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IIT JEE PHYSICS PAPER SOLUTION

28 JUNE 2022 EVENING SHIFT

QUESTIONS BASED ON

UNIT AND DIMENSION, LADDER PROBLEM,YDSE,RADIOACTIVITY ,DIODE FILTER CIRCUIT WAVEFORM & ZENER DIODE ARE TRICKY

Q1: Velocity (v) and acceleration (a) in two system of units 1 and 2 are related as $v_2 = \frac{n}{m^2} v_1$ and $a_2 = \frac{a_1}{mn}$ respectively. Here m and n are constant. The relations for distance and time in two systems respectively are:

(A) $\frac{n^3}{m^3} L_1 = L_2$ and $\frac{n^2}{m} T_1 = T_2$ ✓

(B) $L_1 = \frac{n^4}{m^2} L_2$ and $T_1 = \frac{n^2}{m} T_2$

(C) $L_1 = \frac{n^2}{m} L_2$ and $T_1 = \frac{n^4}{m^2} T_2$

(D) $\frac{n^2}{m} L_1 = L_2$ and $\frac{n^4}{m^2} T_1 = T_2$

we know that

$$a = \frac{v^2}{s} \Rightarrow s = \frac{v^2}{a} = L$$

$$\frac{v_1^2}{a_1} = L_1 , \quad \frac{v_2^2}{a_2} = L_2$$

$$\frac{v_1^2}{v_2^2} \times \frac{a_2}{a_1} = \frac{L_1}{L_2}$$

$$\frac{v_1^2}{\left(\frac{n}{m^2} v_1\right)^2} \times \left(\frac{1}{mn}\right) = \frac{L_1}{L_2}$$

$$\frac{v_1^2}{\left(\frac{n^2 v_1^2}{m^4}\right)} \times \frac{1}{mn} = \frac{L_1}{L_2}$$

$$\frac{m^4}{n^2} \times \frac{1}{mn} = \frac{L_1}{L_2}$$

$$\boxed{\frac{L_1}{L_2} = \frac{m^3}{n^3}}$$

$$\frac{v}{a} = T$$

$$\frac{T_1}{T_2} = \frac{v_1}{a_1} \frac{a_2}{v_2} = \left(\frac{v_1}{v_2}\right)\left(\frac{a_2}{a_1}\right)$$

$$= \left(\frac{m^2}{n}\right)\left(\frac{1}{mn}\right) = \frac{m}{n^2}$$

Q2: A ball is spun with angular acceleration $\alpha = 6t^2 - 2t$ where t is in second and α is in $rads^{-2}$ .at $t = 0$, the ball has angular velocity of $10 rads^{-1}$ and angular position of 4 rad. The most appropriate expression for the angular position of the ball is:

(A) $\frac{3}{2}t^4 - t^2 + 10t$

(B) $\frac{t^4}{2} - \frac{t^3}{3} + 10t + 4$ ✓

(C) $\frac{2t^4}{3} - \frac{t^3}{6} + 10t + 12$

(D) $2t^4 - \frac{t^3}{2} + 5t + 4$

$\alpha = 6t^2 - 2t$

at $t = 0$
$\omega = 10\,rad/sec$
$\theta = 4\,rad$
} → Initial Condition

$\frac{d\omega}{dt} = 6t^2 - 2t$

$\int d\omega = \int (6t^2 - 2t)\,dt$

$\omega = \frac{6t^3}{3} - \frac{2t^2}{2} + c$

at $t = 0$
$\omega = 10\,rad/sec$

$10 = c$

$\omega = 2t^3 - t^2 + 10$

$\frac{d\theta}{dt} = 2t^3 - t^2 + 10$

$\int d\theta = \int (2t^3 - t^2 + 10)\,dt$

$\theta = \frac{2t^4}{4} - \frac{t^3}{3} + 10t + c$

at $t = 0$, $\theta = 4$ rad

$4 = c$

$\theta = \frac{t^4}{2} - \frac{t^3}{3} + 10t + 4$

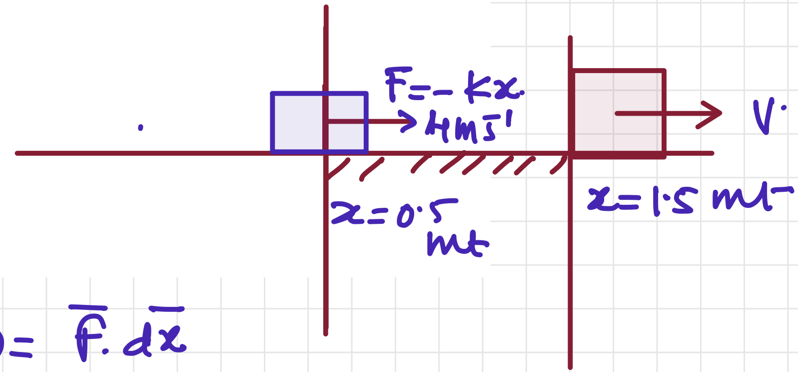
Q3: A block of mass 2 kg moving on a horizontal surface with speed of $4ms^{-1}$ enters a rough surface ranging from x = 0.5 m to x = 1.5 in. The retarding force in this range of rough surface is related to distance by $F = -kx$ where $k = 12Nm^{-1}$. The speed of the block as it just crosses the rough surface will be:

(A) Zero

(B) $1.5ms^{-1}$

(C) $2.0ms^{-1}$ ✓

(D) $2.5ms^{-1}$



$$dW = \vec{F}\cdot\vec{dx}$$

$$dW = F\,dx$$

$$\int dW = \int_{0.5}^{1.5} (-kx)\,dx$$

$$= -\frac{k}{2}\left[x^2\right]_{0.5}^{1.5} = -\frac{k}{2}\left[(1.5)^2 - (0.5)^2\right]$$

