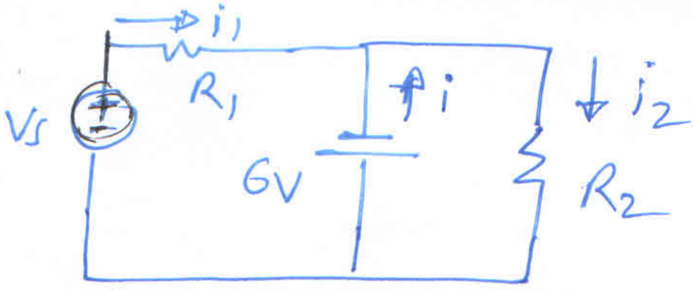
Q: 2(a)

Assume diode 'D' is ON



$$i_1 = \frac{V_s - (-6)}{R_1} = \frac{V_s + 6}{2000}$$

$$i_2 = \frac{-6}{R_2} = \frac{-6}{4000} = -1.5 \text{ mA}$$

For diode to be ON $i > 0$

$$i = i_2 - i_1$$

$$= -1.5\times10^{-3} - \left(\frac{V_s + 6}{2000}\right)$$

$$= -1.5\times10^{-3} - \frac{V_s}{2000} - 3\times10^{-3}$$

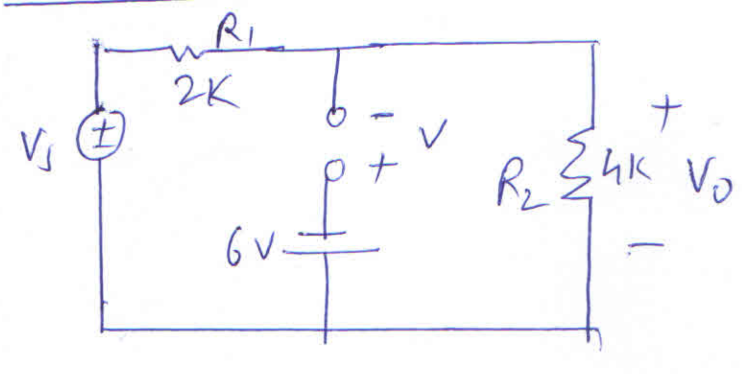
$$= \frac{-V_s}{2000} - 4.5\times10^{-3}$$

$$\frac{-V_s}{2000} - 4.5\times10^{-3} > 0$$

$$\frac{V_s}{2000} + 4.5\times10^{-3} < 0$$

$$V_s < -9V \longrightarrow 4$$

For $V_s \geq -9V$ diode is OFF



$$V_0 = \frac{R_2}{R_1 + R_2} V_s = \frac{4K}{4K + 2K} V_s$$

$$= \frac{2}{3} V_s$$

By KVL:

