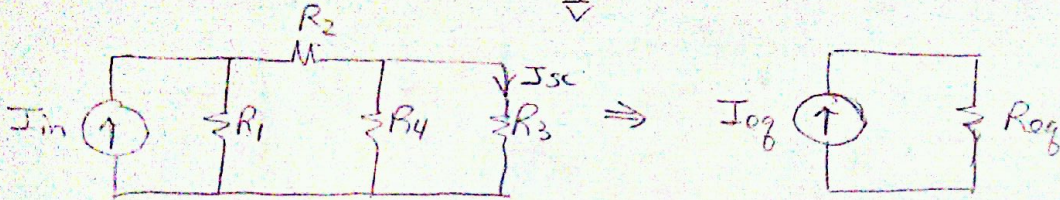
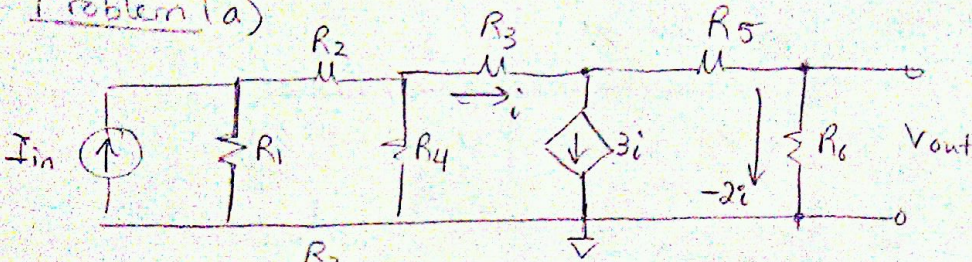


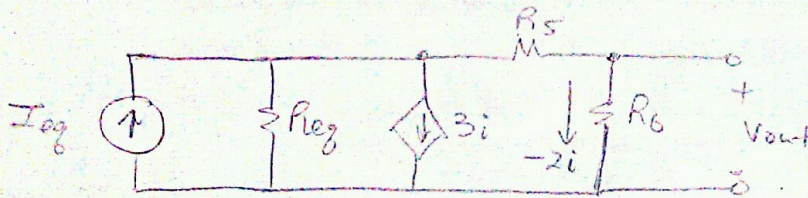
Mid term Solutions, EE40 MT1

Problem 1a)



$$R_{oq} = (R_1 + R_2) \parallel R_4 + R_3$$

$$I_{oq} = \frac{R_3 \parallel R_4}{R_3 \parallel R_4 + R_1 + R_2} \cdot R_1 I_{in} \cdot \frac{1}{R_3} = I_{sc}$$



$$-2i = (I_{oq} - 3i) \frac{R_{oq}}{R_{oq} + R_5 + R_6} = \frac{I_{oq} R_{oq}}{R_{oq} + R_5 + R_6} - \frac{3 R_{oq} i}{R_{oq} + R_5 + R_6}$$

$$i = \frac{I_{oq} R_{oq}}{R_{oq} + R_5 + R_6}$$

$$\frac{3 R_{oq}}{R_{oq} + R_5 + R_6} - 2$$

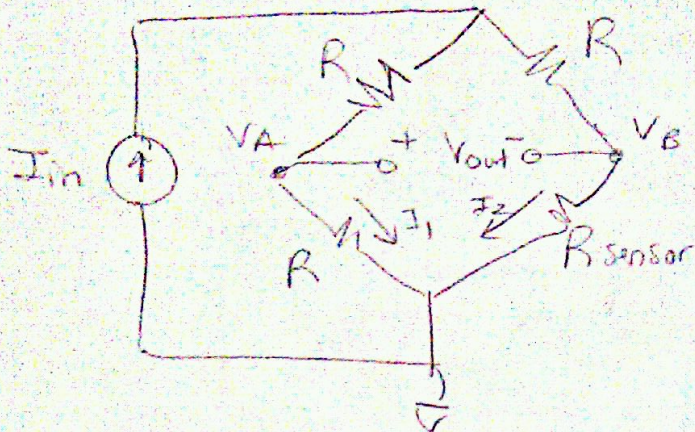
$$V_{out} = -2i R_6$$

$$= \frac{-2 R_6 R_{oq}}{R_{oq} + R_5 + R_6} I_{oq} = \frac{-2 R_6 R_{oq} I_{oq}}{R_{oq} - 2(R_5 + R_6)}$$

$$\frac{3 R_{oq}}{R_{oq} + R_5 + R_6} - 2$$

$$V_{out} = \frac{-2 R_6 [(R_1 + R_2) \parallel R_4 + R_3] \frac{R_3 \parallel R_4}{R_3 \parallel R_4 + R_1 + R_2} \cdot \frac{R_1}{R_3} \cdot I_{in}}{(R_1 + R_2) \parallel R_4 + R_3 - 2(R_5 + R_6)} \quad [V]$$

