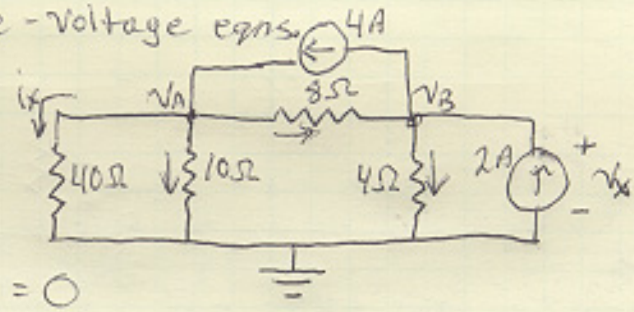
Homework III | Ch. 3: 2, 5, 6, 7, 9, 11, 12, 17, 72, 74

$\underbrace{9, 11, 12}_{\text{use nodal analysis}}$

P.3.2

a) formulate node-voltage eqns.
b) find v_x & i_x.



$i_x = \frac{1}{40} v_A$

$v_x = v_B$

(A) $-\frac{1}{40} v_A - \frac{1}{10} v_A - \frac{1}{8}(v_A - v_B) + 4A = 0$

$$\left(\frac{1}{40} + \frac{1}{10} + \frac{1}{8}\right) v_A - \frac{1}{8} v_B = 4$$

(B) $\frac{1}{8}(v_A - v_B) - \frac{1}{4} v_B - 4A + 2A = 0$

$$\frac{1}{8} v_A - \left(\frac{1}{8} + \frac{1}{4}\right) v_B = 2$$

$v_A = 16V$

$v_B = 0$

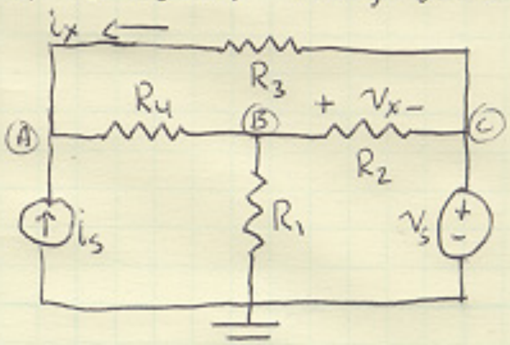
$\boxed{v_x = v_B = 0}$

$i_x = \frac{1}{40} v_A$

$\boxed{i_x = 2/5 A = 0.4 A}$

P.3.5

a) formulate node-voltage eqns.
b) find v_x & i_x for when $R_1 = R_2 = R_3 = R_4 = 10k\Omega$, $v_s = 20V$, $i_s = 2mA$



by inspection

$$\begin{array}{c} \\ (A) \\ (B) \\ (C) \end{array} \begin{array}{c} \quad (A) \qquad\qquad (B) \qquad\qquad (C) \\ \begin{bmatrix} \frac{1}{R_3} + \frac{1}{R_4} & -\frac{1}{R_4} & -\frac{1}{R_3} \\ -\frac{1}{R_4} & \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_4} & -\frac{1}{R_2} \\ -\frac{1}{R_3} & -\frac{1}{R_2} & \frac{1}{R_2} + \frac{1}{R_3} \end{bmatrix} \end{array} \begin{pmatrix} v_A \\ v_B \\ v_C \end{pmatrix} = \begin{bmatrix} i_s \\ 0 \\ 0 \end{bmatrix}$$

$v_C = v_s$

$$\begin{bmatrix} \frac{1}{R_3} + \frac{1}{R_4} & -\frac{1}{R_4} \\ -\frac{1}{R_4} & \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_4} \end{bmatrix} \begin{bmatrix} v_A \\ v_B \end{bmatrix} = \begin{bmatrix} i_s + \frac{1}{R_3} v_s \\ \frac{1}{R_2} v_s \end{bmatrix}$$

