PHYSICS

JEE–MAIN EXAMINATION – JUNE, 2022

28 June S - 02 Paper Solution

SECTION-A

1. Velocity (v) and acceleration (a) in two systems 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 constants. 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 $\frac{n^4}{m^2}T_1 = T_2$

Ans. (A)

Sol. $\frac{L_2}{T_2} = \frac{n}{m^2}\frac{L_1}{T_1}$

$\frac{L_2}{T_2^2} = \frac{L_1}{T_1^2 \times mn}$

$\frac{n}{m^2} \times \frac{T_2}{T_1} = \frac{T_2^2}{T_1^2 \times mn}$

$\frac{n^2}{m} = \frac{T_2}{T_1}$

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

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

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

Ans. (B)

Sol. $\frac{dw}{dt} = 6t^2 - 2t$

$\int_{10}^{w} dw = 2t^3 - t^2$

$w = 10 + 2t^3 - t^2$

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

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

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

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

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

(A) Zero (B) 1.5 ms^{-1}

(C) 2.0 ms^{-1} (D) 2.5 ms^{-1}

Ans. (C)

Sol. $a = \frac{-kx}{2} = \frac{-12x}{2} = -6x$

$$\frac{vdv}{dx} = -6x$$

$$\int_4^v vdv = -\int_{\frac{1}{2}}^{3/2} 6xdx$$

$$\frac{v^2 - 4^2}{2} = -\frac{6}{2}\left[\left(\frac{3}{2}\right)^2 - \left(\frac{1}{2}\right)^2\right]$$

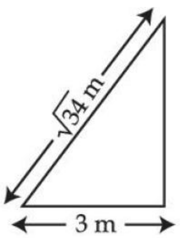
$$v^2 - 16 = -6\left(\frac{9}{4} - \frac{1}{4}\right)$$

$$v^2 = 16 - 6 \times 2 = 4$$

V = 2 m/s

4. A $\sqrt{34}$ m long ladder weighing 10 kg leans on a frictionless wall. Its feet rest on the floor 3 m 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 F_w/F_f will be:

(Use g = 10 m/s^2)

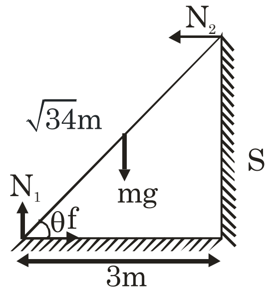


(A) $\frac{6}{\sqrt{110}}$ (B) $\frac{3}{\sqrt{113}}$

(C) $\frac{3}{\sqrt{109}}$ (D) $\frac{2}{\sqrt{109}}$

Ans. (C)

Sol.



$$f = N_2$$

$$N_1 = mg$$

$$N_2 \times \ell \sin\theta = mg\frac{\ell}{2}\cos\theta$$

$$N_2 = \frac{mg}{2}\cot\theta$$

$$\frac{F_w}{F_f} = \frac{\frac{mg}{2}\cot\theta}{\sqrt{(mg)^2 + \left(\frac{mg}{2}\cot\theta\right)^2}}$$

$$= \frac{1}{\sqrt{1 + \frac{4}{\cot^2\theta}}}$$

$$= \frac{3}{\sqrt{109}}$$

5. Water fall from a 40 m high dam at the rate of 9×10^4 kg per hour. Fifty percentage of gravitational potential energy can be converted into electrical energy. Using this hydroelectric energy number of 100W lamps, that can be lit, is:

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

(A) 25 (B) 50

(C) 100 (D) 18

Ans. (B)

Sol. $\frac{9 \times 10^4 \times g \times 40}{3600} \times 0.5 = n \times 100$

$$\frac{10^4 \times 0.5}{100} = n$$

$$100 \times 0.5 = n$$

n = 50

6. 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

Ans. (C)

Sol. $F = \frac{Gm^2}{r^2}$

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

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

7. 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 $1.8\times10^{-5}\,Nsm^{-2}$ and its density is negligible as compared to that of water $10^6\,gm^{-3}$. Terminal velocity of the water drop is:

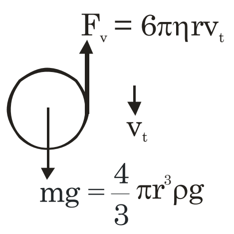
(Take acceleration due to gravity = 10 ms^{-2})

(A) $145.4\times10^{-6}\,ms^{-1}$ (B) $118.0\times10^{-6}\,ms^{-1}$

(C) $132.6\times10^{-6}\,ms^{-1}$ (D) $123.4\times10^{-6}\,ms^{-1}$

Ans. (D)

Sol.



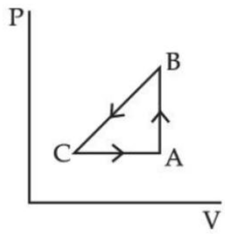
$$6\pi\eta r v_t = \frac{4}{3}\pi r^3\rho g$$

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

$$v_t = \frac{4}{3}\times\frac{\pi r^3\rho g}{6\pi\eta r} = \frac{2\times10^{-12}\times10^3\times10}{9\times1.8\times10^{-5}}$$

$= 123.4\times10^{-6}$ m/s

8. 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 60J of heat during CA. A work 50J is done on the gas during the part BC. The internal energy of the gas at A is 1560J. The work done by the gas during the part CA is:

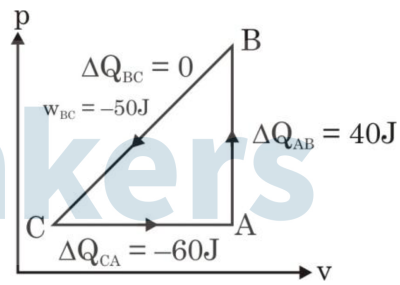


(A) 20 J (B) 30 J

(C) –30J (D) –60 J

Ans. (B)

Sol.



$\Delta Q_{cycle} = 40 - 60 = \Delta W$

$\Rightarrow \Delta W = -20J = W_{BC} + W_{CA}$

$\Rightarrow W_{CA} = -20J - W_{BC}$

$= -20 - (-50)$

$= 30$ J

9. 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. (B)

Sol. $V_{rms} = \sqrt{\frac{3RT}{M}}$

$T \rightarrow 2T$

$M \rightarrow \frac{M}{2}$

$V_{rms} \propto \sqrt{\frac{T}{M}}$

$\Rightarrow (V_{rms})_{atomic} = (V_{rms})_{molecular} \times \sqrt{\frac{2}{1/2}} = 2(V_{rms})_{molecular}$

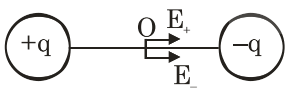
10. Two point charges A and B of magnitude $+8\times10^{-6}C$ and $-8\times10^{-6}C$ respectively are placed at a distance d apart. The electric field at the middle point O between the charges is $6.4\times10^{4}NC^{-1}$. The distance 'd' between the point charges A and B is:

(A) 2.0 m (B) 3.0 m

(C) 1.0 m (D) 4.0 m

Ans. (B)

Sol.



$E_0 = 2\times\frac{Kq}{(d/2)^2}$

$\Rightarrow E_0 = 8\frac{Kq}{d^2}$

$\Rightarrow d^2 = \frac{8\times9\times10^{9}\times8\times10^{-6}}{6.4\times10^{4}}$

d = 3 m

11. Resistance of the wire is measured as 2Ω and 3Ω at 10°C and 30°C respectively. Temperature co–coefficient of resistance of the material of the wire is :

(A) $0.033°C^{-1}$ (B) $-0.033°C^{-1}$

(C) $0.011°C^{-1}$ (D) $0.055°C^{-1}$

Ans. (A)

Sol. $R = R_0(1+\alpha\Delta T)$

$3 = R_0(1+\alpha(30-0))$

$2 = R_0(1+\alpha(10-0))$

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

$\alpha = \frac{1}{30} = 0.033$

12. The space inside a straight current carrying solenoid is filled with a magnetic material having magnetic susceptibility equal to 1.2×10^{-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}

