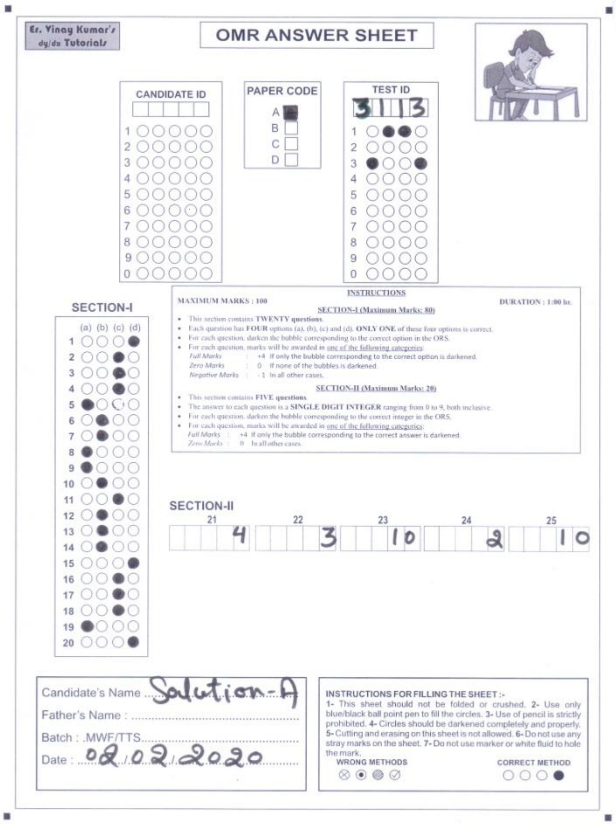
SET-A



Q5. $\frac{M_1}{M_2} = \frac{13}{5}$ ..... (1)

$$T_1 = 2\pi\sqrt{\frac{I}{(M_1+M_2)B_0}} \text{ .....(2)}$$

$$T_2 = 2\pi\sqrt{\frac{I}{(M_1-M_2)B_0}} \text{ .....(3)}$$

$$\frac{(2)}{(3)} \Rightarrow \frac{T_1}{T_2} = \sqrt{\frac{M_1-M_2}{M_1+M_2}} \Rightarrow \frac{f_2}{f_1} = \sqrt{\frac{\frac{M_1}{M_2}-1}{\frac{M_1}{M_2}+1}}$$

$$\Rightarrow \frac{f_2}{15} = \sqrt{\frac{\frac{13}{5}-1}{\frac{13}{5}+1}} \Rightarrow \frac{f_2}{15} = \sqrt{\frac{8}{18}}$$

$$\Rightarrow \frac{f_2}{15} = \sqrt{\frac{4}{9}} \Rightarrow \frac{f_2}{15} = \frac{2}{3} \Rightarrow f_2 = 10$$

Q6. $V = i_g G \;\Rightarrow\; 0.5 = i_g \times 0.5 \;\Rightarrow\; i_g = 1A$

$$R = \left(\frac{i_g}{i - i_g}\right)G = \left(\frac{1}{10-1}\right)\times 0.5 = \frac{0.5}{9} = 0.055\,\Omega$$

Q7. $R = \frac{V}{i_A} - R_A = \frac{100}{1} - 0.5$

$= 99.5\ \Omega$

Q8. $\frac{V_S}{V_P} = \frac{N_S}{N_P} \Longrightarrow \frac{V_S}{240} = \frac{1}{20}$

$$\Rightarrow V_S = \frac{240}{20} = 12V$$

$$i_S = \frac{V_S}{R_S} = \frac{12}{6} = 2A$$

$$\frac{i_P}{i_S} = \frac{N_S}{N_P} \Longrightarrow \frac{i_P}{2} = \frac{1}{20} \Longrightarrow i_P = 0.10\ A$$

Q9. $V_L = V_C = 400$ V

$$e = \sqrt{V_R^2 + (V_L \sim V_C)^2}$$

$$\Rightarrow 100 = \sqrt{V_R^2 + (400 \sim 400)}$$

$\Rightarrow V_R = 100\ V \Rightarrow$ Reading on voltmeter which reads the resistance voltage is 100 V

Since $V_L = V_C \Rightarrow X_L = X_C$

$$Z = \sqrt{R^2 + (X_L \sim X_C)^2}$$

$$\Rightarrow Z = \sqrt{50^2 + 0} \Rightarrow Z = 50\ \Omega$$

$$I = \frac{e}{Z} = \frac{100}{50} = 2A$$

Q10. $e = \sqrt{V_R^2 + (V_L \sim V_C)^2}$

$$\Rightarrow e = \sqrt{10^2 + (10 \sim 10)^2}$$

$\Rightarrow e = 10$ V

When the capacitance is short circuited there remain resistance and inductance only in the circuit.