1b)



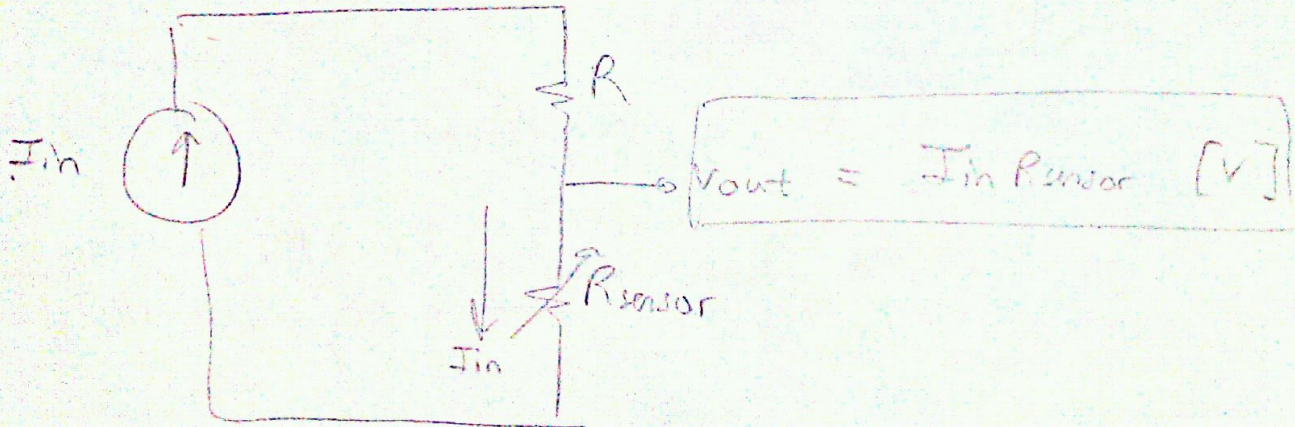
$$V_{out} = V_A - V_B$$

$$= R I_1 - R_{sensor} I_2$$

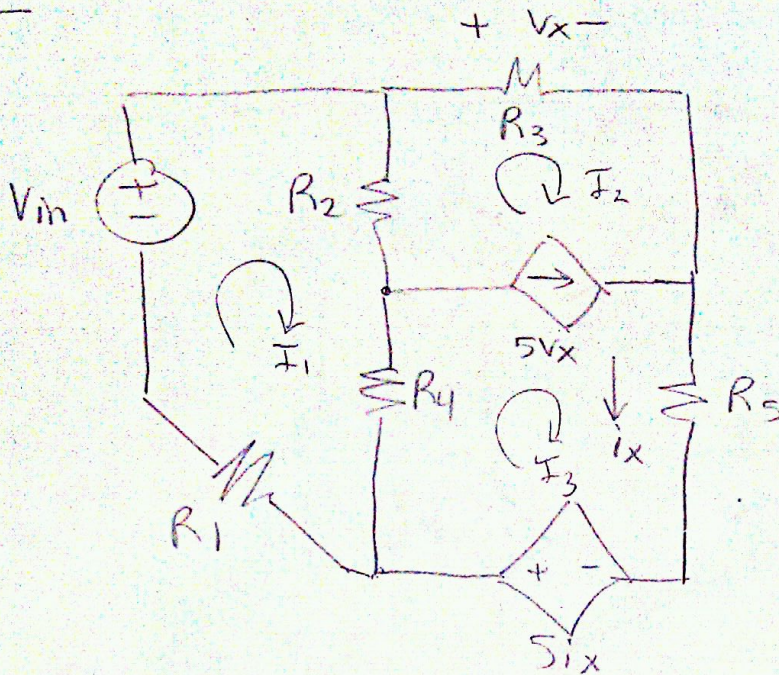
$$= R I_{in} \frac{R_{sensor} + R}{3R + R_{sensor}} - R_{sensor} I_{in} \frac{2R}{3R + R_{sensor}}$$

