Homework 2

Coverage: Chapter 4 and 5

Due date: 5th November 2024

Problem 1

Find v_x in the below circuit:

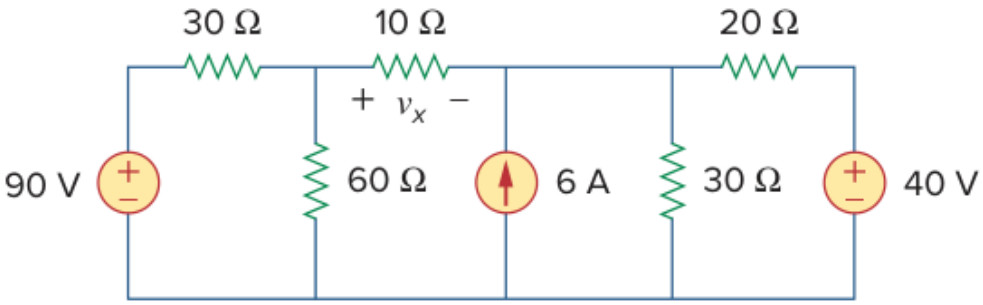
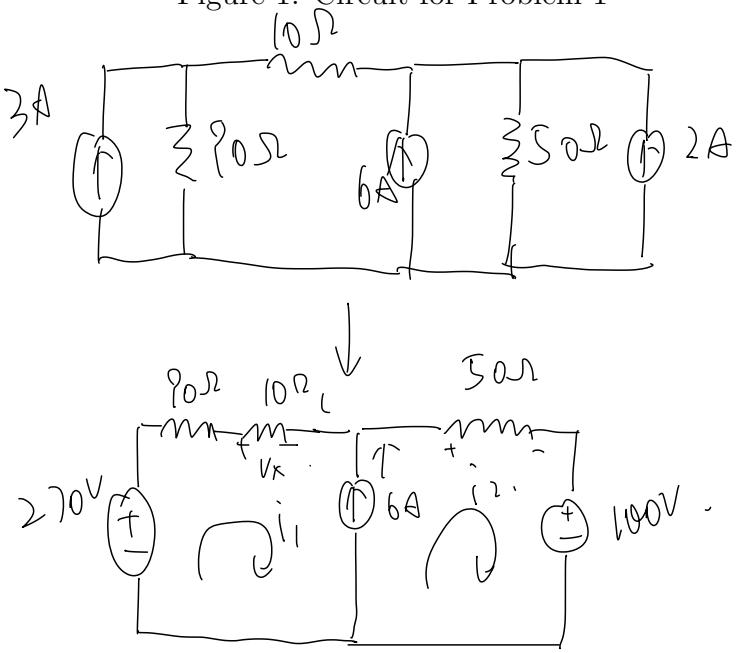


Figure 1: Circuit for Problem 1



$$\begin{cases} i_1 + 6 = i_2 \\ -270 + 20 i_1 + 10 i_1 + 50 i_2 + 100 = 0 \end{cases}$$

$$\begin{cases} i_1 = -\frac{13}{15}\ \text{A} \\ i_2 = \frac{77}{15}\ \text{A} \end{cases} \qquad V_x = i_1 \cdot 10\Omega = -8.67\ \text{V}$$

Problem 2

Use source transformation to find i_x in the circuit

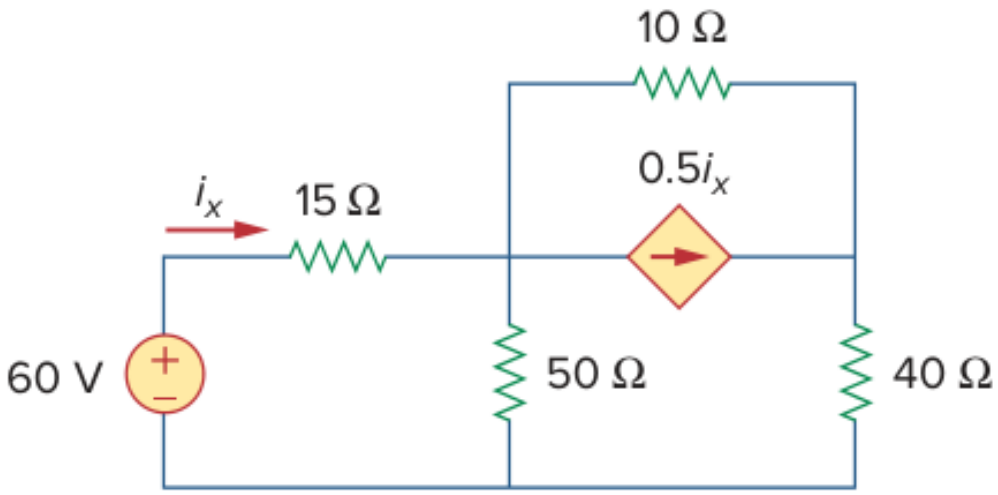
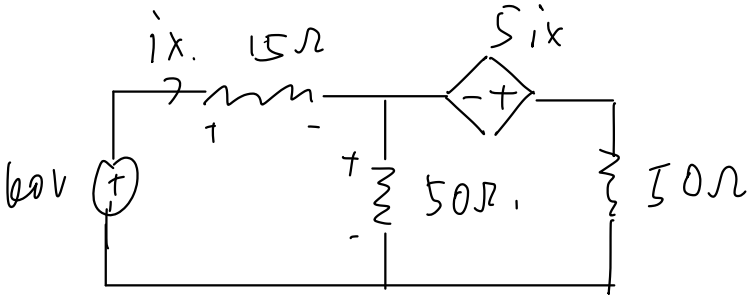


