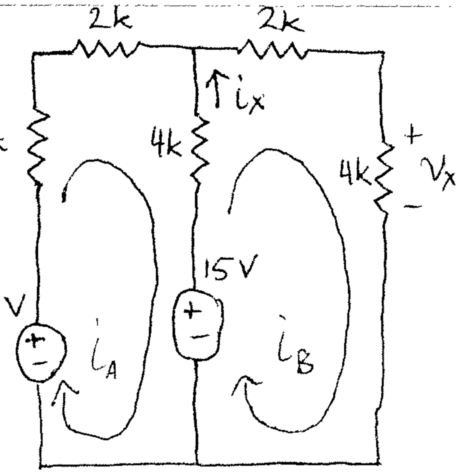
3.10

a) form mesh eqns



$$\begin{bmatrix} 2000+2000+4000 & -4000 \\ -4000 & 4000+2000+4000 \end{bmatrix} \begin{bmatrix} i_A \\ i_B \end{bmatrix} = \begin{bmatrix} 5-15 \\ 15 \end{bmatrix}$$

b) find i_x & V_x

$i_A = -0.625\ mA$

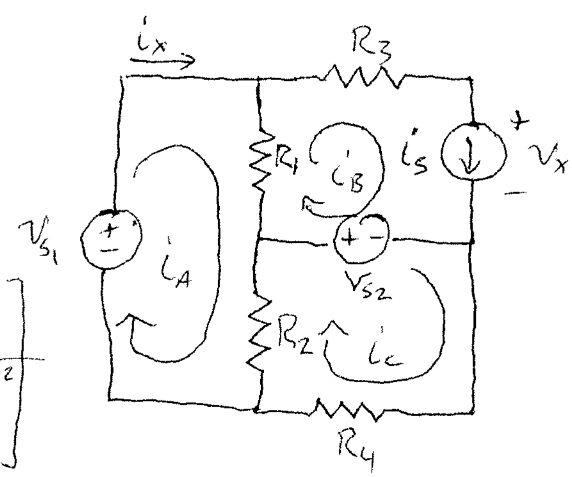
$i_B = 1.25\ mA$

$i_x = i_B - i_A = \boxed{1.875\ mA}$

$V_x = i_B \cdot 4k\Omega = \boxed{5\ V}$

3.13

a) form mesh eqns



$i_B = i_s$

$$\begin{bmatrix} R_1+R_2 & -R_1 & -R_2 \\ \sout{-R_1} & \sout{R_1+R_3} & \sout{0} \\ -R_2 & 0 & R_2+R_4 \end{bmatrix} \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix} = \begin{bmatrix} V_{S1} \\ \sout{V_x + V_{S2}} \\ -V_{S2} \end{bmatrix}$$

$$\begin{bmatrix} R_1+R_2 & -R_2 \\ -R_2 & R_2+R_4 \end{bmatrix} \begin{bmatrix} i_A \\ i_C \end{bmatrix} = \begin{bmatrix} V_{S1} + i_s R_1 \\ -V_{S2} \end{bmatrix}$$

b) solve for i_x & V_x when $R_1 = 10\ k\Omega$, $R_2 = 10\ k\Omega$, $R_3 = 2\ k\Omega$, $R_4 = 1\ k\Omega$, $V_{S_1} = 12\ V$, $V_{S2} = 0.5\ V$, $i_s = 2.5\ mA$