$$V + V_0 + 6 = 0$$

$$V = -V_0 - 6$$

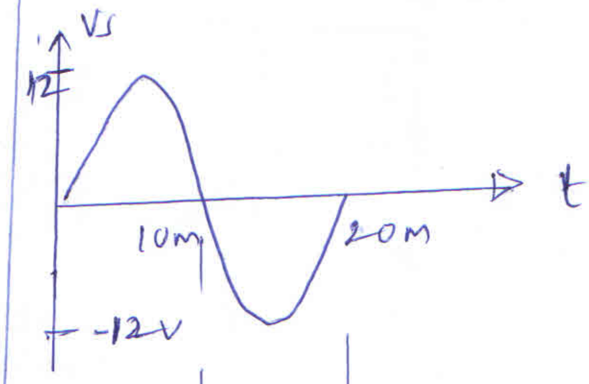
$$V = -\frac{2}{3} V_s - 6$$

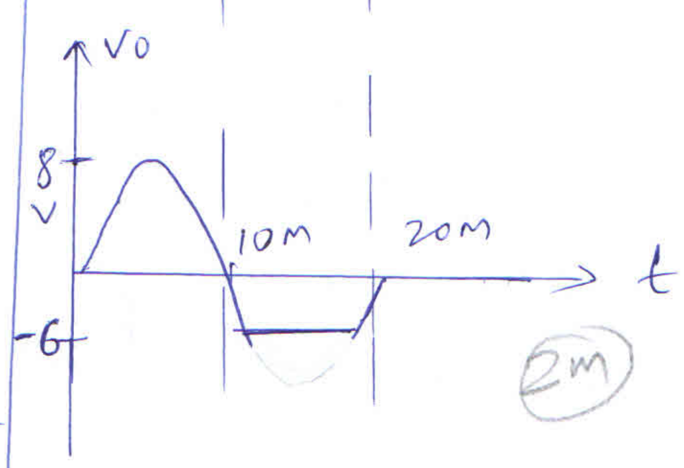
$$V \leq 0$$

$$-\frac{2}{3} V_s - 6 \leq 0$$

$$\frac{2}{3} V_s + 6 \geq 0$$

$$V_s \geq -9V \longrightarrow 4$$





2m

Q: 2(b)

$V_E = V_{EB} = 0.7V$ (2)

$I_E = \frac{10-0.7}{2} = 4.65\ mA$ (2)

$\alpha = \frac{\beta}{\beta+1} = \frac{100}{101} = 0.99$

$I_C = \alpha I_E = 4.6\ mA$ (2)

$V_C = -10 + I_C R_C$

$= -10 + 4.6 \times 1$

$= -5.4\ V$ (2)

$I_B = I_E - I_C = 0.05\ mA$ (2)

$V_{CE} = V_C - V_E = -5.4 - (0.7)$

$= -6.1\ V$

$V_{CE} < -0.2V$

∴ PNP BJT is in active region. (2)

OR

$V_{CB} = V_{EB} + V_{CE}$

$= 0.7 + (-6.1)$

$= -5.4\ V$

$V_{CB} < V_\gamma$

∴ Collector Base junction is Reverse biased.

∴ PNP BJT is in active region.

Q: 3(a)

$V_2 = \frac{30}{1500} \times 1000 = 20V$ (2)

$V_{GS} = V_2 - I_D R_S$

$= 20V - 2.5 \times 10^{-3} \times 5K$

$= 7.5\ V$ (2)

$\Rightarrow V_{GS} - V_t = 6.5\ V$

$V_D = 30 - 3.5 \times 2.5$

$= 21.25\ V$

$V_S = I_D R_S = 2.5 \times 5$

$= 12.5\ V$

$\therefore V_{DS} = 8.75\ V$ (3)

$V_{DS} > V_{GS} - V_t$

∴ transistor is in active/saturation region. (2)

$K = \frac{i_D}{(V_{GS}-V_t)^2}$

$= \frac{2.5 \times 10^{-3}}{(6.5)^2}$ (3)

$= 5.91 \times 10^{-5}\ A/V^2$

Ans 1 (b)

$$v_1 - v_2 = a i_x \quad \text{— (1)} \quad \text{—— } 1$$

$$5 + i_x = \frac{V_1 - V_2}{8} + i_D \quad \text{— (2) — 2M}$$

$$3 + i_D = \frac{V_2 - V_1}{8} + \frac{V_2}{10} \quad \text{— (3) — 2M}$$

$$i_x = \frac{-V_1}{10} \quad \text{— (4)}$$

$$V_1 - V_2 = 5 \times \left(\frac{-V_1}{10}\right)$$

$$V_1 - V_2 = \frac{-V_1}{2}$$

$$V_1 \left[\frac{3}{2}\right] = V_2$$

$$3V_1 = 2V_2$$

$$5 + \left(\frac{-V_1}{10}\right) = \frac{V_1 - V_2}{8} + i_D$$

$$i_D = 5 - \frac{V_1}{10} - \left(\frac{V_1 - V_2}{8}\right)$$

$$3 + 5 - \frac{V_1}{10} - \left(\frac{V_1 - V_2}{8}\right) = \frac{V_2 - V_1}{8} + \frac{V_2}{10}$$

$$8 - \frac{V_1}{10} + \left(\frac{\cancel{V_2 - V_1}}{\cancel{8}}\right) = \frac{\cancel{V_2 - V_1}}{\cancel{8}} + \frac{V_2}{10}$$