If all the devices initially have equal potential drops in series they have equal resistance and reactance values.

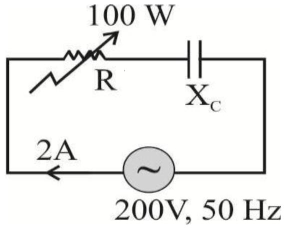
Therefore in second case also

$R = X_L \Rightarrow V_R = V_L$

$e = \sqrt{V_R^2 + V_L^2} \Rightarrow 10 = \sqrt{V_L^2 + V_L^2}$

$\Rightarrow \mathbf{10} = \sqrt{2}V_L \Rightarrow V_L = 5\sqrt{2}\ V$

Q11.



$$Z = \frac{e}{i} = \frac{200\ V}{2A} = 100\ \Omega$$

$P = i^2 R \Rightarrow 100 = 2^2 \times R \Rightarrow R = 25\Omega$

$Z = \sqrt{R^2 + X_C^2} \Rightarrow 100 = \sqrt{25^2 + X_C^2}$

$\Rightarrow 10000 = 625 + X_C^2 \Rightarrow X_C^2 = 9375$

$\Rightarrow X_C = \sqrt{9375} \Rightarrow X_C = \sqrt{625 \times 15}$

$= 25\sqrt{15}\Omega$

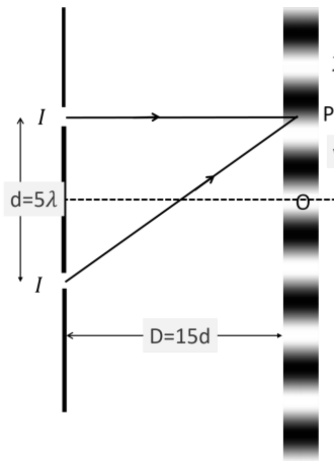
Q12. During resonance the current from main becomes absent because inductance & capacitor loop circuit does not take any current from the source and since resistance is in series (not in parallel) the current does not pass through the resistance also.

$\Rightarrow V_1 = V_2 = 0$

Q13. $P = e\ i \cos\phi \Rightarrow 650 = 200 \times 5 \times \cos\phi$

$\Rightarrow \cos\phi = 0.65$

Q14.



$y = \Delta x\left(\frac{D}{d}\right) \Rightarrow \Delta x = y\left(\frac{d}{D}\right)$

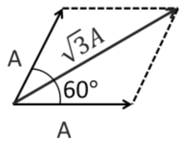
$\Rightarrow \Delta x = \frac{d}{2}\left(\frac{d}{15d}\right)$

$\Rightarrow \Delta x = \frac{d}{30}$

$\Rightarrow \Delta x = \frac{5\lambda}{30} \quad \Rightarrow \Delta x = \frac{\lambda}{6}$

$I_{max} = I_0 \Rightarrow I = \frac{I_0}{4}$

$\Delta x = \frac{\lambda}{6} \Rightarrow \Delta\varphi = \frac{2\pi}{6} \Rightarrow \Delta\varphi = \frac{\pi}{3}$



$A_R = \sqrt{3}A \Rightarrow A_R^{\ 2} = 2A^2 \Rightarrow I_R = 3I$

$\Rightarrow I_R = 3\frac{I_0}{4} \Rightarrow I_R = \frac{3I_0}{4}$

Q15. **For first maximum :**

$b\sin\theta = (2\overset{1}{\cancel{n}}+1)\frac{\lambda}{2} \Rightarrow b\sin 30° = 3\frac{\lambda}{2} \Rightarrow b\frac{1}{2} = 3\frac{\lambda}{2}$

$\Rightarrow b = 3\lambda$......(1)

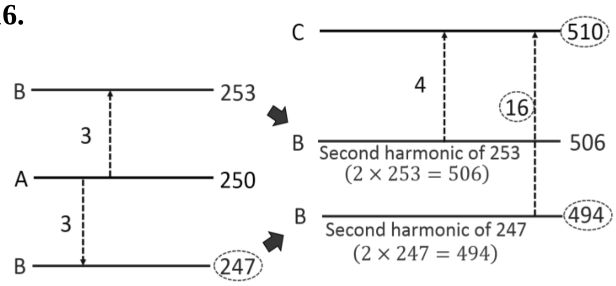
For first minimum :

$b\sin\theta' = \overset{1}{\cancel{n}}\lambda \Rightarrow b\sin\theta' = \lambda$ ... (2)

From eq (1) and (2): $\Rightarrow 3\lambda\sin\theta' = \lambda \Rightarrow \sin\theta' = \frac{1}{3}$

$\Rightarrow \boldsymbol{\theta' = \sin^{-1}\frac{1}{3}}$

Q16.