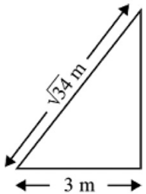
$$= -\frac{k}{2}(2)(1.0) = \frac{1}{2}mv^2 - \frac{1}{2}m(4)^2$$

$$-6\times 2\times 1.0 = \frac{1}{2}\times 2\,(v^2 - 16)$$

$$-12 = v^2 - 16 \Rightarrow v^2 = 4 \Rightarrow v^2$$

$$V = 2ms^{-1}$$

Q4: A $\sqrt{34}m$long ladder weighting 10 kg leans on a frictionless wall. Its feet rest on the floor 3m away from the wall as shown in the figure. If $F_f$and F_w are the reaction forces of the floor and the wall< then ratio of $\frac{F_w}{F_f}$will be:



(A) $\frac{6}{\sqrt{110}}$

(B) $\frac{3}{\sqrt{113}}$

(C) $\frac{3}{\sqrt{109}}$ ✓

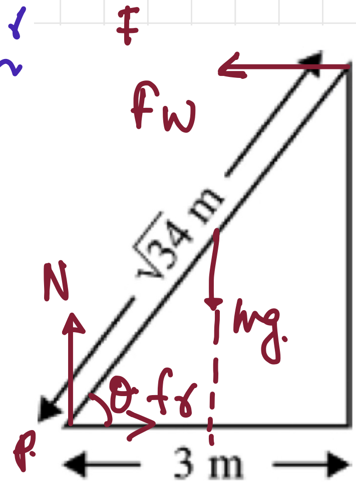
(D) $\frac{2}{\sqrt{109}}$

Since ladder is under equilibrium position hence

$\Sigma F_x=0, \quad \Sigma F_y=0$

$f_f = f_w, \quad N = mg$

Take torque about point P



$F_f = \sqrt{N^2+f_f^2}$

$f_w(5) = mg\left(\frac{\sqrt{34}}{2}\right)\cos\theta$

$f_w(5) = mg\left(\frac{\sqrt{34}}{2}\right)\left(\frac{3}{\sqrt{34}}\right) \Rightarrow f_w = \frac{3}{10}mg$

$$\frac{f_w}{f_f} = \frac{\frac{3}{10}mg}{\sqrt{(mg)^2+\left(\frac{3}{10}mg\right)^2}} = \frac{3/10}{\sqrt{\frac{109}{100}}} = \frac{3}{\sqrt{109}}$$

Q5: Water falls from a 40 in high dam at the rate of 9 x 10^4 kg per hour. Fifty percentage of gravitational potential energy can be converted into electrical energy. Using this hydro electric energy number of 100 W lamps, that can be lit, is : (Take $g = 10 ms^{-2}$)

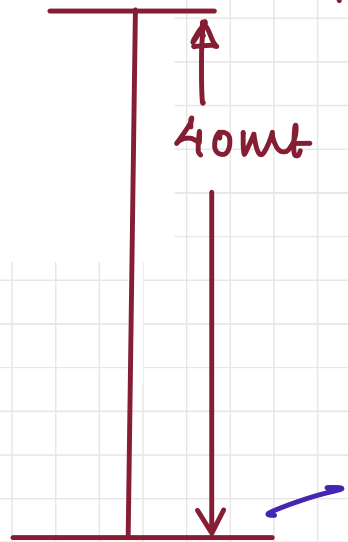
(A) 25

(B) 50

(C) 100

(D) 18

9×10^4 kg per hour



Power generated at the base $= \dfrac{mgh}{t}$

$= \dfrac{9 \times 10^4 \times 10 \times 40}{60 \times 60}$ watt

ENERGY GENERATED

$= \dfrac{1}{2}\left(\dfrac{9 \times 10^4 \times 400}{3600}\right)$

$= \dfrac{10^4}{2}$ watt

one bulb = 100 watt

Total bulb can be used $= \dfrac{10^4}{2 \times 100} = \dfrac{100}{2}$

$= 50$

Q6: Two objects of equal masses placed at certain distance from each other attracts each other with a force of F. If one-third mass of one object is transferred to the other object, then the new force will be

(A) $\frac{2}{9}F$

(B) $\frac{16}{9}F$

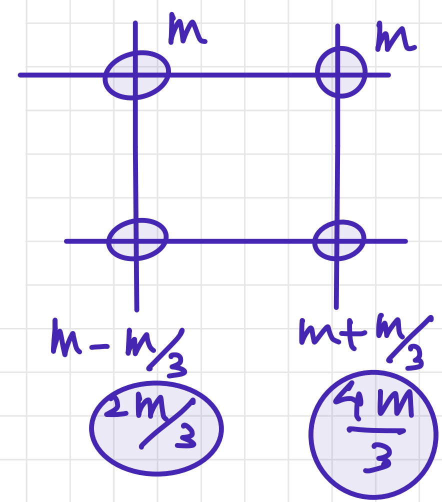
~~(C)~~ $\frac{8}{9}F$

(D) F

$$F = \frac{G m m}{d^2}$$

New force

$$F' = \frac{G\left(\frac{2m}{3}\right)\left(\frac{4m}{3}\right)}{d^2}$$



$$\frac{F'}{F} = \frac{8}{9}$$

$$F' = \frac{8}{9}F$$

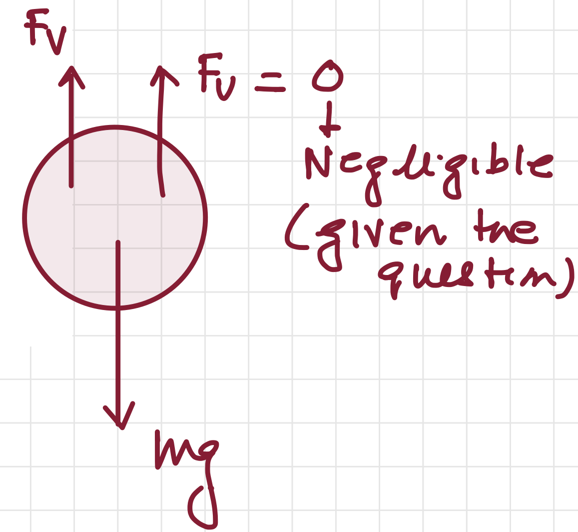
Q7: A water drop of radius $1 \mu m$ falls in a situation where the effect of buoyant force is negligible. Co-efficient of viscosity of air is $1.8 \times 10^{-5} Nsm^2$ and its density is negligible as compared to that of water $10^6 gm^{-3}$. Terminal velocity of the water drop is: (Take acceleration due to gravity $= 10 ms^{-2}$)