Ans. (A)

Sol. $\chi = 1.2\times10^{-5}$

$\mu_r = 1+\chi = 1+1.2\times10^{-5}$

Fractional Change

$= \frac{\Delta B}{B} = \frac{\mu_0\mu_r ni - \mu_0 ni}{\mu_0 ni} = (\mu_r - 1)$

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

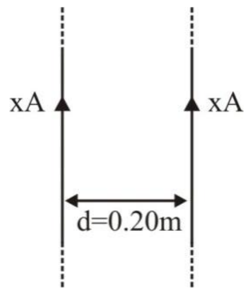
13. Two parallel, long wires are kept 0.20 m apart in vacuum, each carrying current of x A in the same direction. If the force of attraction per meter of each wire is $2\times10^{-6}N$, then the value of x is approximately:

(A) 1 (B) 2.4

(C) 1.4 (D) 2

Ans. (C)

Sol.



Force per unit length = $\frac{\mu_0 i_1 i_2}{2\pi d}$

$= \frac{\mu_0 \cdot x^2}{2\pi \times 0.2}$

$F = 2 \times 10^{-6} = \frac{4\pi \times 10^{-7} \times x^2}{2\pi \times 0.2}$

$\Rightarrow \ 10^{-6} = 10^{-7} \frac{x^2}{0.2}$

$\Rightarrow \ x^2 = 10 \times 0.2$

$= 2$

$\Rightarrow \ x = \sqrt{2} \approx 1.4$ Amp.

14. 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

Ans. (D)

Sol. $P = \frac{\varepsilon^2}{R} = \frac{\left(NA\frac{dB}{dt}\right)^2 \times A_C}{\rho\ell}$

$P' = \frac{\left(\frac{NA}{2}\frac{dB}{dt}\right)^2 \times 4A_C}{\rho\ell / 2}$

$\Rightarrow P' = 2P$

15. An EM wave propagating in x-direction has a wavelength of 8 mm. The electric field vibrating y-direction has maximum magnitude of 60 Vm^{-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) $E_y = 2\times 10^{-7}\sin\left[\frac{\pi}{4}\times 10^3\left(x - 3\times 10^8 t\right)\right]\hat{j}Vm^{-1}$

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

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

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

Ans. (B)

Sol. $B_0 = \frac{E_0}{c} = \frac{60}{3\times 10^8} = 2\times 10^{-7}T$

$\hat{E}\times\hat{B}$ must be direction of propagation.

So, $\hat{B} \rightarrow$ z-axis

$k = \frac{2\pi}{\lambda} = \frac{\pi}{4}\times 10^3 m^{-1}$

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

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

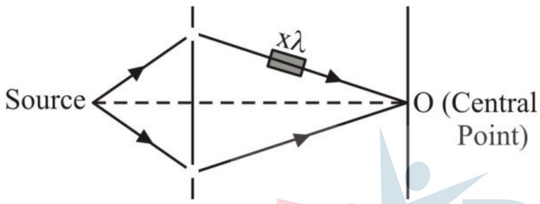
16. In young's double slit experiment performed using a monochromatic light of wavelength λ, when a glass plate $(\mu = 1.5)$ of thickness $x\lambda$ is introduced in the path of the one of the interfering beams, the intensity at the position where the central maximum occurred previously remains unchanged.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

(A) 3 (B) 2

(C) 1.5 (D) 0.5

Ans. (B)

Sol.



Path difference at O = $(\mu - 1)t$.

If the intensity at O remains (maximum) unchanged, path difference must be $n\lambda$.