Q17. $y = A\sin k\,(x-1)\cos\omega t$

Amplitude $\Rightarrow A\sin k\,(x-1)$

To find position of nodes:

$\Rightarrow Amp_{\min} = 0\ (nodes) \Rightarrow \sin k\,(x-1) = 0$

$\Rightarrow k\,(x-1) = 0,\ \pi,\ 2\pi, 3\pi \ldots\ n\pi$

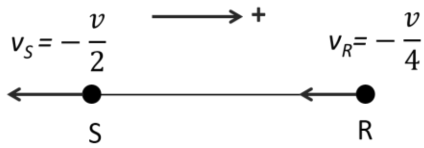
$\Rightarrow k\,(x-1) = n\pi$

$\Rightarrow \frac{2\cancel{\pi}}{\lambda}\cdot(x-1) = n\cancel{\pi} \Rightarrow x - 1 = n\frac{\lambda}{2} \Rightarrow x = n\frac{\lambda}{2} + 1$

where $n = 0,1,2,3 \ldots.$

$\Rightarrow x = (+1), \left(\frac{\lambda}{2}+1\right), (\lambda+1), \left(\frac{3\lambda}{2}+1\right) \ldots\ldots\ldots$

Q18.



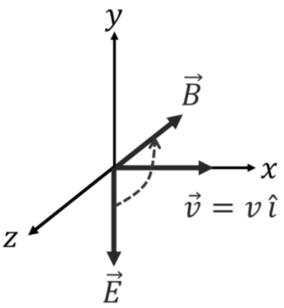
$$\Delta f = f\left[\frac{v_S - v_R}{v - v_S}\right] \quad \Rightarrow \frac{\Delta f}{f} = \left(\frac{v_S - v_R}{v - v_S}\right)$$

$$= \frac{\left(-\frac{v}{2}\right) - \left(-\frac{v}{4}\right)}{v - \left(-\frac{v}{2}\right)} = \frac{\frac{v}{4} - \frac{v}{2}}{\frac{3v}{2}} = \frac{-\frac{v}{4}}{\frac{3v}{2}} = -\frac{v}{4} \times \frac{2}{3v}$$

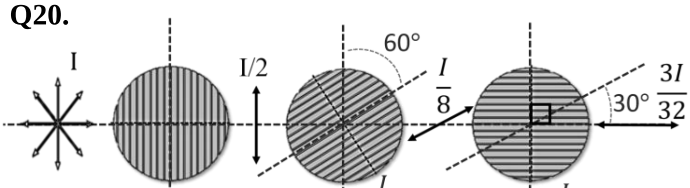
$$= -\frac{1}{6} \times 100 = -16.67\% \,(decreased)$$

Q19.

Direction of propagation is along $\vec{E} \times \vec{B}$



Q20.



$\frac{I}{2}cos^2 60°$ | $\frac{I}{8}cos^2 30°$

$= \frac{I}{2}\left(\frac{1}{2}\right)^2 = \frac{I}{2} \times \frac{1}{4} = \frac{I}{8}$ | $= \frac{I}{8}\left(\frac{\sqrt{3}}{2}\right)^2 = \mathbf{\frac{3I}{32}}$