(A) $145.4 \times 10^{-6} ms^{-1}$

(B) $118.0 \times 10^{-6} ms^{-1}$

(C) $132.6 \times 10^{-6} ms^{-1}$

(D) $123.4 \times 10^{-6} ms^{-1}$ ✓



$$mg - F_v - F_U = 0$$

$$F_U = 0$$

$$mg = F_v$$

$$\frac{4}{3}\pi r^3 \rho g = 6\pi \eta r v$$

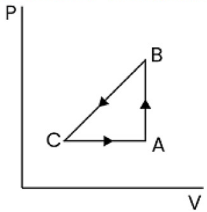
$$v = \frac{\frac{4}{3} r^3 \rho g}{6 \eta r}$$

$$= \frac{4}{3}\frac{r^2 \rho g}{\eta \times 6} = \frac{4}{3}\frac{(1\times 10^{-6})^2 \times 10^3 \times 10}{1.8\times 10^{-5}\times 6}$$

$$= \frac{40}{3}\times \frac{10^{-12}\times 10^4}{1.8\times 10^{-5}\times 6}$$

$$= \frac{40}{3\times 1.8\times 6}\times 10^{-3} = 123.4\times 10^{-6}\, ms^{-1}$$

Q8: A sample of an ideal gas is taken through the cyclic process ABCA as shown in figure. It absorbs, 40 J of heat during the part AB, no heat during BC and rejects 60 J of heat during CA. A work of 50 J is done on the gas during the part BC. The internal energy of the gas at A is 1560 J. The work done by the gas during the part CA is:



(A) 20 J

(B) 30 J

(C) -30 J

(D) -60 J

AB – Isochoric

$\Delta U_{AB} = 40$

$\Delta Q = 0$, For BC

$\Delta U_{BC} + W_{BC} = 0$

$\Delta U_{BC} = 50$

$Q_{CA} = -60$

$\Delta U_{CA} + W_{CA} = -60$

$W_{CA} = 30J$

$\Delta U = 0$ → for whole process

Q9: What will be the effect on the root mean square velocity of oxygen molecules if the temperature is doubled and oxygen molecule dissociates into atomic oxygen?

(A) The velocity of atomic oxygen remains same

(B) The velocity of atomic oxygen doubles ✓

(C) The velocity of atomic oxygen becomes half

(D) The velocity of atomic oxygen becomes four times

ANS

$$v = \sqrt{\frac{3RT}{M}}$$

M → molar mass

If temp gets doubled i.e. 2T

oxygen dissociated in to atomic oxygen is $M/2$

$$v' = \sqrt{\frac{3R(2T)}{(M/2)}} = 2\sqrt{\frac{3RT}{M}} = 2v$$

Q10: Two point charges A and B of magnitude $+8 \times 10^{-6} C$ and $-8 \times 10^{-6} C$ respectively are placed at a distance d apart. The electric field at the middle point 0 between the charges is $6.4 \times 10^{4} NC^{-1}$. The distance 'd' between the point charges A and B is:

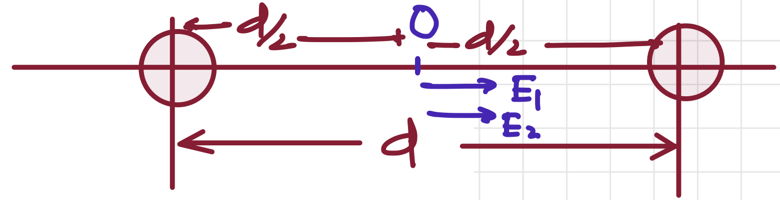
(A) 2.0 m

(B) 3.0 m ✓

(C) 1.0 m

(D) 4.0 m

$q_1 = 8 \times 10^{-6} C$ $\qquad$ $q_2 = -8 \times 10^{-6} C$



$$E_{NET} = |E_1| + |E_2|$$

$$= \frac{1}{4\pi\epsilon_0}\frac{q}{(d/2)^2} + \frac{1}{4\pi\epsilon_0}\frac{q}{(d/2)^2}$$

$$= \left(\frac{1}{4\pi\epsilon_0}\frac{q\,4}{d^2}\right) \times 2 = 8\left(\frac{1}{4\pi\epsilon_0}\right)\frac{q}{d^2}$$

$$6.4 \times 10^4 = 8 \times 9 \times 10^9 \times \frac{q}{d^2}$$

$$d^2 = \frac{72 \times 10^9 \times 8 \times 10^{-6}}{6.4 \times 10^4}$$

$d = 3\ mt$

Q11: Resistance of the wire is measured as 2Ω and 3Ω at 10°C and 30°C respectively. Temperature co-efficient of resistance of the material of the wire is :

(A) $0.033^{\circ}C^{-1}$

(B) $-0.033^{\circ}C^{-1}$

(C) $0.011^{\circ}C^{-1}$

(D) $0.055^{\circ}C^{-1}$

$R_t = R_0(1+\alpha t)$

$2 = R_0(1+10\alpha)$

$3 = R_0(1+30\alpha)$

$\frac{2}{3} = \frac{1+10\alpha}{1+30\alpha}$

$2+60\alpha = 3+30\alpha$

$30\alpha = 1$

$\alpha = 1/30 = .033\ C^{-1}$

Q12: The space inside a straight current carrying solenoid is filled with a magnetic material having magnetic susceptibility equal to 1.2 x 10^{-5}. What is fractional increase in the magnetic field inside solenoid with respect to air as medium inside the solenoid ?