Figure 2: Circuit for Problem 2



$$\begin{cases} -60 + 15i_x + 50(i_x - i_2) = 0 \\ -5i_x + 50i_2 + 50(i_2 - i_x) = 0 \end{cases}$$

$$\begin{cases} 65i_x - 50i_2 = 60 \\ -55i_x + 100i_2 = 0 \end{cases}$$

$$\begin{cases} i_x = 1.6\,A \\ i_2 = 0.88\,A \end{cases}$$

Problem 3

Find the Thevenin equivalent of a-b

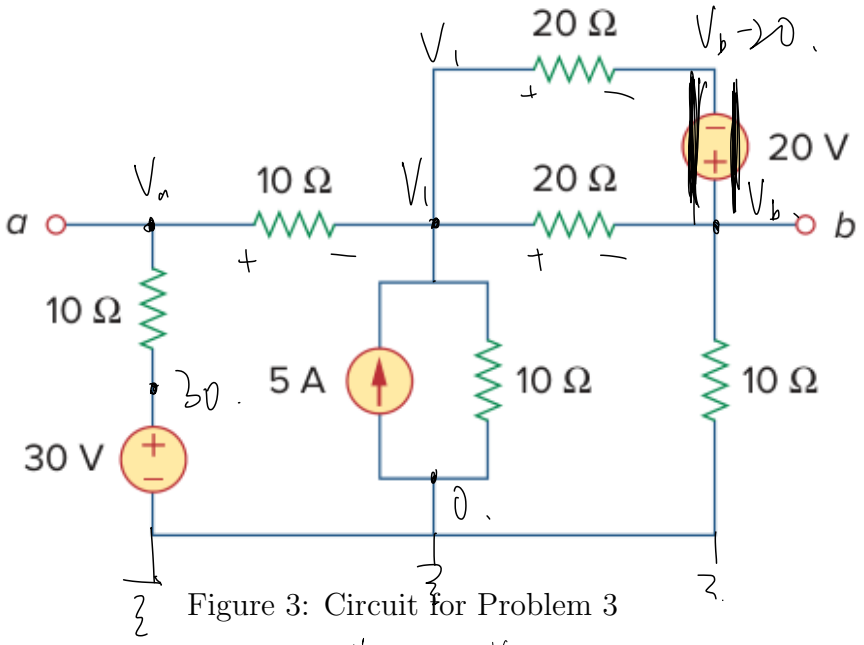
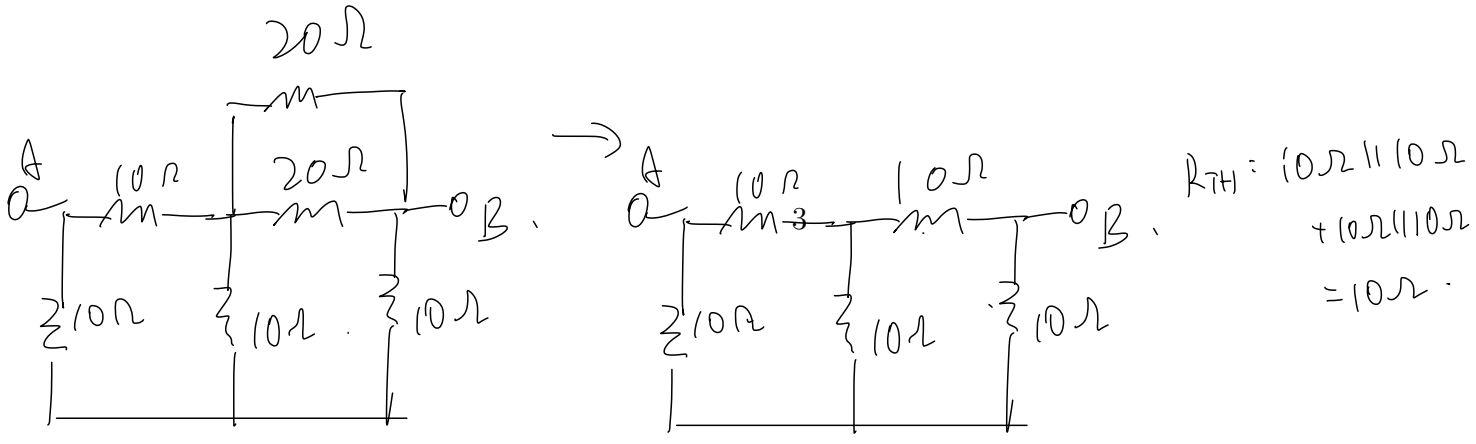


