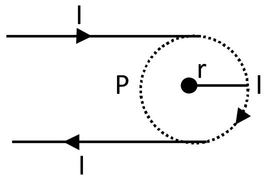
$\because$ differentiating equation (3) w.r.to temp.

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

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

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)

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

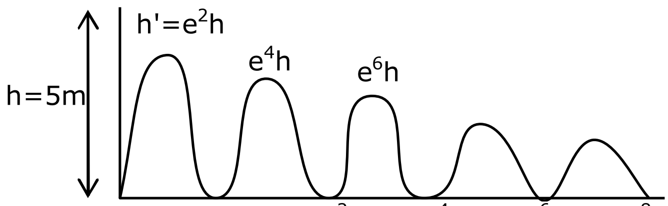
$= \frac{\mu_0 I}{2\pi r} + \frac{\mu_0 I}{4r}$

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

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

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

Sol. (1)



Total distance $d = h + 2e^2h + 2e^4h + 2e^6h + 2e^8h + ...$

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

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

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

Total time $= T + 2\,eT + 2e^2T + 2e^3\,T + ...$

Total time $= T + 2e\,T\,(1+e+e^2+e^3+......)$

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

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

Average speed of the ball

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

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

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

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

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

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

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

= 2.50 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)**

$X_L = \omega L$

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

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

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

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 filed intensity produced by the radiation coming from 60 W at the same distance is

$\sqrt{\frac{x}{5}}E$. Where the value of x = ________

Sol. **(3)**

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

$E^2 \propto I$

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

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

$E \propto \sqrt{P}$

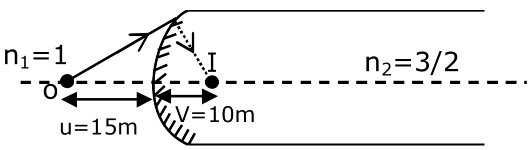
$\frac{E'}{E} = \sqrt{\frac{60}{100}}$

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

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 $\frac{2^{nd}}{3}$ 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)**



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

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

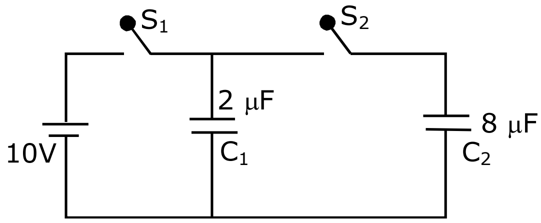
$\frac{3}{20} + \frac{1}{15} = \frac{1}{2R}$

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

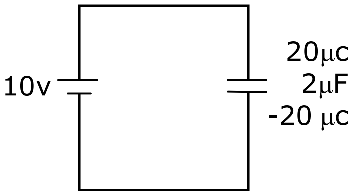
$R = \frac{30}{13} m$

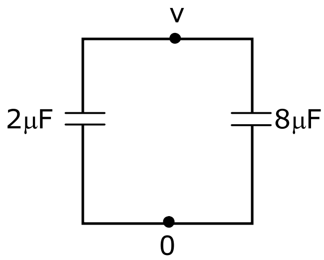
Then the value of x = 30

3. A $2\mu F$ 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 μF. 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 volt

$\because Q = CV$

$Q = 8 \times 2 = 16\mu c$

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 $n^{\frac{1}{\alpha}}$, where α is ______

Sol. **(3)**

$$\vec{F} = -\frac{d\vec{u}}{dr}$$

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

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

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

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

Then $v \propto r^2$

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

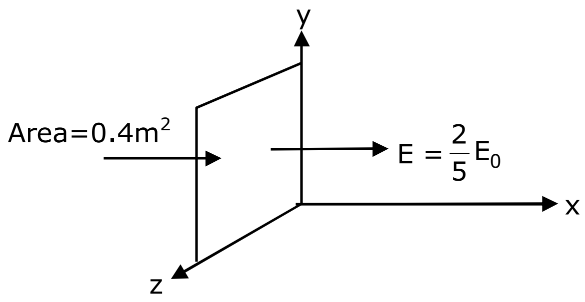
Then $r^3\ \alpha\ n$

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

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

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

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

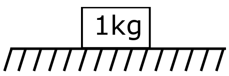
$= \frac{2}{5} \times 4 \times 10^3 \times 0.4$

ϕ = 640 $Nm^2\ c^{-1}$

-----

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 ms^{-2}]

Sol. **(5)**



$\mu = \frac{1}{\sqrt{3}}$

Minimum possible force ⇒

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

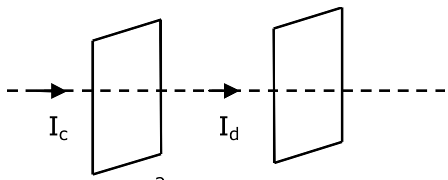
$F_{min} = \frac{\frac{1}{\sqrt{3}} \times 1 \times 10}{\sqrt{1+\frac{1}{3}}}$