(A) 1.2×10^{-5}

(B) 1.2×10^{-3}

(C) 1.8×10^{-3}

(D) 2.4×10^{-5}

$$\chi = 1.2 \times 10^{-5}$$

$$\mu_r = \chi + 1$$

$$B_m = \mu n i$$

$$B_m = \mu_0 \mu_r n i$$

$$B_{air} = \mu_0 n i$$

$$\frac{B_m - B_{air}}{B_a} = \frac{\mu_0 \mu_r n i - \mu_0 n i}{\mu_0 n i}$$

$$= \frac{\mu_0 n i (\mu_r - 1)}{\mu_0 n i} = \frac{\mu_r - 1}{\mu_r} = 1.2 \times 10^{-5} + 1 - 1$$

$$= 1.2 \times 10^{-5}$$

Q13: Two parallel, long wires are kept 0.20 m apart in vacuum, each carrying current of x A in the same direction. If the force of attraction per meter of each wire is $2 \times 10^{-6} N$, then the value of x is approximately:

(A) 1

(B) 2.4

(C) 1.4

(D) 2

$$\frac{f}{l} = \frac{\mu_0}{4\pi} \frac{2 i_1 i_2}{a}$$

$$\frac{f}{l} = \frac{\mu_0}{4\pi} \frac{2 i^2}{a}$$

$$2 \times 10^{-6} = \frac{10^{-7} \times 2 \times i^2}{0.20}$$

$$i^2 = \frac{2 \times 10^{-6} \times 0.20}{2 \times 10^{-7}}$$

$$i^2 = \frac{10 \times 0.20}{100} = 2$$

$$i = \sqrt{2}$$

$$= 1.4 \text{ Amp}$$

Q14: A coil is placed in a time varying magnetic field. if the number of turns in the coil were to be halved and the radius of wire doubled, the electrical power dissipated due to the current induced in the coil would be : (Assume the coil to be short circuited.)

(A) Halved

(B) Quadrupled ✓

(C) The same

(D) Doubled

$$E = -N\frac{d\phi}{dt} = -NA\frac{dB}{dt} = -N\pi r^2\frac{dB}{dt}$$

$$P = \frac{E^2}{R} \quad R \rightarrow \text{constant}$$

$$P \propto E^2 \propto N^2 r^4$$

$$\frac{P_1}{P_2} = \frac{N_1^2 r_1^4}{N_2^2 r_2^4} = \frac{N^2}{(N/2)^2}\frac{(r)^4}{(2r)^4}$$

$$= \frac{N^2 \times 4}{N^2} \times \frac{r^4}{(2)^4 r^4} = \frac{4}{4 \times 4}$$

$$P_2 = 4P_1$$

Q15: An EM wave propagating in x-direction has a wavelength of 8 mm. The electric field vibrating y-direction has maximum magnitude of $60 V m^{-1}$. Choose the correct equations for electric and magnetic fields if the EM wave is propagating in vacuum:

(A) $E_y = 60 \sin\left[\frac{\pi}{4} \times 10^3 \left(x - 3 \times 10^8 t\right)\right] \hat{j}\, Vm^{-1} B_z = 2 \sin\left[\frac{\pi}{4} \times 10^3 \left(x - 3 \times 10^8 t\right)\right] \hat{k}\, T$

✓(B) $E_y = 60 \sin\left[\frac{\pi}{4} \times 10^3 \left(x - 3 \times 10^8 t\right)\right] \hat{j} Vm^{-1} B_z = 2 \times 10^{-7} \sin\left[\frac{\pi}{4} \times 10^3 \left(x - 3 \times 10^8 t\right)\right] \hat{k}\, T$

(C) $E_y = 60 \sin\left[\frac{\pi}{4} \times 10^3 \left(x - 3 \times 10^8 t\right)\right] \hat{j} Vm^{-1} B_z = 60 \sin\left[\frac{\pi}{4} \times 10^3 \left(x - 3 \times 10^8 t\right)\right] \hat{k} T$

(D) $E_y = 2 \times 10^{-7} \sin\left[\frac{\pi}{4} \times 10^3 \left(x - 4 \times 10^8 t\right)\right] \hat{j} Vm^{-1} B_z = 60 \sin\left[\frac{\pi}{4} \times 10^4 \left(x - 4 \times 10^8 t\right)\right] \hat{k} T$

propagating in x direction

E → y direction.

B → z direction.

$c = \frac{E_0}{B_0}$

$B_0 = \frac{E_0}{c} = \frac{60}{3 \times 10^8}$

$= 20 \times 10^{-8}$

$= 2 \times 10^{-7}$ wb

$E_y = E_0 \sin \frac{2\pi}{\lambda} (vt - x)$

$E_y = 60 \sin \frac{2\pi}{8 \times 10^{-3}} (3 \times 10^8 t - x)$

$= 60 \sin \frac{\pi}{4} \times 10^3 (3 \times 10^8 t - x)$

$B_z = 2 \times 10^{-7} \sin \frac{\pi}{4} \times 10^3 (3 \times 10^8 t - x)$

Q16: In young's double slit experiment performed using a monochromatic light of wavelength λ. when a glass plate $(\mu = 1.5)$ of thickness $x\lambda$ is introduced in the path of the one or the interfering beams, the intensity at the position where the central maximum occurred previously remains unchanged. The value of x will be:

(A) 3

(B) 2 ✓

(C) 1.5

(D) 0.5

$t = x\lambda$

path difference

$\Delta x = (\mu - 1)t$

$= (1.5-1)x\lambda = n\lambda$

$n = 1$ given

$0.5x = 1$

$x = \frac{10}{0.5} = 2$

Q17: Let K_1 and K_2 be the maximum kinetic energies of photo-electrons emitted when two monochromatic beams of wavelength λ_1 and λ_2, respectively are incident on a metallic surface. If $\lambda_1 = 3\lambda_2$ then :

(A) $K_1 > \frac{K_2}{3}$

(B) $K_1 < \frac{K_2}{3}$ ✓

(C) $K_1 = \frac{K_2}{3}$

(D) $K_2 = \frac{K_1}{3}$

$$\frac{hc}{\lambda_1} = W_0 + K_1$$

$$K_1 = \frac{hc}{\lambda_1} - W_0$$

$$K_2 = \frac{hc}{\lambda_2} - W_0$$

$$\frac{K_1}{K_2} = \frac{\frac{hc}{3\lambda_2} - W_0}{\frac{hc}{\lambda_2} - W_0}$$

$$K_1 < \frac{K_2}{3}$$

Q18: Following statements related to radioactivity are given below

A) Radioactivity is a random and spontaneous process and is dependent on physical and chemical conditions.