$v_A = 28V$

$v_B = 16V$

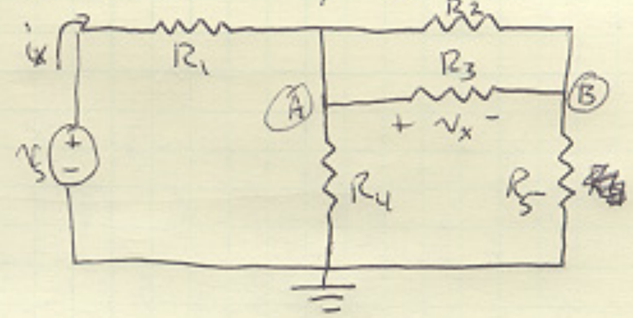
$v_x = v_B - v_s$

$\boxed{v_x = -4V}$

$i_x = \frac{1}{R_3}(v_C - v_A)$

$\boxed{i_x = -0.8 mA}$

P.3.6 a) formulate node-voltage eqns.
b) find v_x & i_x when $R_1 = R_2 = R_3 = R_4 = R_5 = 10k\Omega$, $V_s = 20V$



$$\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_4} & -\frac{1}{R_2}-\frac{1}{R_3} \\ -\frac{1}{R_2}-\frac{1}{R_3} & \frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_5} \end{bmatrix} \begin{bmatrix} v_A \\ v_B \end{bmatrix} = \begin{bmatrix} \frac{1}{R_1} v_s \\ 0 \end{bmatrix}$$

$v_A = 7.5\ V$

$v_B = 5\ V$

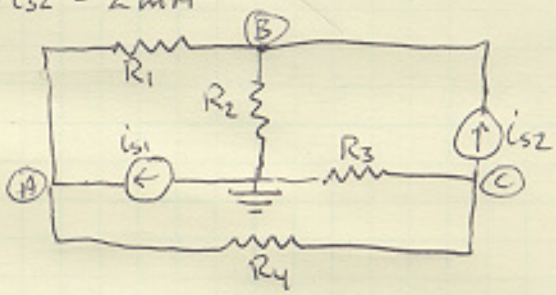
$v_x = v_A - v_B$

$\boxed{v_x = 2.5V}$

$i_x = \frac{1}{R_1}(v_s - v_A)$

$\boxed{i_x = 1.25\ mA}$

P.3.7 a) formulate node-voltage eqns.
b) solve for v_A, v_B & v_C when $R_1 = 1k\Omega$, $R_2 = 2k\Omega$, $R_3 = 4k\Omega$, $R_4 = 2k\Omega$ & $i_{s1} = i_{s2} = 2mA$



$$\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_4} & -\frac{1}{R_1} & -\frac{1}{R_4} \\ -\frac{1}{R_1} & \frac{1}{R_1}+\frac{1}{R_2} & 0 \\ -1/R_4 & 0 & \frac{1}{R_3}+\frac{1}{R_4} \end{bmatrix} \begin{bmatrix} v_A \\ v_B \\ v_C \end{bmatrix} = \begin{bmatrix} i_{s1} \\ i_{s2} \\ -i_{s2} \end{bmatrix}$$

$\boxed{v_A = 4V}$ $\boxed{v_B = 4V}$ $\boxed{v_C = 0V}$

P.3.9 a) formulate node-voltage eqns
b) find v_x & i_x

(A) $-\frac{1}{10}(v_A - 12V) - \frac{1}{10}(v_A - 8V) - \frac{1}{5} v_A = 0$

$\left(\frac{1}{10}+\frac{1}{10}+\frac{1}{5}\right) v_A = \frac{12}{10} + \frac{8}{10}$

$v_A = 5V$

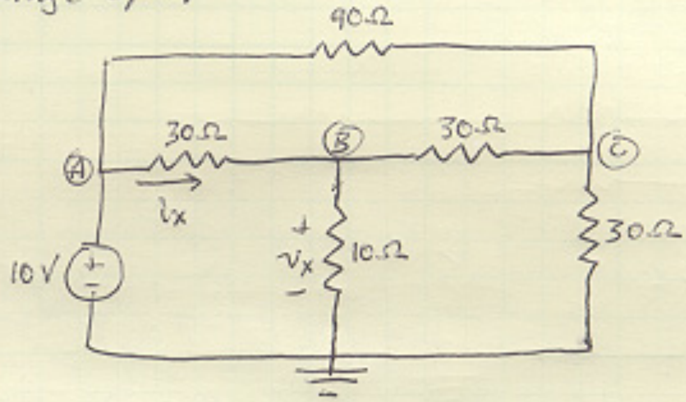
$v_x = v_A - 8V$

$\boxed{v_x = -3V}$

$i_x = \frac{1}{5k\Omega} v_A$

$\boxed{i_x = 1\,mA}$

P.3.11 a) formulate node-voltage eqns.
b) find v_x & i_x



$v_x = v_B$

$i_x = \frac{1}{30\Omega}(v_A - v_B)$

$$\begin{bmatrix} \frac{1}{30}+\frac{1}{90} & -\frac{1}{30} & -\frac{1}{90} \\ -\frac{1}{30} & \frac{1}{30}+\frac{1}{10}+\frac{1}{30} & -1/30 \\ -\frac{1}{90} & -\frac{1}{30} & \frac{1}{90}+\frac{1}{30}+\frac{1}{30} \end{bmatrix} \begin{bmatrix} v_A \\ v_B \\ v_C \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$v_A = 10V$$