$$= I_{in} \frac{(R R_{sensor} + R^2 - 2R R_{sensor})}{3R + R_{sensor}}$$

$$V_{out} = I_{in} \frac{(R^2 - R R_{sensor})}{3R + R_{sensor}} \quad [V]$$



P2



$$0 = (R_1 + R_2 + R_4) I_1 - R_2 I_2 - R_4 I_3 - V_{in}$$

$$0 = (-R_4 - R_2) I_1 + (R_2 + R_3) I_2 + (R_4 + R_5) I_3 - 5I_3$$

$$5V_x = 5(I_2 R_3) = I_3 - I_2$$

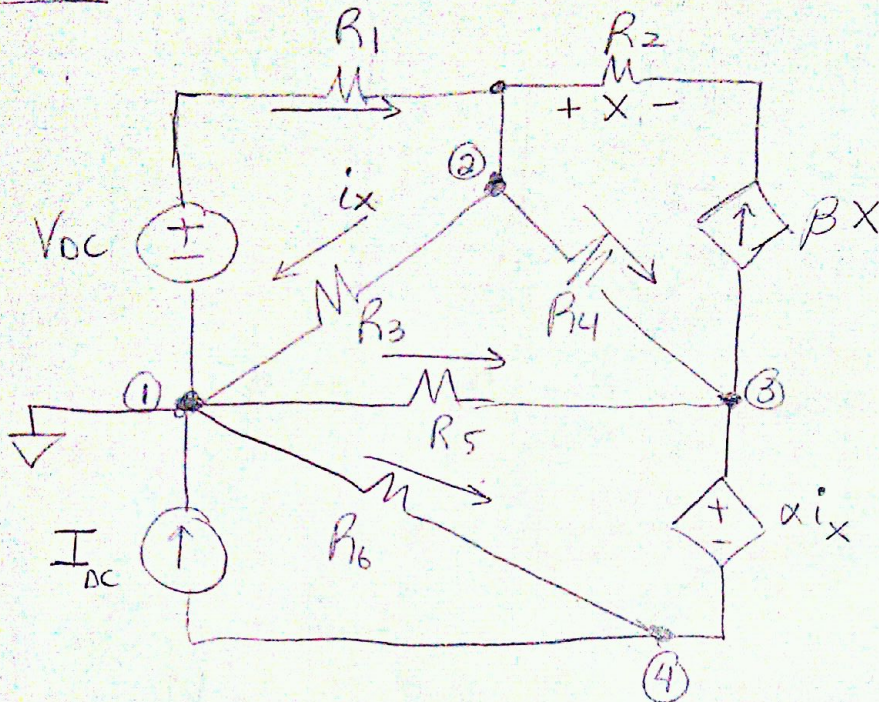
$$0 = (5R_3 + 1) I_2 - I_3$$

$$\underline{(R_1 + R_2 + R_4) I_1} + \underline{(-R_2) I_2} + \underline{(-R_4) I_3} = \underline{V_{in}}$$

$$\underline{(-R_4 - R_2) I_1} + \underline{(R_2 + R_3) I_2} + \underline{(R_4 + R_5 - 5) I_3} = \underline{0}$$

$$\underline{0 I_1} + \underline{(5R_3 + 1) I_2} + \underline{(-1) I_3} = \underline{0}$$

P3



$$x = \beta x \quad \text{so let } x = 0$$

$$\frac{V_{DC} - V_2}{R_1} = \frac{V_2 - V_1}{R_3} + \frac{V_2 - V_3}{R_4} \quad (\text{KCL @ } \textcircled{2})$$

$$\therefore \frac{V_{DC}}{R_1} = \left(\frac{-1}{R_3}\right) V_1 + \left(\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_1}\right) V_2 + \left(\frac{-1}{R_4}\right) V_3 + \underline{0 \cdot V_4}$$

$$\frac{V_2 - V_3}{R_4} + \frac{(V_1 - V_3)}{R_5} + \frac{V_3 - V_4}{R_6} = I_{DC} \quad (\text{KCL at } \textcircled{3}, \textcircled{4})$$