F_{min} = 5N

7. Seawater at a frequency $f = 9 \times 10^2$ Hz, has permitivity $\varepsilon = 80\varepsilon_0$ and resistivity $\rho = 0.25\ \Omega$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 : $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ Nm^2C^{-2}$)

Sol.7 (6)



Given $f = 9 \times 10^2\ H_z$

$\epsilon = \epsilon_0 \epsilon_r$

$\epsilon = 80\ \epsilon_0$

So $\epsilon_r = 80$

$\rho = 0.25\ \Omega m$

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

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

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

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

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

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

divide equation (1) and (2)

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

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

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

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

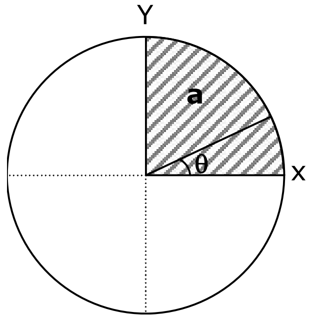
$\frac{I_d}{I_c} = \frac{1}{10^6}$

$I_c = 10^6\ I_d$

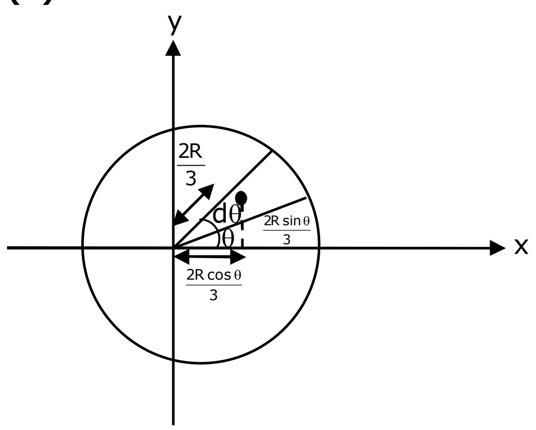
So x = 6

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 $\frac{x}{3}\frac{a}{\pi}, \frac{x}{3}\frac{a}{\pi}$.

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 $x \times 10^{-14}$ m.

Where x is __________.

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

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

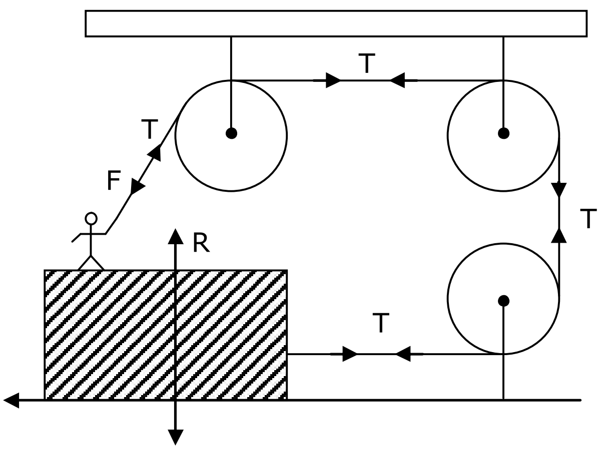
$$4 \times 10^{-4} x \times \frac{10^{-2}}{10^{-6}} = 100 \times \frac{4}{3}\pi \frac{3}{40\pi} \times 10^{-9} \times 10^{-6}$$

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

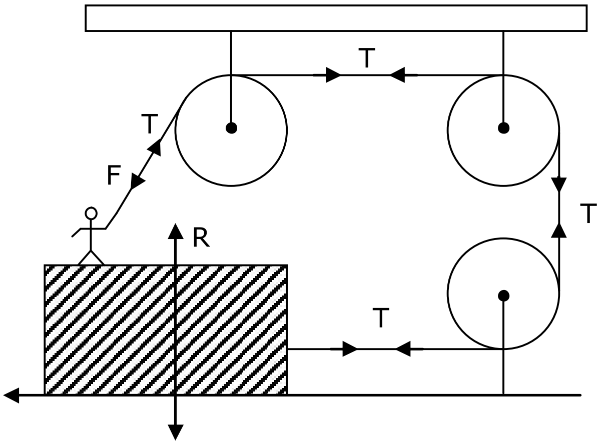
$$x = \frac{1}{4} \times 10^{-14} = 0.25 \times 10^{-14} m$$

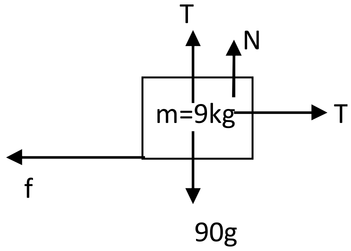
10. A boy of mass 4 kg is standing on a piece of wood having mass 5 kg. If the coefficient of friction between the wood and the floor is 0.5, the maximum force that the boy can exert on the rope so that the piece of wood does not move from its place is _________N. (Round off to the Nearest Integer)

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



Sol. **(30)**





$\because f = T$

$\mu N = T$

$\mu(90-T) = T$

$0.5\,(90-T) = T$

$90 - T = 2T$

$3T = 90$

$T = 30\ N$