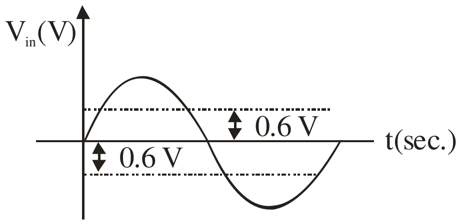
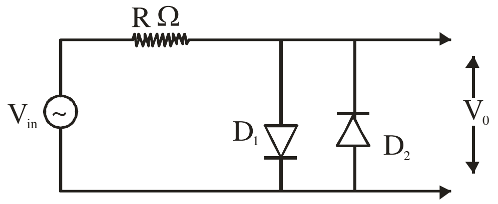
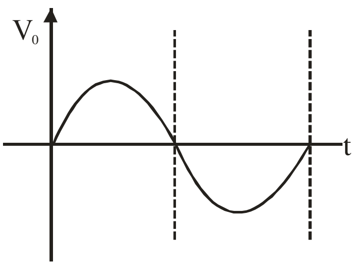
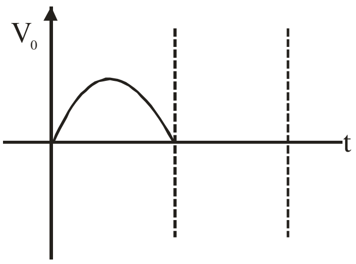
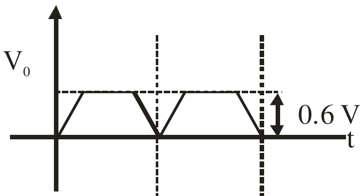
19. In the given circuit the input voltage V_{in} is shown in figure. The cut–in voltage of p–n junction diode (D_1 or D_2) is 0.6 V. Which of the following output voltage (V_0) waveform across the diode is correct?

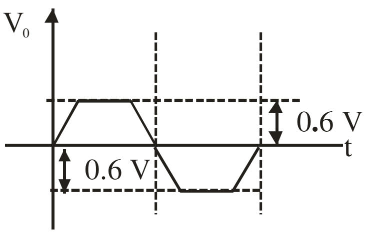




(A)


(B)


(C)


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

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

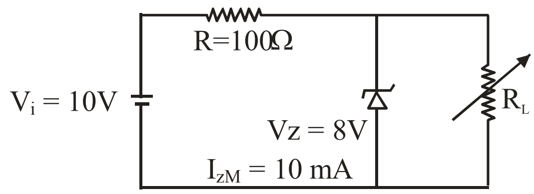
X = 1.21 mm

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

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

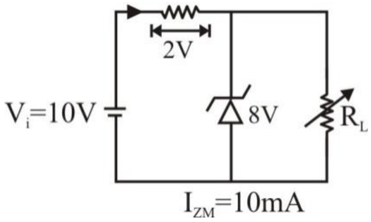
X = 150

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 ________

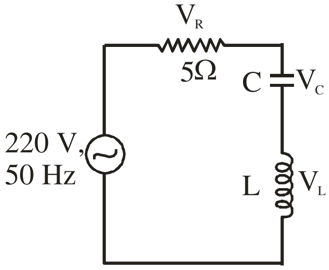
Ans. (4)

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. $V_L = V_C = 2V_R$

$X_L = X_C = 2R$

$X_L = 10\Omega$

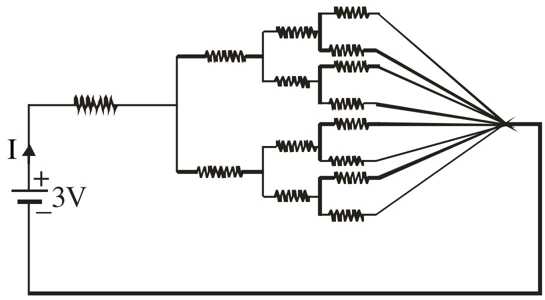
$\omega L = 10$

$2\pi f L = 10$

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

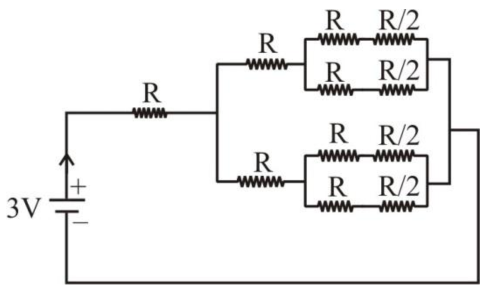
$L = \frac{1}{\frac{1}{100}\pi}$; $K = \frac{1}{100} = 0.01 \approx 0$

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.

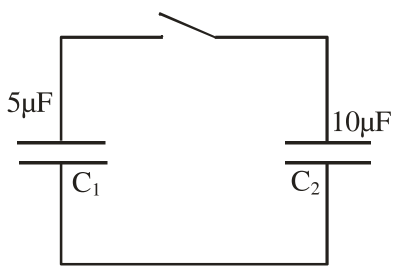


$R_{eq} = \frac{15R}{8} = \frac{15}{8}\Omega$

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

$\therefore\ a = 8$

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

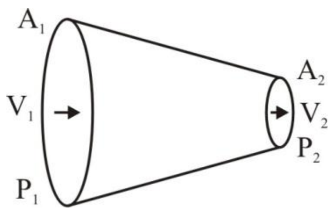
Third resonating length = $\frac{5\lambda}{4} = 125$ cm

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.



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

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

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

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

And $A_1V_1 = A_2V_2$

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

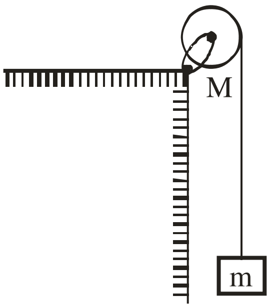
$$4500 = \frac{1}{2} \times 750 \times 3V_1^2$$

$V_1 = 2$ m/s

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

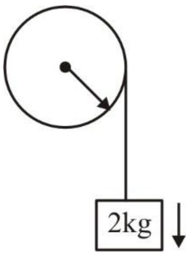
9. A uniform disc with mass M = 4 kg and radius R = 10 cm is mounted on a fixed horizontal axle as shown in figure. A block with mass m = 2 kg hangs from a massless cord that is wrapped around the rim of the disc. During the fall of the block, the cord does not slip and there is no friction at the axle.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

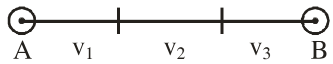
$\alpha = \frac{a}{R}$ …(3)

$T = 2a$

$2g - T = 2a$

$T = g = 10N$

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