$\Rightarrow (\mu - 1)t = n\lambda$

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

$\Rightarrow \quad x = 2n$

For n = 1, x = 2

17. 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) $K_2 = \frac{K_1}{3}$

Ans. (B)

Sol. $\frac{hc}{\lambda_1} - \phi = K_1$

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

$\lambda_1 = 3\lambda_2$

$3K_1 = \frac{3hc}{\lambda_1} - 3\phi$

$3K_1 = \frac{hc}{\lambda_2} - 3\phi$

$3K_1 = K_2 - 2\phi$

$3K_1 < K_2$

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

18. 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 $(T_{1/2})$ is not constant.

Choose the most appropriate answer from the options given below:

(A) (A) and (B) only

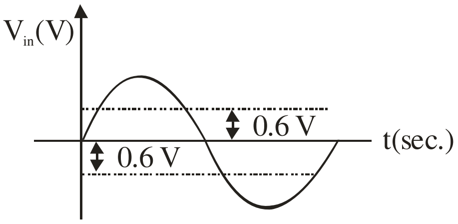
(B) (B) and (D) only

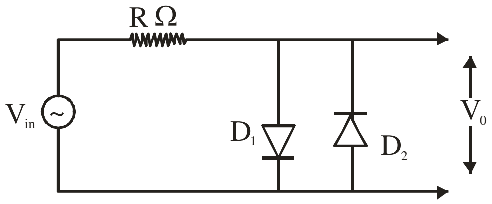
(C) (B) and (C) only

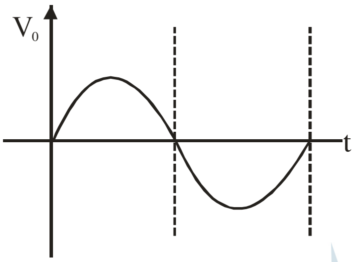
(D) (C) and (D) only

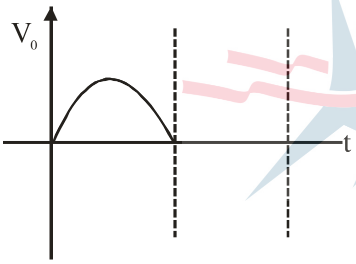
Ans. (C)

19. 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)


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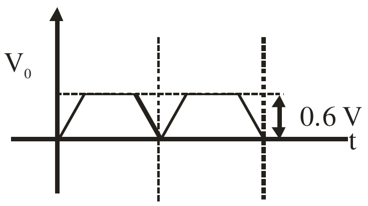
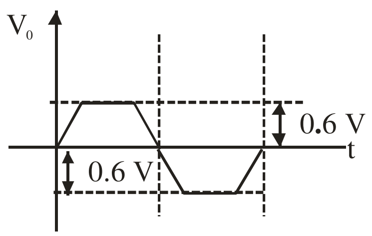


(D)


Ans. (D)

Sol. In +ve half cycle

$D_1 \rightarrow$ F.B.; $D_2 \rightarrow$ R.B.

0 – 0.6 V

V_{out} same as V_{in}

In –ve half cycle

$D_2 \rightarrow$ F.B.; $D_1 \rightarrow$ R.B.

20. Amplitude modulated wave is represented by $V_{AM} = 10\left[1 + 0.4\cos\left(2\pi\times10^4 t\right)\right]\cos\left(2\pi\times10^7 t\right)$.

The total bandwidth of the amplitude modulated wave is :

(A) 10 kHz (B) 20 MHz

(C) 20 kHz (D) 10 MHz

Ans. (C)

Sol. Bandwidth = 2 f_m

= 2×10^4 Hz = 20×10^3 Hz

= 20 kHz

SECTION-B

1. 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 ___

Ans. (150)

Sol. $X = \dfrac{1.22mm + 1.23mm + 1.19mm + 1.20mm}{4}$

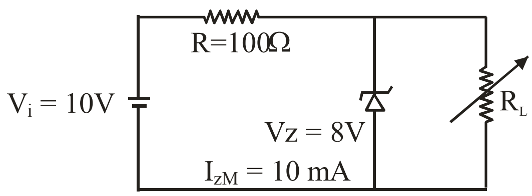
X = 1.21 mm

$\Delta x = \dfrac{0.01 + 0.02 + 0.02 + 0.01}{4} = \dfrac{0.06}{4} = 0.015$

Percentage error = $\dfrac{0.015}{1.21} \times 100$

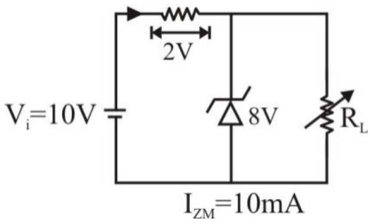
X = 150

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



Ans. (2)

Sol.



