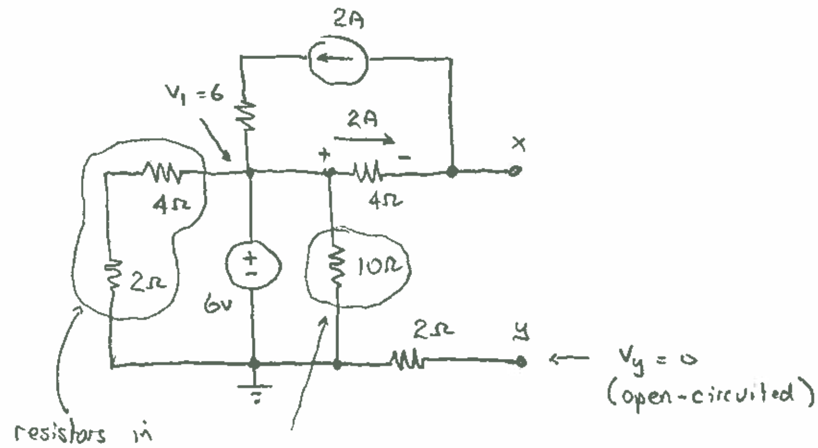
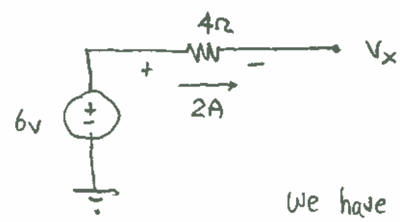
Question 1

(a)



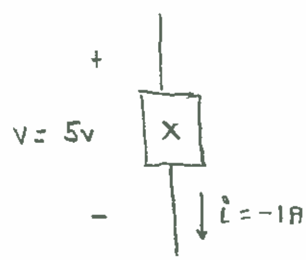
With terminals x and y open-circuited in this way, $V_y = 0$, and V_x is determined by the following key circuit elements.



We have $V_x = 6 - 2 \times 4 = -2$

so $\boxed{V_{xy} = -2v}$

(b)

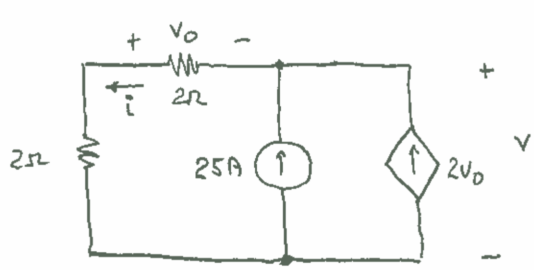


By the passive reference convention,

$P_x = Vi = 5(-1)$

$\boxed{P_x = -5W}$ (so delivering 5W of power)

(c)



We have

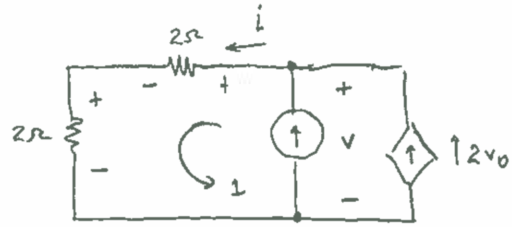
$i = 25 + 2V_o$

and $V_o = -2i$

Combining these two equations, $V_o = -2(25 + 2V_o)$
$= -50 - 4V_o$

so $5V_o = -50$ $\therefore$ $V_o = -10\,V$

We now have



$i = 25 + 2V_o$
$= 25 + 2(-10)$
$= 5\,A$

KVL around loop 1 gives us $-V + 2i + 2i = 0$
$V = 4i$
$V = 20\,W$

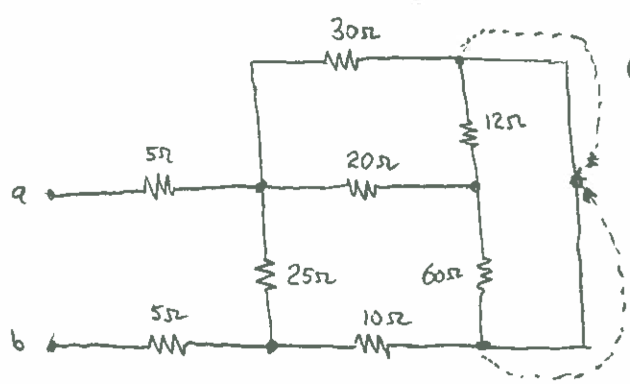
Therefore, the power in the dependent source P_{2vo} is