$i_A = 3.35\ mA$

$i_B = 2.5\ mA$

$i_C = 3\ mA$

$\boxed{i_x = i_A = 3.35\ mA}$

KVL for loop B

$-V_{S2} + V_{R_1} + V_{R_3} + V_x = 0$

$V_x = V_{S2} - (10k\Omega)(i_B - i_A) - (2k\Omega)\, i_B$

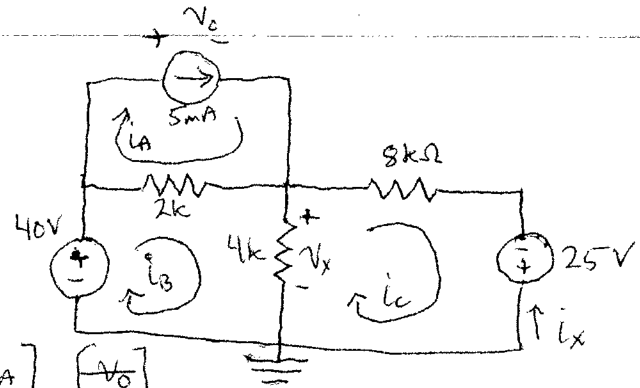
$\boxed{V_x = 4V}$

c) find power supplied by V_{S_1}

$P = i_A \cdot (-V_{S_1}) = \boxed{-40.2\ mW}$

3.15

a) form mesh eqns.



$i_A = 5mA$

$$\begin{bmatrix} \sout{2000} & \sout{-2000} & \sout{0} \\ -2000 & 2000+4000 & -4000 \\ 0 & -4000 & 4000+2000 \end{bmatrix} \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix} = \begin{bmatrix} \sout{v_0} \\ 40 \\ 25 \end{bmatrix}$$

$$\begin{bmatrix} 6000 & -4000 \\ -4000 & 12000 \end{bmatrix} \begin{bmatrix} i_B \\ i_C \end{bmatrix} = \begin{bmatrix} 40 + 2000\, i_A \\ 25 \end{bmatrix}$$

b) solve for i_x & v_x

$i_B = 12.5\,mA$

$i_C = 6.25\,mA$

$i_x = -i_C = \boxed{-6.25\,mA}$

$v_x = 4k\Omega\,(i_B - i_C) = \boxed{25V}$

c) find the total power delivered to the resistors

$P_R = (2k\Omega)(i_A - i_B)^2 + (4k\Omega)(i_B - i_C)^2 + (8k\Omega)(i_C)^2$

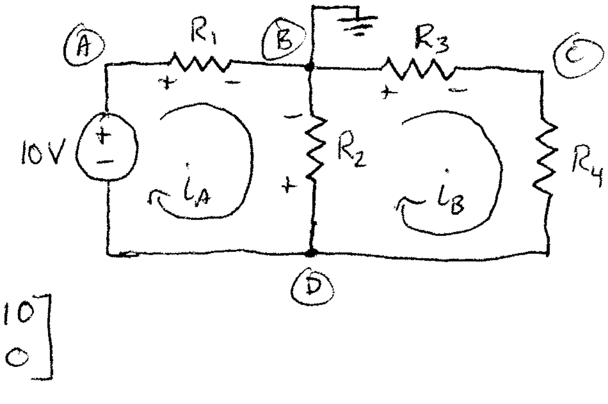
$= \boxed{581\,mW}$

3.17 Find node voltages v_A & v_D, & mesh currents i_A & i_B

$v_C = -2V$

$v_B = 0V$

$R_1 = R_2 = R_3 = R_4 = 1k\Omega$



mesh eqns

$$\begin{bmatrix} 2000 & -1000 \\ -1000 & 3000 \end{bmatrix} \begin{bmatrix} i_A \\ i_B \end{bmatrix} = \begin{bmatrix} 10 \\ 0 \end{bmatrix}$$

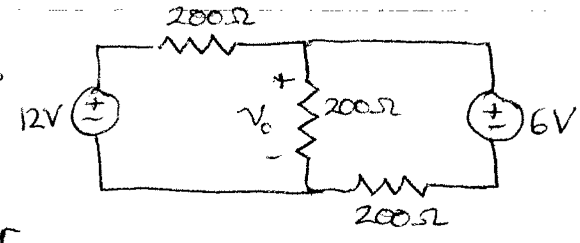
$$\boxed{\begin{aligned} i_A &= 6mA \\ i_B &= 2mA \end{aligned}}$$