$I = \frac{2}{100} = 20mA$ $V_L = I_L R_L$ $8 = 10 \times 10^{-3} \times R_{L_{max}}$ $\frac{4}{5} \times 10^3 = R_{L_{max}}$ $\boxed{800 = R_{L_{max}}}$	$I = I_Z + I_L$ $I_L = 10$ mA If $\boxed{I_Z = 0}$ $I_{L_{max}} = 20mA$ $V_L = I_{L_{max}} \times R_{L_{min}}$ $\frac{8}{20} \times 10^3 = R_{L_{min}}$ $\boxed{400 = R_{L_{min}}}$

$$\frac{R_{L_{max}}}{R_{L_{min}}} = \frac{800}{400} = 2$$

3. 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 7/5, is $\frac{1}{\alpha}$. The value of α is ________

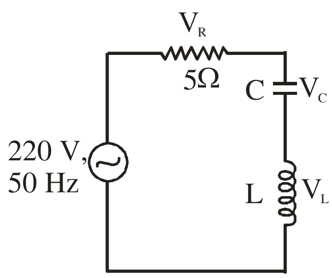
Ans. (4)

Sol. $\beta = \frac{0.35 \times 5}{7} = 0.25$

$\frac{1}{\alpha} = \frac{25}{100}$

$\boxed{\alpha = 4}$

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



Ans. (0)

Sol. $V_L = V_C = 2V_R$

$X_L = X_C = 2R$

$X_L = 10\Omega$

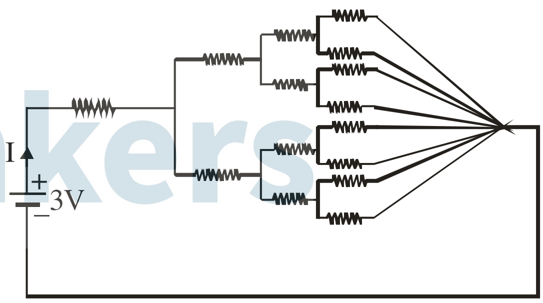
$\omega L = 10$

$2\pi f L = 10$

$L = \frac{10}{2\pi f} = \frac{1}{10\pi} H = \frac{1000}{10\pi} mH$

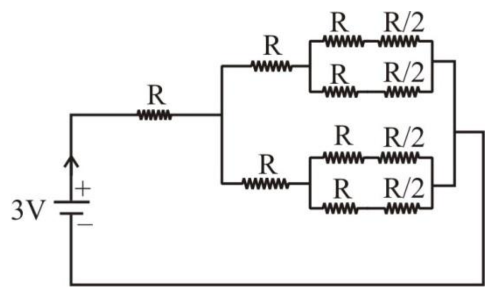
$L = \frac{1}{\frac{1}{100}\pi}$; $\quad K = \frac{1}{100} = 0.01 \approx 0$

5. All resistances in figure are 1Ω each. The value of current 'I' is $\frac{a}{5}$A. The value of a is _______



Ans. (8)

Sol.

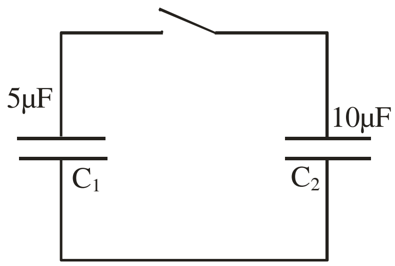


$R_{eq} = \frac{15R}{8} = \frac{15}{8}\Omega$

$I = \frac{3}{\frac{15}{8}} = \frac{8}{5}A$

$\therefore \; a = 8$

6. 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 ________ μC.