$P_{2vo} = -(2V_o)V$ by passive reference convention

$= -(-20)(20) = +400\,W$

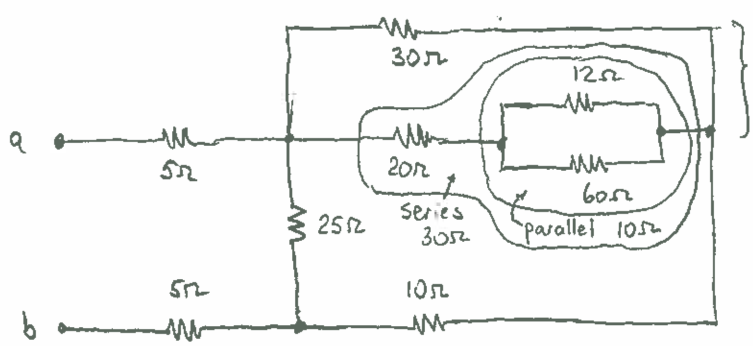
$$\boxed{P_{2v_o} = 400\,W \text{ (absorbing)}}$$

(d)



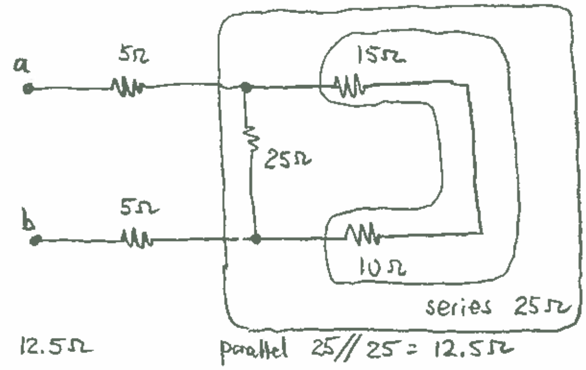
move these connection points

Redraw



parallel
$30\Omega // 30\Omega$
$= 15\Omega$

Simplify

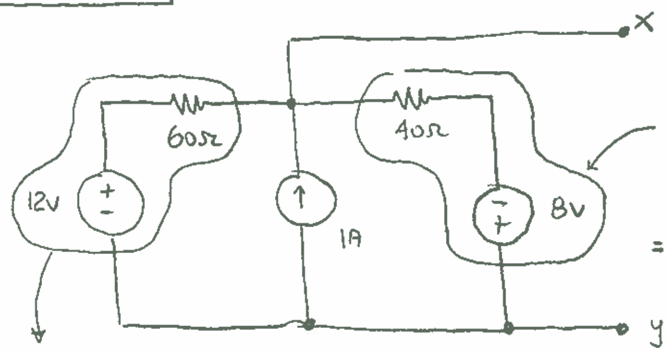


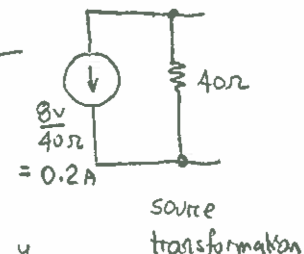
Finally,

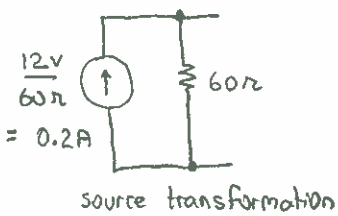
$R_{eq} = 5\Omega + 5\Omega + 12.5\Omega$

$$\boxed{R_{eq} = 22.5\,\Omega}$$

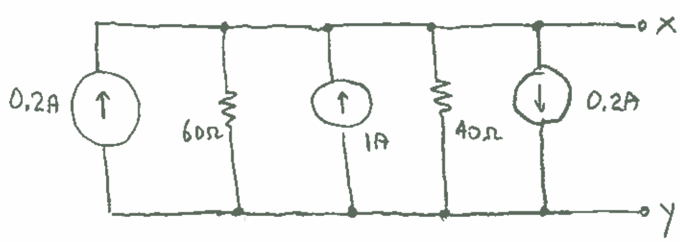
(e)