Figure 3: Circuit for Problem 3

$$\begin{cases} \frac{V_a - V_1}{10} + 5 = \frac{V_1}{10} + \frac{V_1 - V_b}{20} + \frac{V_1 - V_b + 20}{20} \\ \frac{V_1 - V_b + 20}{20} + \frac{V_1 - V_b}{20} = \frac{V_b}{10} \\ \frac{V_a - 30}{10} + \frac{V_a - V_b}{10} = 0 \end{cases}$$

$$\begin{cases} V_a = 30\,V \\ V_b = 20\,V \\ V_1 = 30\,V \end{cases}$$

$$V_{Th} = 30\,V - 20\,V = 10\,V.$$



$$R_{TH} = 10\Omega \,||\, 10\Omega + 10\Omega \,||\, 10\Omega = 10\Omega.$$

Problem 4

Find the maximum power transferred to resistor R

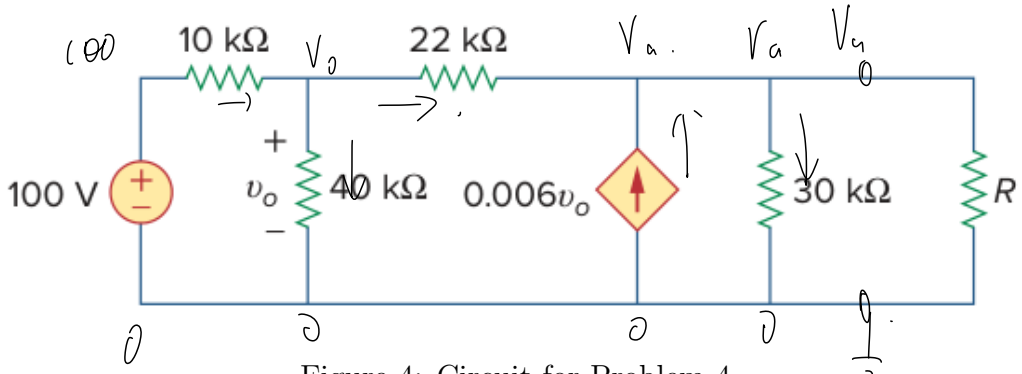


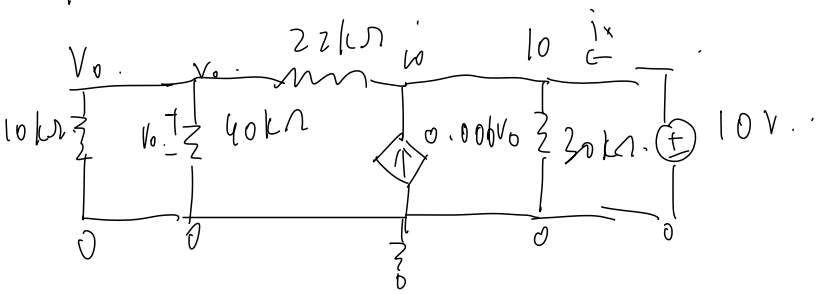
Figure 4: Circuit for Problem 4

$$\frac{100 - V_0}{10k} = \frac{V_0}{40k} + \frac{V_0 - V_a}{22k}$$

$$\frac{V_0 - V_a}{22k} + 0.006V_0 = \frac{V_a}{30k}$$

$$V_a = -231.3V \qquad V_{Th} = -231.3V$$

$$V_0 = -3.0V$$



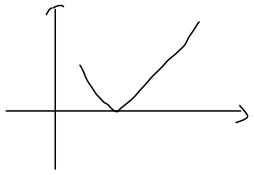
$$\frac{V_0}{10k} + \frac{V_0}{40k} = \frac{10 - V_0}{22k}$$

$$\frac{10 - V_0}{22k} + \frac{10}{30k} = 0.006V_0 + i_x$$

$$V_0 = \frac{8}{3}$$

$$i_x = -0.015A$$

$$R_{Th} = \frac{10}{i_x} = \frac{10}{-0.015} = -666.7\Omega < 0$$



Therefore, $P = \left(\frac{V_{Th}}{R_{Th} + R}\right)^2 \cdot R = \frac{V_{Th}^2}{\frac{R_{Th}^2}{R} + 2R_{Th} + R}$, if $R = -R_{Th} = 666.7\Omega$, P reaches the maximum, $P \to \infty$, So P_m DNE.