$$80 = V_1 + V_2$$

$$240 = 2V_2 + 3V_2$$

$$5V_2 = 240$$

$$V_2 = \frac{\cancel{240}^{48}}{\cancel{5}}$$

$$\therefore V_1 = \frac{2}{\cancel{3}} \times \cancel{48}^{16} = 32$$

$V_1 = 32V$ — 2M

$V_2 = 48V$ — 2M

4

Ques. 3 (a)

$$V_2 = \frac{R_2}{R_1+R_2} \cdot 30V = \frac{1}{1.5} \times 30 = 20V \quad 2m$$

$$V_{GS} = V_2 - I_D R_S$$

$$= 20 - (2.5 \times 10^{-3})(5 \times 10^3)$$

$$\Rightarrow 20 - 12.5$$

$$= 7.5V \quad 2m$$

$$V_{GS} - V_t = 7.5 - 1 \Rightarrow 6.5V$$

$$V_S = I_S R_S = (2.5 \times 10^{-3}) \times 5K \Rightarrow 12.5V$$

$$V_D = 30 - I_D R_D$$

$$\Rightarrow 30 - (2.5 \times 10^{-3})(3.5 \times 10^3)$$

$$\Rightarrow 30 - 8.75$$

$$V_D \Rightarrow 21.25$$

hence $V_{DS} \Rightarrow 8.75V$ — 3m

$V_{DS} \geq V_{GS} - V_t$; hence transister in saturation/active region.

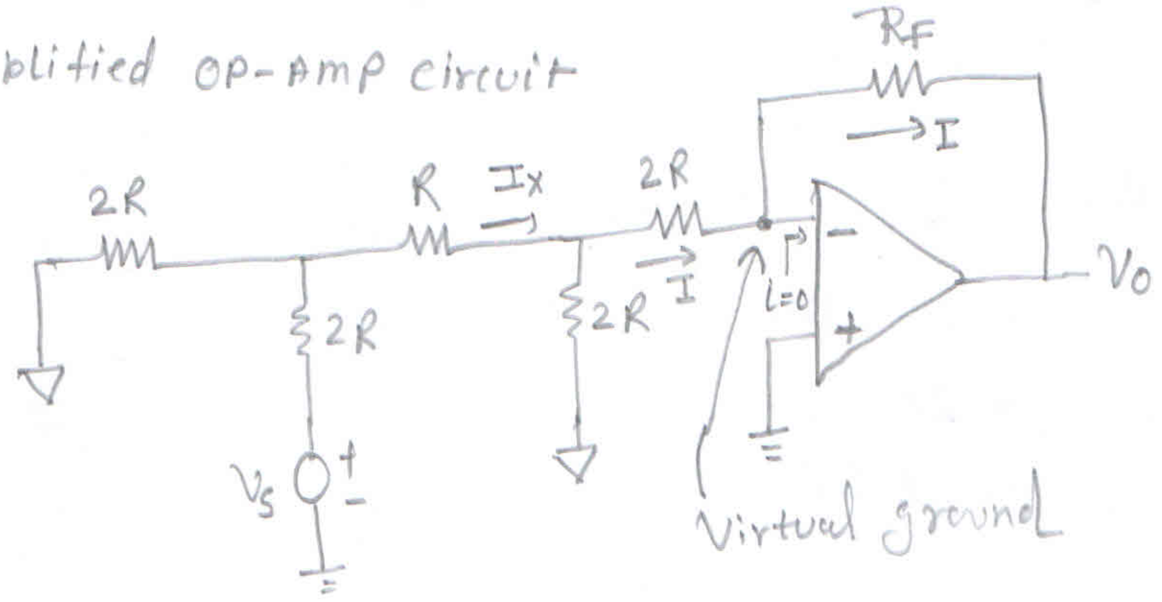
$$K = \frac{I_D}{(V_{GS} - V_t)^2} = \frac{2.5 \times 10^{-3}}{(6.5)^2} \quad 3m$$