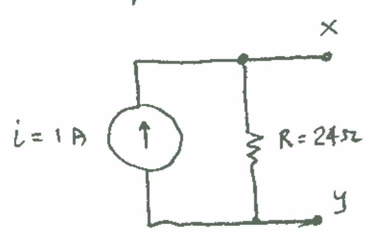
Redrawing



Current sources in parallel add:

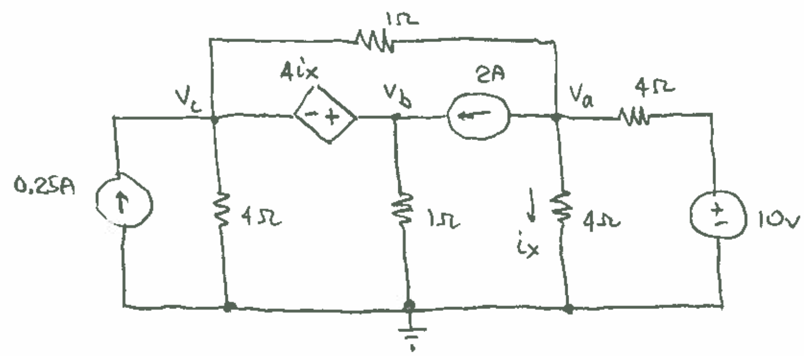
$0.2 + 1 - 0.2 = 1\text{A}$

Resistors in parallel: $\frac{60 \times 40}{60 + 40} = 24\Omega$



Question 2

(a) Setting up for node-voltage method



Node a : $\frac{V_a - 10}{4} + \frac{V_a}{4} + \frac{V_a - V_c}{1} + 2 = 0$

$$V_a - 10 + V_a + 4V_a - 4V_c + 8 = 0$$

$$6V_a - 4V_c = 2 \qquad (1)$$

Supernode bc : $\frac{V_c}{4} - 0.25 + \frac{V_c - V_a}{1} + \frac{V_b}{1} - 2 = 0$

$$V_c - 1 + 4V_c - 4V_a + 4V_b - 8 = 0$$

$$-4V_a + 4V_b + 5V_c = 9 \qquad (2)$$

Supernode dependence : $V_b - V_c = 4i_x$ and $i_x = \frac{V_a}{4}$

so $V_b - V_c = 4\frac{V_a}{4} = V_a$

$$-V_a + V_b - V_c = 0 \qquad (3)$$

Solve for 3 unknowns, 3 equations

Subtract 4 times equation (3) from (2)

$$\begin{array}{rl} (2) & -4V_a + 4V_b + 5V_c = 9 \\ -\ 4 \times (3) & \underline{-4V_a + 4V_b - 4V_c = 0} \end{array}$$

$= 9V_c = 9$, so $\boxed{V_c = 1.}$

From (1), $6V_a - 4(1) = 2$

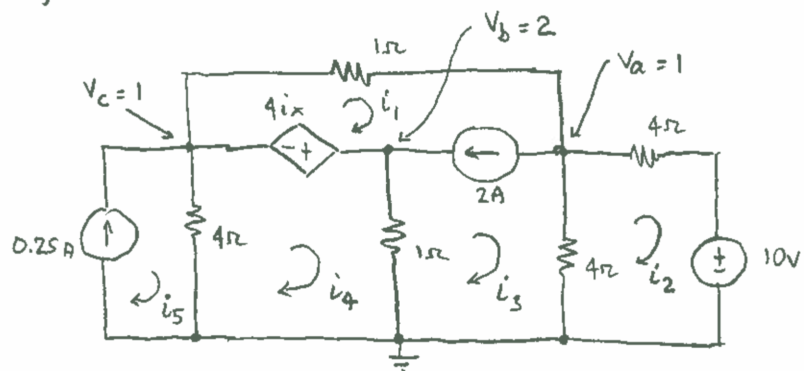
$6V_a = 6$

so $\boxed{V_a = 1}$

and from (3), $-1 + V_b - 1 = 0$

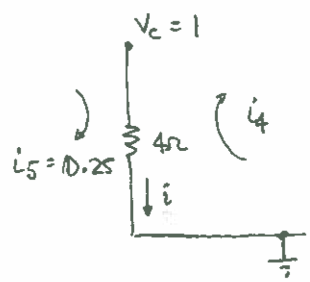
so $\boxed{V_b = 2}$

(b) Any method will do.