(B) The number of un-decayed nuclei in the radioactive sample decays exponentially with time. (C) Slope of the graph of $\log_e$ (no. of undecayed nuclei) Vs. time represents the reciprocal of mean life time (τ).

(D) Product of decay constant (λ) and half-life time $\left(T_{\frac{1}{2}}\right)$ is not constant

Choose the most appropriate answer from the options given below :

(A) (A) and (B) only

(B) (B) and (D) only

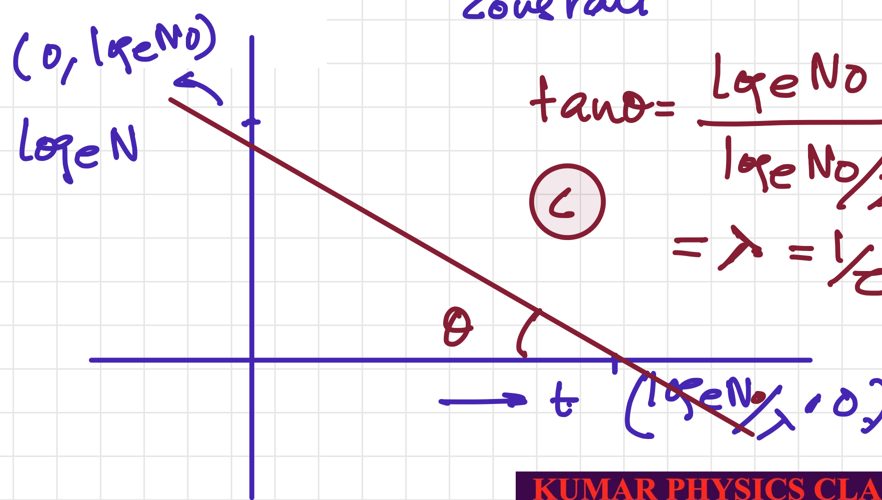
(C) (B) and (C) only

(D) (C) and (D) only

$N = N_0 e^{-\lambda t}$ — B

$\log_e N = \log_e N_0 - \lambda t \log_e e$

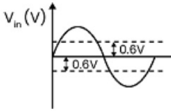
$\log_e N = \underbrace{\log_e N_0}_{\text{constant}} - \lambda t$

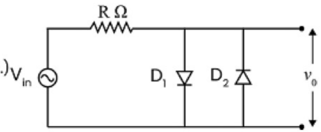


$\tan\theta = \dfrac{\log_e N_0}{\log_e N_0/\lambda}$ — C

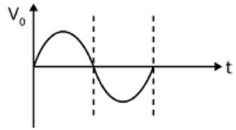
$= \lambda = 1/\tau$

Q19: In the given circuit the input voltage V_{in} is shown in figure. The cut-in voltage of p-n junction diode (D_1 or D_2) is 0.6 V. Which of the following output voltage (V_0) waveform across the diode is correct?

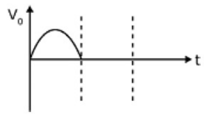




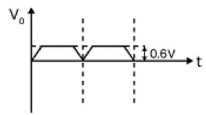
(A)



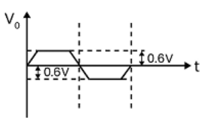
(B)

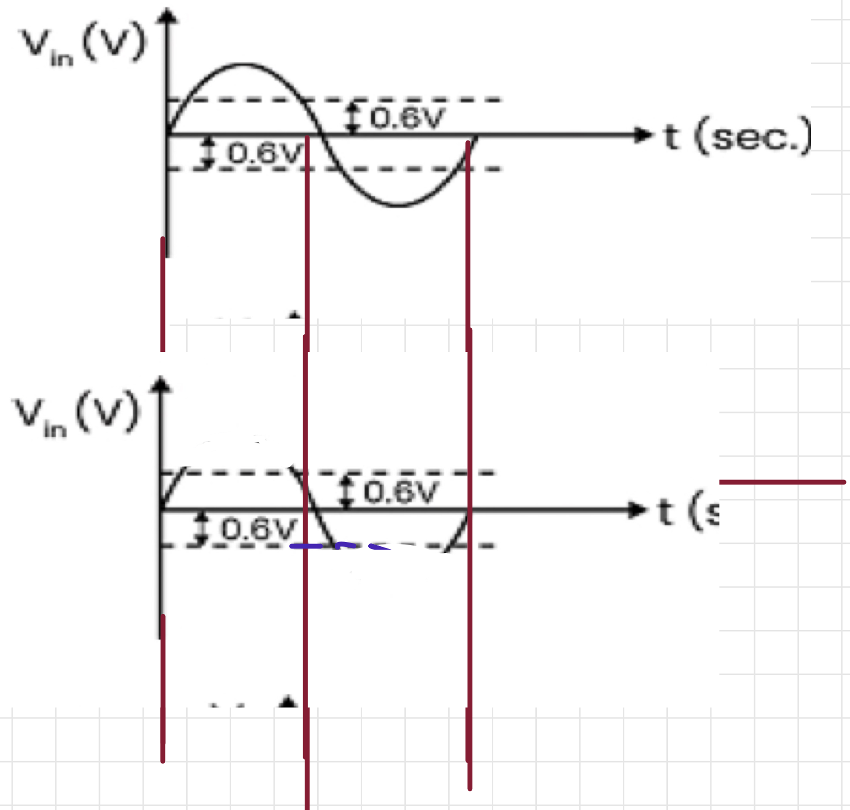


(C)



(D)