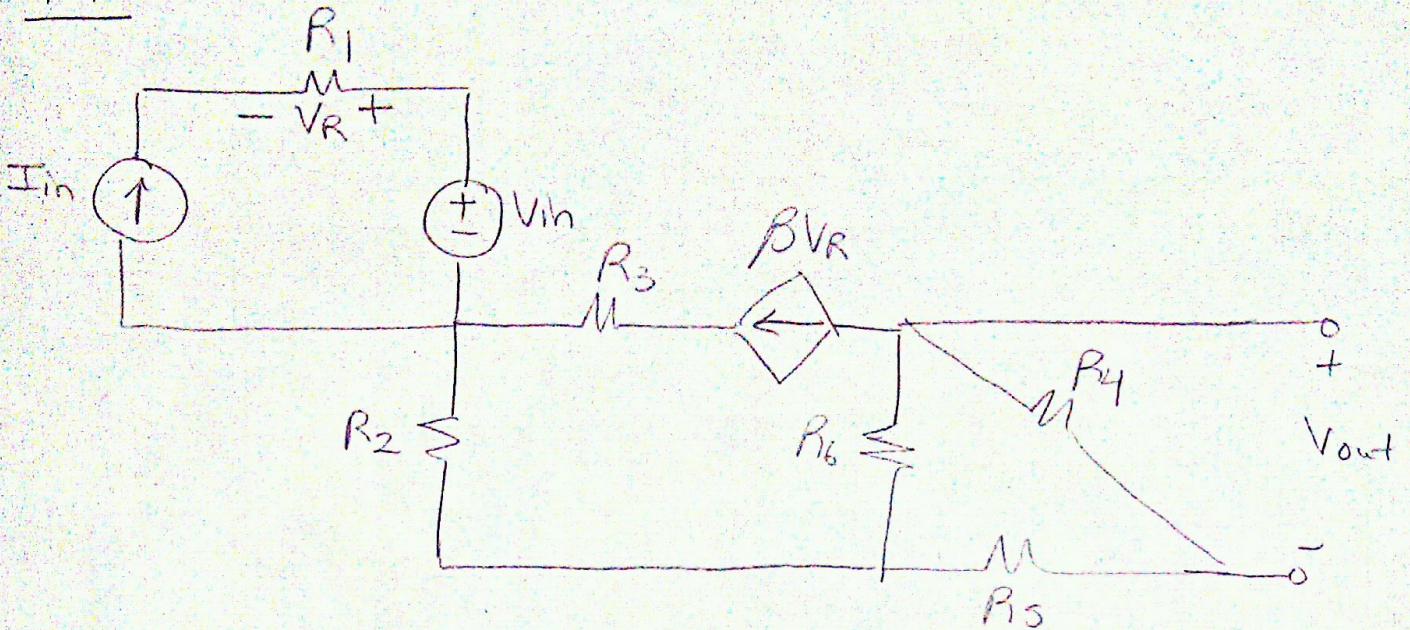
$$\therefore \underline{I_{DC}} = \left(\frac{1}{R_5} + \frac{1}{R_4}\right) V_1 + \frac{1}{R_4} V_2 + \left(\frac{-1}{R_4} - \frac{1}{R_5}\right) V_3 + \left(\frac{-1}{R_6}\right) V_4$$

$$\alpha i_x = \alpha \frac{(V_2 - V_1)}{R_3} = V_3 - V_4$$

$$\therefore \underline{0} = \left(\frac{-\alpha}{R_3}\right) V_1 + \left(\frac{\alpha}{R_3}\right) V_2 + \underline{(-1)} V_3 + \underline{1 \cdot} V_4$$

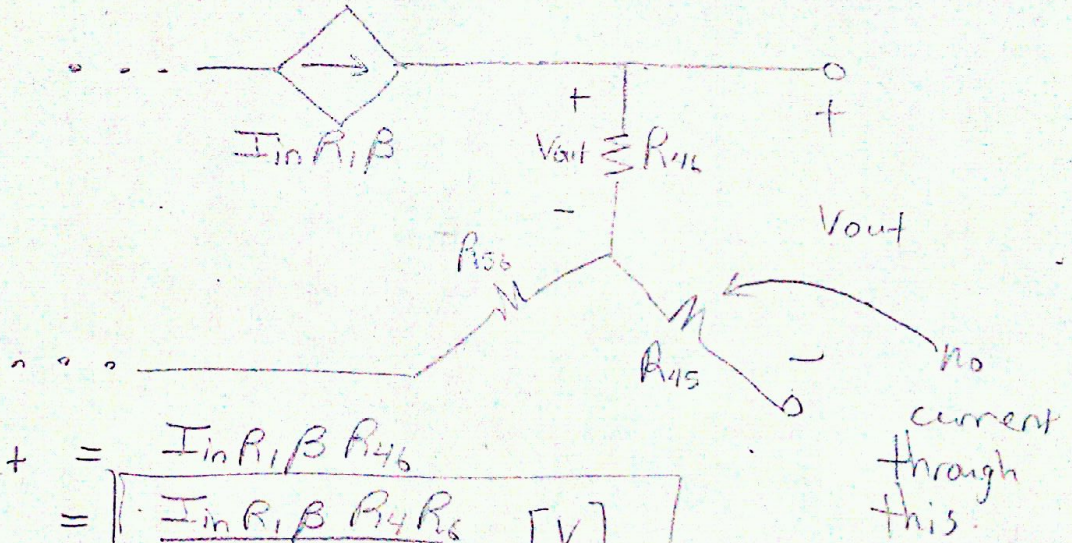
$$\text{and } \underline{1 \cdot V_1 + 0 \cdot V_2 + 0 \cdot V_3 + 0 \cdot V_4 = 0}$$

P4



$$V_R = -I_{in} R_1$$

$$\beta V_R = -I_{in} R_1 \beta$$



$$V_{out} = \frac{I_{in} R_1 \beta R_4 R_6}{R_4 + R_5 + R_6} \text{ [V]}$$