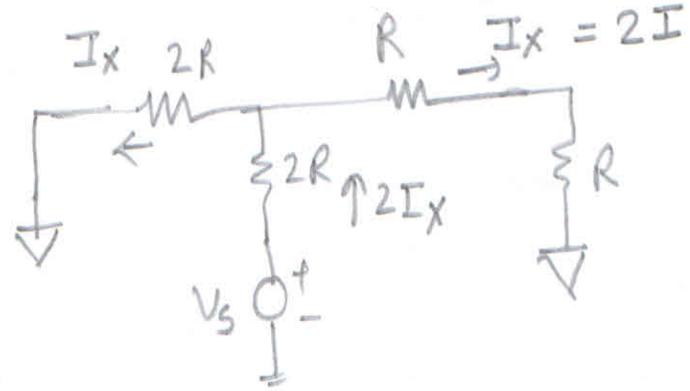
$$\Rightarrow .0591 \, mA/V^2$$

$$= 59.17 \, \mu A/V^2$$

Ques_3 b(ii)

Simplified OP-Amp circuit





(4m)

$$2R \cdot 2I_x + 2RI_x = V_s$$

$$6RI_x = V_s$$

$$I_x = V_s/6R$$

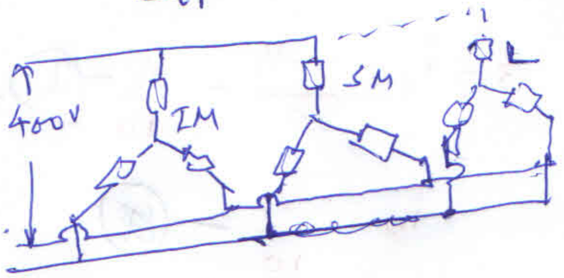
$$\boxed{I = V_s/12R}$$

→ (8m)

Q.1 (a).

$$V_p = \frac{400}{\sqrt{3}} = \underline{230.9 \text{ volts}}$$

$Z_{ip} = 3 + j4 = 5\angle 53.13\ \Omega$, $I_p = \dfrac{V_p}{Z_{ip}} = 46.18\angle -53.15^\circ A$



$I_{il} = I_{ip} = 46.18\angle -53.15^\circ$

$I_{sl} = 100\angle 31.79^\circ$ A.

$I_l = I_{sl} + I_{il} = 113.79\angle 7.95^\circ$

$= (112.7 + j15.74)$ Amp

(a) $\phi = \underline{7.95^\circ}$, $\underline{\cos\phi = .9904 \text{ (leading)}}$ (5)

(b) $P = \sqrt{3} \times 400 \times 113.79 \times \cos 7.95$

$= 78 \times 10^3$ watts

$Q = \sqrt{3} \times 400 \times 113.79 \times \sin 7.95$

$= 10.9 \times 10^3$ VAR

(5)

(c) $= \dfrac{231\angle 0}{112.7 + j15.74} = (2.01 - j.28) = Z_{eq}$

To have 0.8 p.f lagging

$Z'_{eq} = (2.01 - j.28 + jX_L)$

Inductor will be <u>connected</u>

$\dfrac{(X_L - .28)}{2.01} = 0.75$

$X_L = 1.787 = \omega L$

$L = \underline{0.005 \text{ Henry}}$.

(5)

20 Ans 1 (b)

$$v_1 - v_2 = a\, i_x \quad \text{—} (1) \quad \text{—} 1$$

$$5 + i_x = \frac{v_1 - v_2}{8} + i_D \quad \text{—} (2) \quad \text{— 2M}$$

$$3 + i_D = \frac{v_2 - v_1}{8} + \frac{v_2}{10} \quad \text{—} (3) \quad \text{— 2M}$$

$$i_x = \frac{-v_1}{10} \quad \text{—} (4)$$

$$v_1 - v_2 = 5 \times \left(\frac{-v_1}{10}\right)$$

$$v_1 - v_2 = \frac{-v_1}{2}$$

$$v_1\left[\frac{3}{2}\right] = v_2$$

$$3v_1 = 2v_2$$

$$5 + \left(\frac{-v_1}{10}\right) = \frac{v_1 - v_2}{8} + i_D$$

$$i_D = 5 - \frac{v_1}{10} - \left(\frac{v_1 - v_2}{8}\right)$$

(3) $3 + 5 - \frac{v_1}{10} - \left(\frac{v_1 - v_2}{8}\right) = \frac{v_2 - v_1}{8} + \frac{v_2}{10}$