Q20: Amplitude modulated wave is represented by $V_{AM} = 10\left[1 + 0.4\cos\left(2\pi \times 10^4 t\right)\right]\cos\left(2\pi \times 10^7\right)t$. The total bandwidth of the amplitude modulated wave is

(A) 10 kHz

(B) 20 MHz ✓

(C) 20 kHz

(D) 10 MHz

$$V_{AM} = 10\left[1 + 0.4\cos(2\pi \times 10^4 t)\right]\cos(2\pi \times 10^7)t$$

$$= 10\cos 2\pi \times 10^7 t + 10 \times 0.4\left[\cos(2\pi \times 10^4)t \cos(2\pi \times 10^7)t\right]$$

$$= 10\cos 2\pi \times 10^7 t + 2\left[2\cos(2\pi \times 10^4)t \cos(2\pi \times 10^7)t\right]$$

$$= 10\cos(2\pi \times 10^7 t) + 2\left[\cos(2\pi \times 10^4 - 2\pi \times 10^7)t + \cos(2\pi \times 10^4 + 2\pi \times 10^7)t\right]$$

$$= 10\cos(2\pi \times 10^7)t + 2\left[\cos 2\pi(10^4 - 10^7)t + \cos 2\pi(10^4 + 10^7)t\right]$$

$$\omega_m = 10^7 \times 2\pi \Rightarrow 2\pi f_m \Rightarrow f_m = 10^7\,\text{Hz} = 10\,\text{MHz}$$

BAND WIDTH $= 2f_m = 20\,\text{MHz}$

Q21: A student in the laboratory measures thickness of a wire using screw gauge. The readings are 1.22 mm, 1.23 mm, 1.19 mm and 1.20 mm. The percentage error is $\frac{x}{121}\%$. The value of x is _______

150

$$T_{AVG} = \frac{1.22+1.23+1.19+1.20}{4}$$

$$= 1.21$$

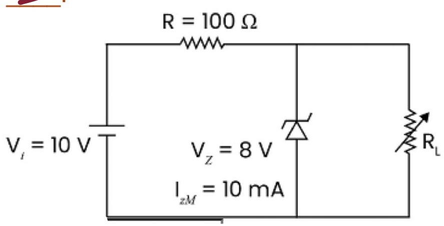
$$\Delta T = \frac{.01+.02+.02+.01}{4}$$

$$= \frac{0.06}{4} = \frac{.03}{2}$$

$$\Delta P = \frac{.03/2}{1.21} \times 100 = \frac{150}{121} = \frac{x}{121}$$

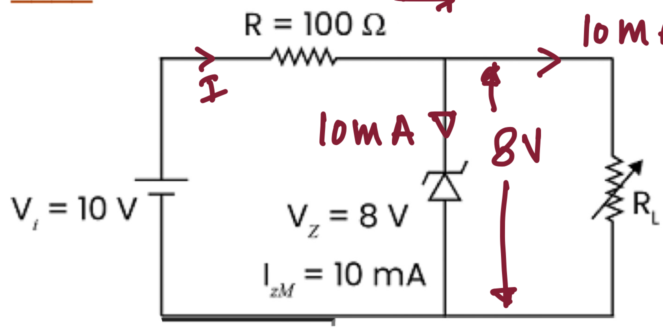
$$x = 150$$

Q22: A zener of breakdown voltage $V_Z = 8V$ and maximum zener current, $I_{ZM} = 10mA$ is subjected to an input voltage V_i =10 V with series resistance $R = 100\Omega$. In the given circuit RL represents the variable load resistance. The ratio of maximum and minimum value of R_L is 2.



$I = \frac{2 \times 10}{100 \times 10} = 20 mA$

← 2 volt →



$8 = R_L \times 10 \times 10^{-3}$

$R_L = \frac{8}{10^{-2}}$

$= 800\text{-ohm}$

$R_{L(max)} = 800\text{-ohm}$

For R_L (max)

$8 = R_L|_{min} \times 20 \times 10^{-3}$

$R_L|_{min} = \frac{8 \times 1000}{20} = 400\text{-ohm}$

$\frac{R_L max}{R_L min} = \frac{800}{400} = 2$

Q23: In a Young's double slit experiment, an angular width of the fringe is 0.35° on a screen placed at 2 m away for particular wavelength of 450 nm. The angular width of the fringe, when whole system is immersed in a medium of refractive index $\frac{7}{5}$, is $\frac{1}{\alpha}$. The value of $\alpha$is ______.

4

$$\theta = \frac{\beta}{D}, \quad \beta = \frac{D\lambda}{d}$$

$$= \frac{D\lambda}{dD} = \frac{\lambda}{d} \quad \text{— (1)}$$

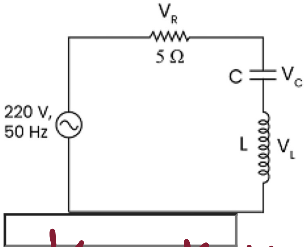
when immersed in the medium of refractive index = 7/5, then wave length change

$$\theta' = \frac{\lambda'}{d} \quad \text{— (2)}$$

$$\frac{\theta}{\theta'} = \frac{\lambda}{\lambda'} \Rightarrow \mu \Rightarrow \theta' = \frac{\theta}{\mu} = \frac{0.35}{7/5} = \frac{0.35 \times 5}{7} = .25$$

$$\frac{\theta}{\theta'} = 0.25 = 1/\alpha \Rightarrow \alpha = 4$$

Q24: In the given circuit, the magnitude of V_L and V_C are twice that of V_R. Given that f = 50Hz, the inductance of the coil is $\frac{1}{K\pi} mH$. The value of K is _______.