$$\begin{bmatrix} \frac{1}{30}+\frac{1}{10}+\frac{1}{30} & -1/30 \\ -1/30 & \frac{1}{90}+\frac{1}{30}+\frac{1}{30} \end{bmatrix} \begin{bmatrix} v_B \\ v_C \end{bmatrix} = \begin{bmatrix} \frac{1}{30}v_A \\ \frac{1}{90}v_A \end{bmatrix}$$

$v_B = 2.5\,V$

$v_C = 2.5\,V$

$v_x = v_B$

$\boxed{v_x = 2.5\,V}$

$i_x = \frac{1}{30\Omega}(v_A - v_B)$

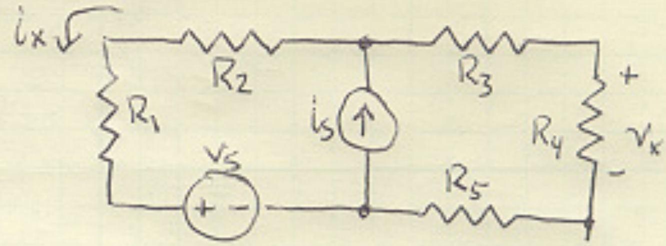
$\boxed{i_x = 1/4\,A = 0.25\,A}$

P.3.12

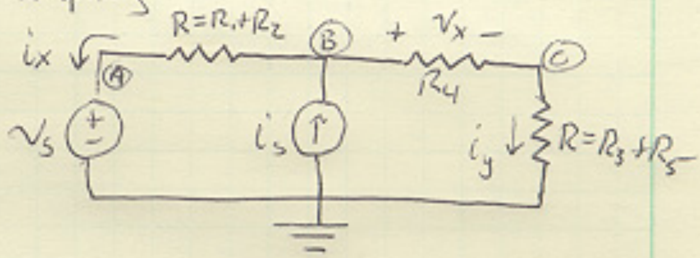
a) formulate node voltage eqns.

b) find v_x & i_x when $R_1 = 200\Omega$, $R_2 = 300\Omega$, $R_3 = 50\Omega$, $R_4 = 250\Omega$, $R_5 = 200\Omega$, $i_s = 50mA$, & $v_s = 15V$

c) find the total power dissipated in the circuit



simplify



$$\begin{bmatrix} \frac{1}{R_1+R_2} & -\frac{1}{R_1+R_2} & 0 \\ -\frac{1}{R_1+R_2} & \frac{1}{R_1+R_2}+\frac{1}{R_4} & -\frac{1}{R_4} \\ 0 & -\frac{1}{R_4} & \frac{1}{R_4}+\frac{1}{R_3+R_5} \end{bmatrix} \begin{pmatrix} v_A \\ v_B \\ v_C \end{pmatrix} = \begin{pmatrix} 0 \\ i_s \\ 0 \end{pmatrix}$$

$$v_A = v_s$$

$$\begin{bmatrix} \frac{1}{R_1+R_2}+\frac{1}{R_4} & -\frac{1}{R_4} \\ -\frac{1}{R_4} & \frac{1}{R_4}+\frac{1}{R_3+R_5} \end{bmatrix} \begin{bmatrix} v_B \\ v_C \end{bmatrix} = \begin{bmatrix} \frac{v_s}{R_1+R_2}+i_s \\ 0 \end{bmatrix}$$

$$v_A = 15V, \quad v_B = 20V, \quad v_C = 10V$$

$$v_x = v_B - v_C \qquad i_x = \frac{1}{R_1+R_2}(v_B - v_A)$$

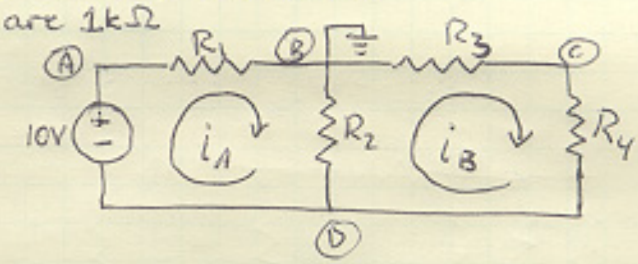
$$\boxed{v_x = 10V} \qquad \boxed{i_x = 10mA}$$