$$8 - \frac{v_1}{10} + \cancel{\left(\frac{v_2 - v_1}{8}\right)} = \cancel{\frac{v_2 - v_1}{8}} + \frac{v_2}{10}$$

$$80 = v_1 + v_2$$

$$240 = 2v_2 + 3v_2$$

$$5v_2 = 240$$

$$v_2 = \frac{\overset{48}{\cancel{240}}}{\cancel{5}}$$

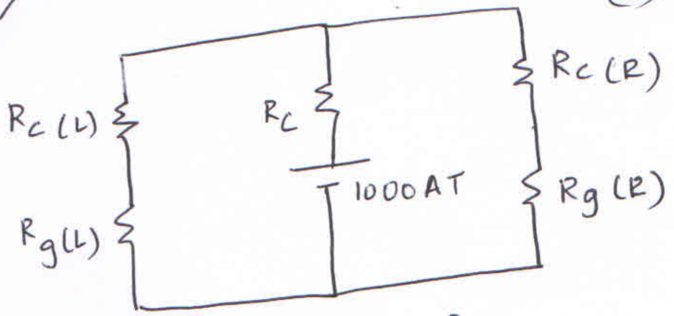
$$v_1 = \frac{2}{\cancel{3}} \times \overset{16}{\cancel{48}} = 32$$

$v_1 = 32\,V$ — 2 M

$v_2 = 48\,V$ — 2 M

4

Q4



(i)

$$R_c = \frac{10 \times 10^{-2}}{1000 \times 4\pi \times 10^{-7} \times 4 \times 10^{-4}}$$

$$= 1.989 \times 10^{5} \text{ AT/Wb.} \quad — (2)$$

$$R_{c(L)} = \frac{29 \times 10^{-2}}{1000 \times 4\pi \times 10^{-7} \times 4 \times 10^{-4}} = 5.769 \times 10^{5} \text{ AT/Wb.}$$

$$R_g(L) = \frac{1 \times 10^{-2}}{4\pi \times 10^{-7} \times 4 \times 10^{-4}} = 1.989 \times 10^{7} \text{ AT/Wb.}$$

$$— (2)$$

$$R_a = R_c(L) + R_g(L) = 20.47 \times 10^{6} \text{ AT/Wb.} \quad — (2)$$

$$R_c(R) = \frac{29.5 \times 10^{-2}}{1000 \times 4\pi \times 10^{-7} \times 4 \times 10^{-4}} = 5.869 \times 10^{5} \text{ AT/Wb.}$$

$$R_g(R) = \frac{0.5 \times 10^{-2}}{4\pi \times 10^{-7} \times 4 \times 10^{-4}} = 9.947 \times 10^{6} \text{ AT/Wb.}$$

$$R_b = R_c(R) + R_g(R) = 10.53 \times 10^{6} \text{ AT/Wb.} \quad — (2)$$

$$R_{total} = R_c + \frac{1}{1/R_a + 1/R_b} = 7.152 \times 10^{6} \text{ AT/Wb.} \quad — (1)$$

(ii)

$$— (2)$$

$$\phi_c = \frac{Ni}{R_{total}} = \frac{1000}{7.152 \times 10^{6}} = 139.82 \,\mu\text{Wb.}$$

$$— (2)$$

$$\phi_a = \phi_c \frac{R_b}{R_a + R_b} = 139.82\mu \cdot \frac{R_b}{R_a + R_b} = 47.49 \,\mu\text{Wb.}$$

$$— (2)$$

$$\phi_b = \phi_c \frac{R_a}{R_a + R_b} = 92.32 \,\mu\text{Wb.}$$

(iii)

$$B_a = \frac{\phi_a}{A_a} = \frac{47.49\mu}{A_a} = \frac{47.49\mu}{4 \times 10^{-4}} = 0.1187 \text{ T} \quad — (1)$$

$$B_b = \frac{92.32\mu}{4 \times 10^{-4}} = 0.2308 \text{ T.} \quad — (1)$$