$1/100 = K \simeq 0$

$V_L = 2V_R$

$V_c = 2V_R$

$I X_L = 2(IR)$

$L = \frac{1}{K\pi} \times 10^{-3} H$

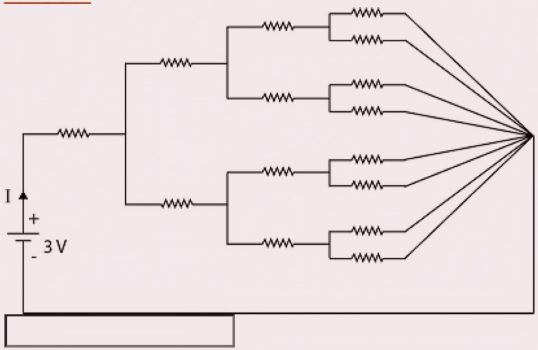
$2\pi f L = 2R$

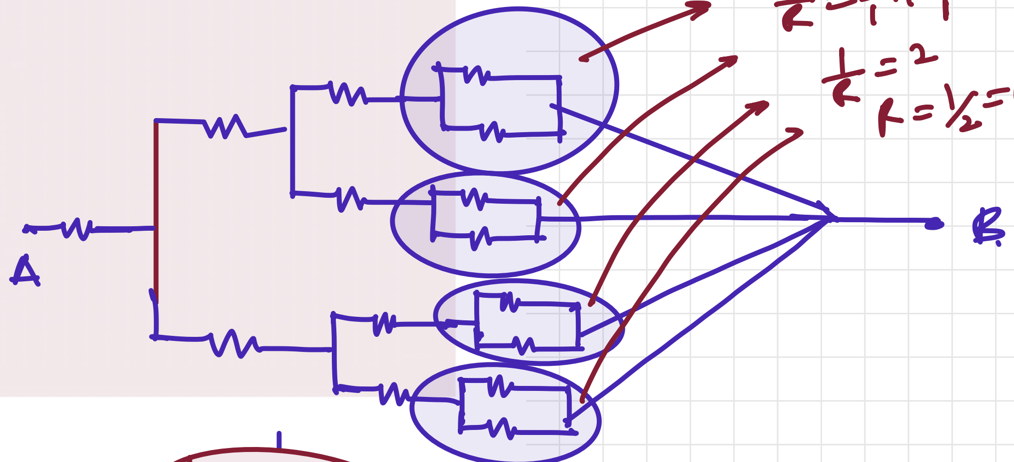
$2\pi \times 50 \times \frac{1 \times 10^{-3}}{K\pi} = 2 \times 5$

$\frac{100 \times 10^{-3}}{K} = 10$

$K = \frac{10^{-1}}{10} = \frac{1}{100}$

Q25: All resistance in figure are 1Ω each. The value of current 'I' is $\frac{a}{5}A$. The value of a is ______.

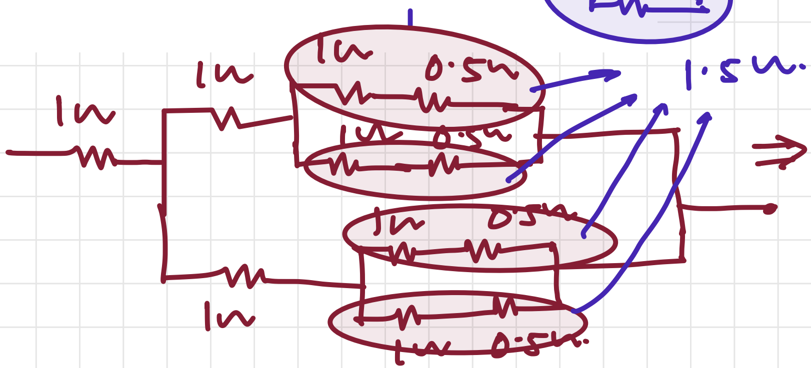


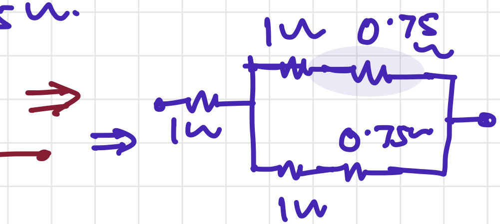


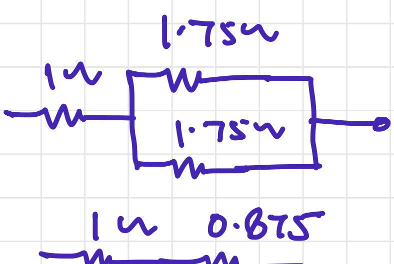
$\frac{1}{R} = \frac{1}{1} + \frac{1}{1}$

$\frac{1}{R} = 2$

$R = \frac{1}{2} = 0.5\Omega$



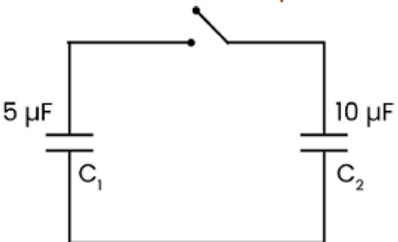




$I = \frac{3000}{1875} = \frac{3000}{5 \times 375} = \frac{8}{5} = \frac{a}{5}$

$a = 8$

Q26: A capacitor C_1 of capacitance $5\mu F$ is charged to a potential of 30 V using a battery. The battery is then removed and the charged capacitor is connected to an uncharged capacitor C_2 of capacitance $10\mu F$ as shown in figure. When the switch is closed charge flows between the capacitors. At equilibrium, the charge on the capacitor C_2 is 100 μC



100 μC

$q_1 = 5\times10^{-6} \times 30 = 150\,\mu C$

$q_2 = 0$

$q_1 + q_2 = q_1' + q_2'$

$150\times10^{-6} = (C_1 + C_2)V$

$V = \dfrac{150\times10^{-6}}{15\times10^{-6}} = 10$ Volt

$q_1' = C_2 V = 10\times10^{-6}\times10 = 100\,\mu C$

Q27: A tuning fork of frequency 340 Hz resonates in the fundamental mode with an air column of length 125 cm in a cylindrical tube closed at one end. When water is slowly poured in it, the minimum height of water required for observing resonance once again is cm. (Velocity of sound in air is $340ms^{-1}$)