$v_A = R_1 i_A = \boxed{6V}$

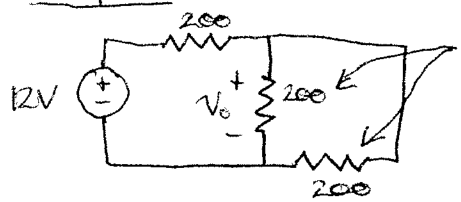
$v_D = R_2 (i_B - i_A) = \boxed{-4V}$

confirm $v_A - v_D = 10V$

3.26 use superposition to find v_o



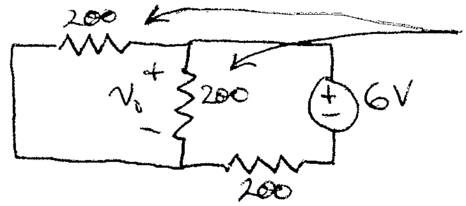
step 1



add in parallel
voltage divider

$$v_o = \frac{100}{300} \cdot 12V = 4V$$

step 2



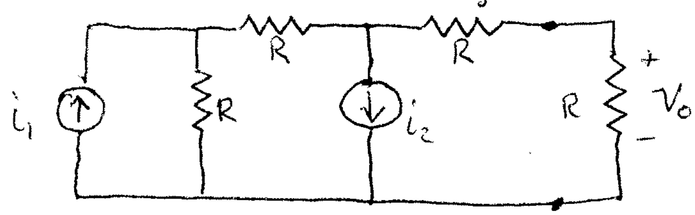
add in parallel
voltage divider

$$v_o = \frac{100}{300} \cdot 6V = 2V$$

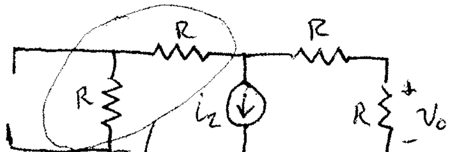
total

$$v_o = 4V + 2V = \boxed{6V}$$

3.31 use superposition to find v_o in terms of i_1, i_2 & R

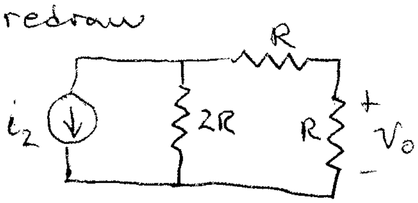


step 1

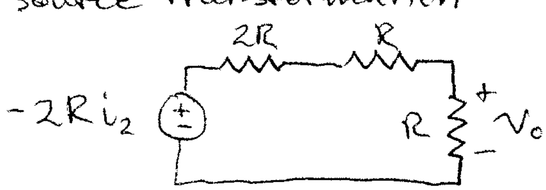


add in series

redraw



source transformation

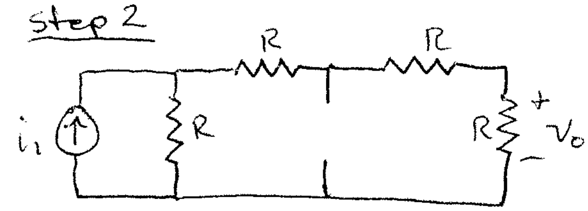


voltage divider

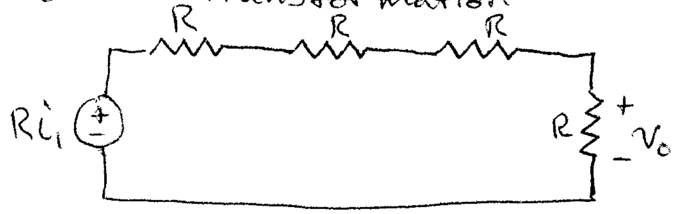
$$v_o = -\frac{R}{4R} \cdot (2Ri_2) = -\frac{Ri_2}{2}$$

3.31 continued

Step 2



source transformation



voltage divider

$$v_o = \frac{R}{4R} \cdot i_1 R = \frac{i_1 R}{4}$$

total

$$v_o = \frac{i_1 R}{4} - \frac{i_2 R}{2}$$

$$\boxed{v_o = \frac{R}{4}(i_1 - 2i_2)}$$

3.32

Can't be sure without looking at the circuit as a whole.