Problem 5

Find v_o and i_o in the circuit

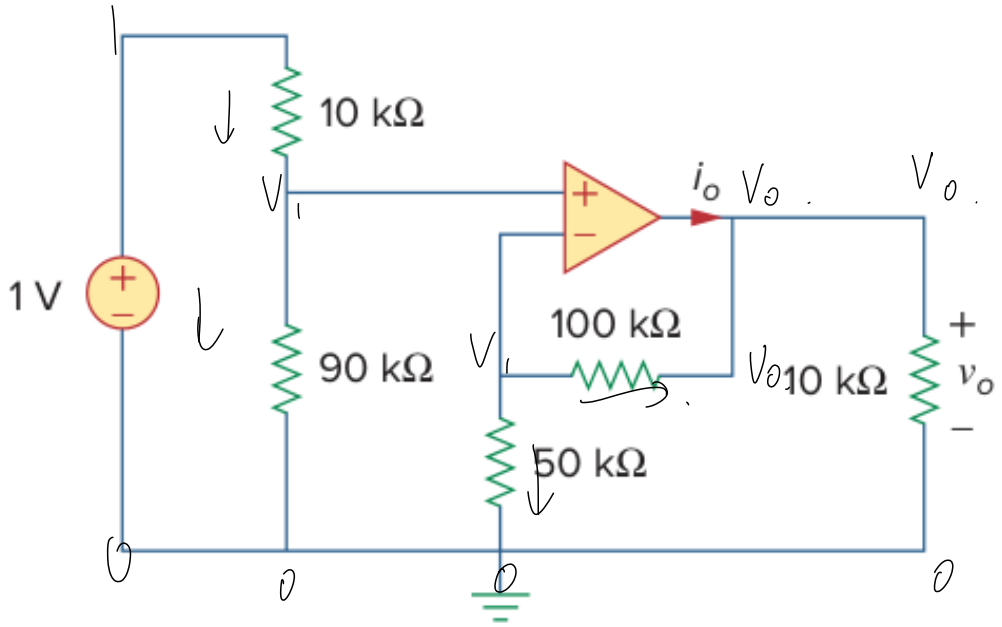


Figure 5: Circuit for Problem 5

$$\frac{0-V_1}{10k} = \frac{V_1}{90k}$$

$$\frac{V_1}{50k} + \frac{V_1 - V_o}{100k} = 0$$

$$V_1 = 0.9V$$

$$V_o = 2.7V$$

$$i_o = \frac{V_o}{10k} + \frac{V_o - V_1}{100k}$$

$$= 2.88 \times 10^{-4} A$$

Problem 6

Find voltage gain v_o/v_i of the circuit

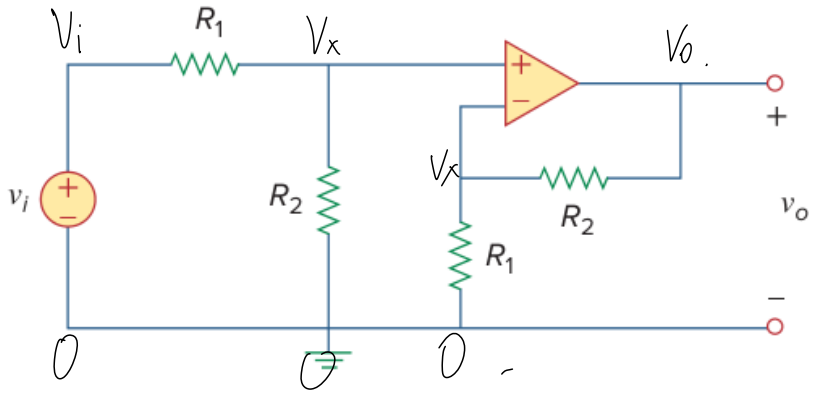


Figure 6: Circuit for Problem 6

$$\begin{cases} \dfrac{V_i - V_x}{R_1} = \dfrac{V_x}{R_2} \\ \dfrac{V_x}{R_1} + \dfrac{V_x - V_o}{R_2} = 0 \end{cases}$$

$$V_i R_2 - V_x R_2 = V_x R_1$$

$$V_x = \frac{V_i R_2}{R_1 + R_2}$$

$$V_x R_2 + V_x R_1 - V_o R_1 = 0$$

$$V_x = \frac{V_o R_1}{R_1 + R_2}$$

$$V_i R_2 = V_o R_1$$

$$\frac{V_o}{V_i} = \frac{R_2}{R_1}$$