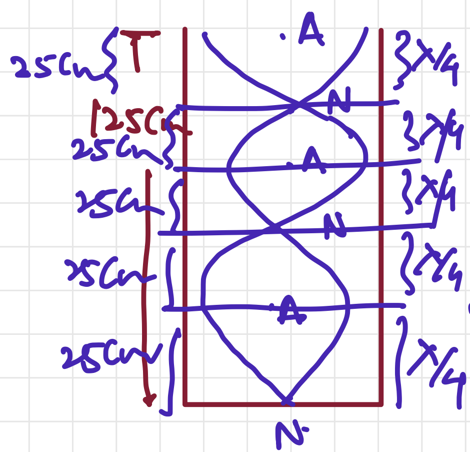
50

$\lambda_1/4 = l \Rightarrow \lambda_1 = 4(l)$

$v = f(4l)$

$l = \frac{v}{4f} = \frac{340}{2\times340} = \frac{1}{2}$ mt

$= 50$ cm



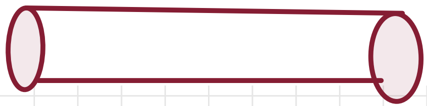
$n\left(\frac{\lambda}{4}\right) = l$, $\lambda = \frac{4l}{n}$

$v = f\lambda$

$340 = 340 \times \frac{4\times125\times10^{-2}}{n}$

$n = 500\times10^{-2} = 5$

Q28: A liquid of density $750 kgm^{-3}$ flows smoothly through a horizontal pipe that tapers in cross-sectional area from $A_1 = 1.2 \times 10^{-2} m^2$ to $A_2 = \frac{A_1}{2}$. The pressure difference between the wide and narrow sections of the pipe is 4500Pa. The rate of flow of liquid is ______ $\times 10^{-3} m^3 s^{-1}$.



$P_1 + \frac{1}{2}\rho v_1^2 + \rho gh = P_2 + \frac{1}{2}\rho v_2^2 + \rho gh$

$\frac{1}{2}\rho(v_1^2 - v_2^2) = P_2 - P_1$

$A_1 v_1 = A_2 v_2$

$A(v_1) = \frac{A}{2} v_2 \Rightarrow v_2 = 2v_1$

$\frac{1}{2}\rho(v_2^2 - v_1^2) = P_1 - P_2$

$\frac{1}{2}\rho(4v_1^2 - v_1^2) = P_1 - P_2$

$\frac{3}{2}\rho v^2 = P_1\ P_2$

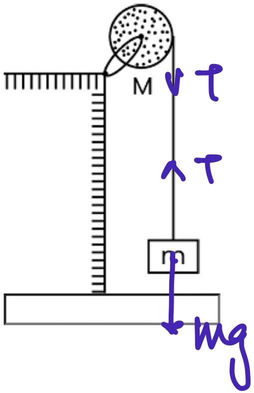
$v = \sqrt{\frac{2(P_1 - P_2)}{3\rho}}$

$= \sqrt{\frac{2 \times 4500}{3 \times 750}}$

$= 2\ ms^{-1}$

$Q = 24 \times 10^{-3}\ mt^3/sec$

Q29: A uniform disc with mass M=4 kg and radius R=10 cm is mounted on a fixed horizontal axle as shown in figure. A block with mass m=2 kg hangs from a massless cord that is wrapped around the rim of the disc. During the fall of the Nock, the cord does not slip and there is no friction at the aide. The tension in the cord is N. (Take $g = 10ms^{-2}$)



$$I = \frac{MR^2}{2} = \frac{4(10\times10^{-2})^2}{2} = 2\times10^{-2} = .02$$

$$20 - T = 2a \quad \text{—(1)}$$

$$(0.1)(T) = (.02)(\alpha)$$

$$\alpha = a/R$$

$$a = R(\alpha)$$

$$(0.1)(T) = (.02)(a/R)$$

$$\frac{0.10(T)(R)}{.02} = a$$

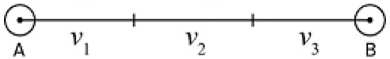
$$5(T)(10\times10^{-2}) = a \Rightarrow a = \frac{5T}{10} = T/2 \quad \text{—(2)}$$

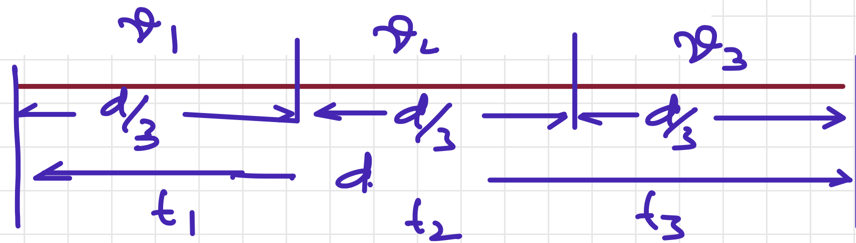
FROM EQUATION —(1)

$$20 - T = 2(T/2)$$

$$20 = 2T \Rightarrow T = 10N$$

Q30: A car covers AB distance with first one-third at velocity $v_1 ms^{-1}$,second one-third at $v_2 ms^{-1}$and last one-thrid at $v_3 ms^{-1}$.If $v_3 = 3v_1$, $v_2 = 2v_1$and $v_1 = 11ms^{-1}$then the average velocity of the car is _______ ms^{-1}.





$$v_1 = \frac{d/3}{t_1} \Rightarrow t_1 = \frac{d}{3v_1}$$

$$v_2 = \frac{d/3}{t_2} \Rightarrow t_2 = \frac{d}{3v_2}$$

$$v_3 = \frac{d/3}{t_3} \Rightarrow t_3 = \frac{d}{3v_3}$$

$$v_{avg} = \frac{d/3 + d/2 + d/3}{t_1 + t_2 + t_3}$$

$$v_{avg} = \frac{d}{\frac{d}{3v_1} + \frac{d}{3v_2} + \frac{d}{3v_3}} = \frac{3}{\frac{1}{11} + \frac{1}{22} + \frac{1}{33}}$$

$$= 18 \text{ mt/sec}$$