Q21. Common potential on circuit after connection of switch

$$V = \frac{C_1V_1 + C_2V_2}{C_1 + C_2} = \frac{4\times 0 + 12\times 16}{4+12} = \frac{12\times 16}{16} = 12V$$

charge on $4\mu F \;\Rightarrow\; q = 4\times 12 = 48\mu C$

$$U_i = \frac{1}{2}\times 12\times (16)^2 + 0 = 6\times (16)^2 = 1536J$$

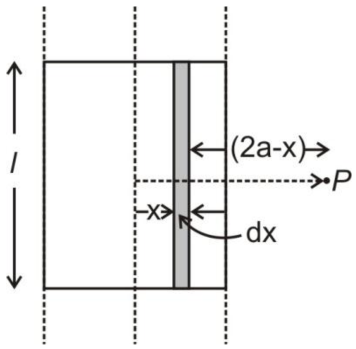
$$U_f = \frac{1}{2}C_1V^2 + \frac{1}{2}C_1V^2$$

$$= \frac{1}{2}(C_1 + C_2)V^2 = \frac{1}{2}\times(12+4)\times 12^2 = 8\times(12)^2 = 1152J$$

energy lost $\Rightarrow\; U_f \sim U_i = 1152 \sim 1536 = 384J$

fraction of energy lost $= \frac{U_f \sim U_i}{U_i} = \frac{384}{1536} = \frac{1}{4}$

Q22. Elemental field at



$$P \quad \Rightarrow \quad dE = \frac{1}{4\pi\epsilon_0}\frac{2\lambda}{(2a-x)}$$

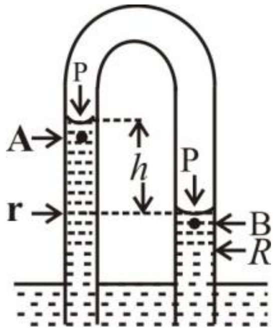
$$= \frac{1}{4\pi\epsilon_0}\frac{2(ldx\sigma)/l}{(2a-x)} = \frac{1}{4\pi\epsilon_0}\frac{2\sigma dx}{(2a-x)}$$

$$E = \int_{-a}^{+a}\frac{1}{4\pi\epsilon_0}\frac{2\sigma dx}{(2a-x)} = \frac{2\sigma}{4\pi\epsilon_0}\left[-\ln(2a-x)\right]_{-a}^{a}$$

$$= \frac{2\sigma}{4\pi\epsilon_0}\left[\ln\frac{3a}{a}\right] = \frac{2\sigma}{4\pi\epsilon_0}\ln 3$$

$$\Rightarrow \quad E = \frac{\sigma}{2\pi\epsilon_0}\ln 3$$

Q23.



$P_A = P - \frac{2T}{r}$ ……….. (1)

$P_B = P - \frac{2T}{R}$ ……….. (2)

$P_A + h\rho g = P_B$

$$h\rho g = P_B - P_A \quad \Rightarrow \quad h\rho g = \left(P - \frac{2T}{R}\right) - \left(P - \frac{2T}{r}\right)$$

$$\Rightarrow \quad h\rho g = 2T\left(\frac{1}{r} - \frac{1}{R}\right)$$

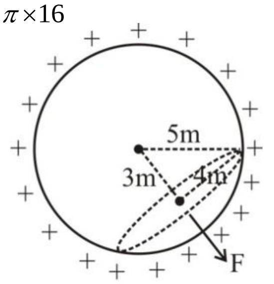
$$\Rightarrow \quad h\times 0.7\times 1000\times 10 = 2\times 70\times 10^{-3}\left(\frac{1}{1\times 10^{-3}} - \frac{1}{2\times 10^{-3}}\right)$$

$$\Rightarrow \quad h = \frac{2\times 70\times\frac{1}{2}}{0.7\times 1000\times 10} = 0.01\,m = 10\,mm$$

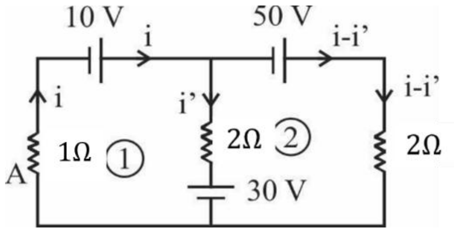
Q24. F = Pressure × projected area

$$= \frac{1}{2}\frac{\sigma^2}{\varepsilon_0} \times \pi 4^2 = \frac{1}{2}\frac{(0.5)^2}{\varepsilon_0} \times \pi \times 16$$

$$\Rightarrow \quad F = \frac{2\pi}{\varepsilon_0}$$



Q25.



In loop ① $-10 + 2i' + 30 + i = 0$

$2i' + i = -20$ …..(1)

In loop ② $-50 + (i - i') \times 2 - 30 - 2i' = 0$

$2i - 2i' - 2i' = 80$

$2i - 4i' = 80 \Rightarrow i - 2i' = 40$ …..(2)

$(1) + (2) \Rightarrow \quad 2i = 20 \Rightarrow$ i=10A