$$i_y = \frac{1}{R_4} v_x = 40mA$$

$$P = i_x^2(R_1+R_2) + i_y^2(R_3+R_4+R_5) + v_s i_x$$

$$\boxed{P = 1W}$$

$\boxed{P.3.17}$ When node B is grounded $v_C = -2V$.
Find node voltages v_A & v_D & mesh currents i_A & i_B when all resistors are $1k\Omega$



$$v_A - v_D = 10V$$

node C

$$i_4 - i_3 = 0$$

$$\frac{1}{R_4}(v_D - v_C) - \frac{1}{R_3}v_C = 0$$

$$\boxed{v_D = -4V}$$

$$v_A = 10V + v_D$$

$$\boxed{v_A = 6V}$$

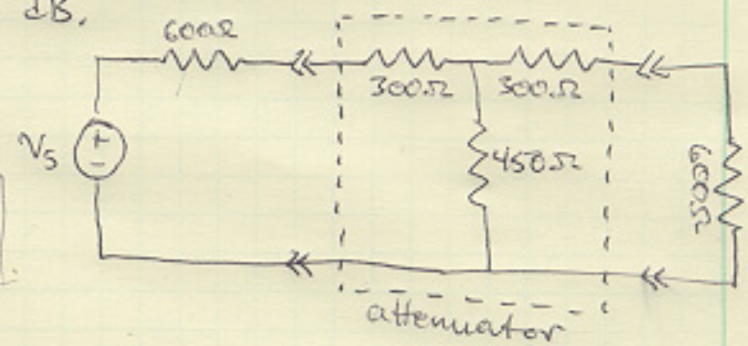
$$i_A = \frac{1}{R_1}(v_A - v_B)$$

$$\boxed{i_A = 6mA}$$

$$i_B = \frac{1}{R_3}(v_B - v_C)$$

$$\boxed{i_B = 2mA}$$

$\boxed{P.3.72}$ Find the power delivered to the load with & with out the attenuator. By what fraction does the ~~power~~ attenuator reduce the power delivered to the load? Express the fraction in dB.



w/out attenuator

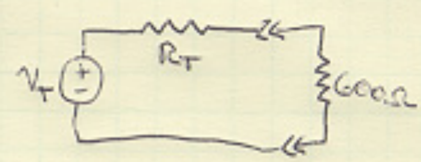
$$v_L = \frac{600}{600+600} v_s = \frac{v_s}{2}$$

$$P = \frac{v_L^2}{R_L} = \left(\frac{v_s}{2}\right)^2 \frac{1}{600} = \boxed{\frac{v_s^2}{2400} W}$$

w/attenuator

$$v_T = \frac{450}{600+300+450} v_s = \frac{v_s}{3}$$

$$R_T = 300 + \frac{450(600+300)}{450+600+300} = 600\Omega$$



Thevenin equiv. to attenuator circuit

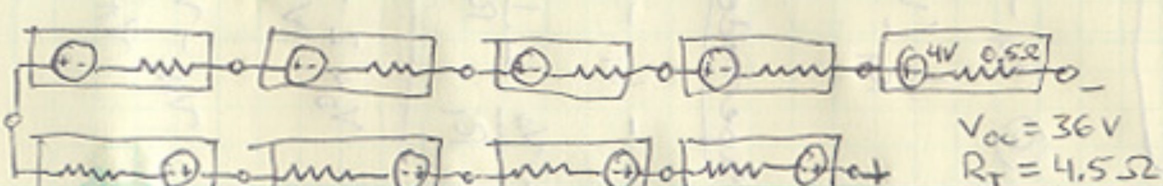
$$v_L = \frac{600}{600+600} v_T = \frac{v_s}{6}$$

$$P = \frac{v_L^2}{R_L} = \left(\frac{v_s}{6}\right)^2 \frac{1}{600} = \boxed{\frac{v_s^2}{21600} W}$$

$$\boxed{\frac{P_{w/o}}{P_{w/}} = \frac{1}{9}}$$

$$10 * \log\left[\frac{P}{P}\right] = 9.54 \text{ dB}$$

$\boxed{P.3.74}$



$V_{oc} = 36V$

$R_T = 4.5\Omega$

$m = 135g$