The answer is not 4.25 W because the power is a product of linear terms, making it non-linear. Therefore superposition does not hold for power.

$i_1 = \sqrt{(250\,mW)/(100\,\Omega)} = 0.05\,A$

$i_2 = \sqrt{(4\,W)/(100\,\Omega)} = 0.2\,A$

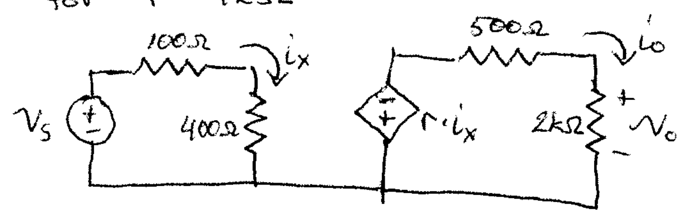
If the currents flow in the same direction through the wire

$$P = (0.2A + 0.05A)^2(100\,\Omega) = 6.25\,W$$

if they oppose one another

$$P = (0.2A - 0.05A)^2(100\,\Omega) = 2.25\,W$$

4.1 find v_o/v_s & i_o/i_x for $r = 4k\Omega$



KVL

$$i_x = \frac{v_s}{100\Omega + 400\Omega}$$

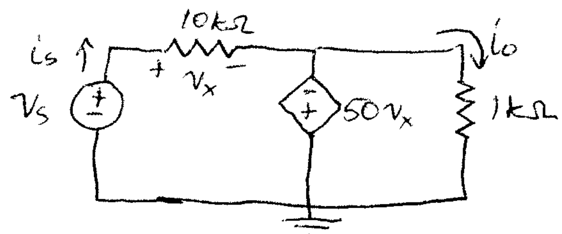
$$i_o = -\frac{r \cdot i_x}{500\Omega + 2k\Omega} = -\frac{40}{25} i_x = -\frac{8}{5} i_x$$

voltage divider

$$v_o = -\frac{2000\Omega}{500\Omega + 2k\Omega} \cdot r i_x = -\frac{2000}{2500} \cdot \frac{4000}{500} v_s = -\frac{32}{5} v_s$$

$$\boxed{\frac{v_o}{v_s} = -\frac{32}{5} = -6.4 \qquad \frac{i_o}{i_x} = -\frac{8}{5} = -1.6}$$

4.5 find i_o/i_s



$$i_o = -\frac{50 v_x}{1000}$$

$$v_x = v_s - (-50 v_x)$$

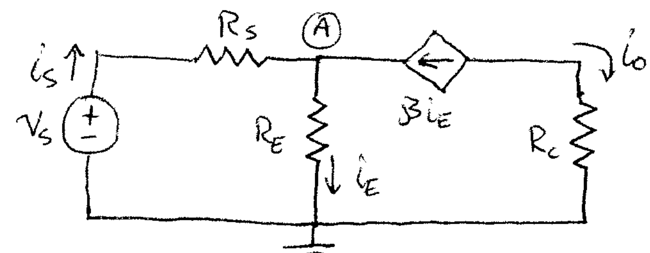
$$v_x = -\frac{v_s}{49}$$

$$i_s = \frac{v_x}{10k\Omega} = -\frac{1}{49} \frac{v_s}{10k\Omega}$$

$$i_o = \frac{50}{1000} \frac{v_s}{49}$$

$$\boxed{\frac{i_o}{i_s} = -500}$$

4.6 find i_o/i_s



KCL

$$i_o = -\beta i_E$$

@ (A)

$$i_E = \beta i_E + i_s$$

$$i_E = \frac{i_s}{(1-\beta)}$$

$$\therefore \quad i_o = -\frac{\beta i_s}{(1-\beta)}$$

$$\boxed{\frac{i_o}{i_s} = -\frac{\beta}{(1-\beta)}}$$