Ans. (100)

Sol. Before closing the switch

$Q = C_1V_0 = 5 \times 30 = 150\mu C$

After closing the switch

$$V = \frac{Q}{C_1 + C_2} = \frac{150}{10+5} = 10\text{ V}$$

$$Q_2 = C_2V = 10 \times 10 = 100\mu C$$

7. 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 340 ms^{-1})

Ans. (50)

Sol. Assumption : Ignore word "**fundamental mode"** in question.

$$\lambda = \frac{V}{f} = \frac{340}{340} = 1\text{m}$$

First resonating length = $\frac{\lambda}{4} = 25$ cm

Second resonating length = $\frac{3\lambda}{4} = 75$ cm

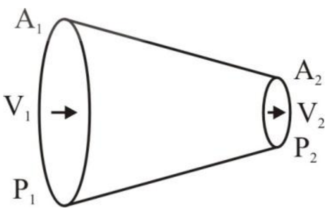
Third resonating length = $\frac{5\lambda}{4} = 125$ cm

Height of water required = 125 – 75 = 50 cm

8. 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 4500 Pa. The rate of flow of liquid is _______ $\times 10^{-3}$ m^3s^{-1}.

Ans. (24)

Sol.



$$A_2 = \frac{A_1}{2}$$

$$P_1 - P_2 = 4500\text{ Pa}$$

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho gh = P_2 + \frac{1}{2}\rho V_2^2 + \rho gh$$

$$P_1 - P_2 = \frac{1}{2}\rho\left(V_2^2 - V_1^2\right) \qquad \ldots(1)$$

And $A_1V_1 = A_2V_2$

$\Rightarrow \quad V_2 = 2V_1 \qquad \ldots(2)$

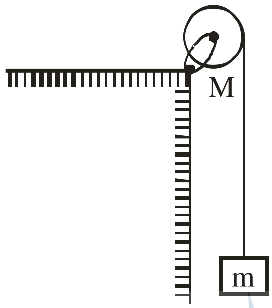
$$4500 = \frac{1}{2} \times 750 \times 3V_1^2$$

$V_1 = 2$ m/s

Volume flow rate = $A_1V_1 = 24 \times 10^{-3}$ m^3s^{-1}

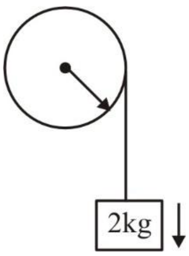
9. A uniform disc with mass M = 4 kg and radius R = 10 cm is mounted on a fixed horizontal axle as shown in figure. A block with mass m = 2 kg hangs from a massless cord that is wrapped around the rim of the disc. During the fall of the block, the cord does not slip and there is no friction at the axle. The tension in the cord is ________N.

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



Ans. (10)

Sol.



$2g - T = 2a$ …(1)

$TR = \frac{MR^2}{2}\alpha$ …(2)

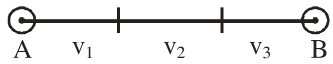
$\alpha = \frac{a}{R}$ …(3)

$T = 2a$

$2g - T = 2a$

$T = g = 10N$

10. 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–third at v_3 ms^{-1}. If $v_3 = 3v_1$, $v_2 = 2v_1$ and $v_1 = 11\ ms^{-1}$ then the average velocity of the car is ________ ms^{-1}.



Ans. (18)

Sol. $< \vec{v} >= \frac{\text{Displacement}}{\text{time}}$

(Let displacement be l)

$= \frac{\ell}{\left(\frac{\ell}{V_3} + \frac{\ell}{V_2} + \frac{\ell}{V_1}\right)\frac{1}{3}}$

$= \frac{3}{\frac{1}{V_1} + \frac{1}{V_2} + \frac{1}{V_3}} = \frac{3}{\frac{1}{11} + \frac{1}{22} + \frac{1}{33}}$

= 18 m/s