Clearly, $i_5 = 0.25$ A. By far the easiest method is to relate branch currents and mesh currents

E.g.,



branch current $i = \frac{V_c}{4} = 0.25$ A

mesh currents $i_5 - i_4 = i$

so $\boxed{i_4 = 0 \text{ A.}}$

Similarly, $i_4 - i_3 = \frac{V_b}{1\Omega}$, so $\boxed{i_3 = -\frac{V_b}{1} = -2A}$

And, $i_3 - i_2 = \frac{V_a}{4}$, so $i_2 = i_3 - \frac{V_a}{4} = -2 - \frac{1}{4}$

$\boxed{i_2 = -2.25 \text{ A}}$

Finally, using the supermesh dependence: $i_1 - i_3 = 2$

$i_1 = 2 + i_3$

$$\boxed{\begin{aligned} i_1 &= 2 + -2 \\ &= 0 \end{aligned}}$$

Alternate (<u>labour-intensive</u>) solution to part (b)!

As before, by inspection $i_5 = 0.25$

<u>Mesh i_4</u>:

$$4(i_4 - i_5) - 4i_x + 1(i_4 - i_3) = 0$$
$$4i_4 - 4i_5 - 4i_x + i_4 - i_3 = 0$$

$$4i_4 - 4(0.25) - 4i_x + i_4 - i_3 = 0$$
$$4i_4 - 1 - 4i_x + i_4 - i_3 = 0$$

$$5i_4 - i_3 - 4i_x = 1$$

And: $i_x = i_3 - i_2$

$$5i_4 - i_3 - 4(i_3 - i_2) = 1$$
$$5i_4 - i_3 - 4i_3 + 4i_2 = 1$$

$$4i_2 - 5i_3 + 5i_4 = 1 \qquad (1)$$

<u>Supermesh</u> $i_1 i_3$:

$$1 \times i_1 + 4(i_3 - i_2) + 1 \times (i_3 - i_4) + 4i_x = 0$$
$$i_1 + 4i_3 - 4i_2 + i_3 - i_4 + 4i_x = 0$$

$$i_1 - 4i_2 + 5i_3 - i_4 + 4i_x = 0$$

And: $i_x = i_3 - i_2$

$$i_1 - 4i_2 + 5i_3 - i_4 + 4(i_3 - i_2) = 0$$
$$i_1 - 4i_2 + 6i_3 - i_4 + 4i_3 - 4i_2 = 0$$

$$i_1 - 8i_2 + 9i_3 - i_4 = 0 \qquad (2)$$

<u>Supermesh dependence</u>: $i_1 - i_3 = 2 \qquad (3)$

<u>Mesh i_2</u>: $4(i_2 - i_3) + 4i_2 + 10 = 0$

$$8i_2 - 4i_3 = -10 \qquad (4)$$

Solve for 4 unknowns and 4 equations:

$$\begin{array}{lr}
4i_2 - 5i_3 + 5i_4 = 1 & (1) \\
i_1 - 8i_2 + 9i_3 - i_4 = 0 & (2) \\
i_1 - i_3 = 2 & (3) \\
8i_2 - 4i_3 = -10 & (4)
\end{array}$$

Add (2) and (4)

$$\begin{array}{rl} & i_1 - 8i_2 + 9i_3 - i_4 = 0 \\ + & \quad\;\; 8i_2 - 4i_3 \qquad\;\; = -10 \\ \hline = & i_1 + 5i_3 - i_4 = -10 \end{array} \qquad (5)$$

From (3), $i_1 = i_3 + 2$, so (5) becomes

$$i_3 + 2 + 5i_3 - i_4 = -10$$

$$6i_3 - i_4 = -12 \qquad (6)$$

From (4), $8i_2 = 4i_3 - 10$, so $i_2 = \frac{1}{8}(4i_3 - 10)$. Substitute into (1),

$$\frac{1}{2}(4i_3 - 10) - 5i_3 + 5i_4 = 1$$
$$4i_3 - 10 - 10i_3 + 10i_4 = 2$$
$$-6i_3 + 10i_4 = 12 \qquad (7)$$

From (6), $i_4 = 12 + 6i_3$, so using (7)

$$-6i_3 + 10(12 + 6i_3) = 12$$
$$-6i_3 + 120 + 60i_3 = 12$$
$$54i_3 = -108 \qquad \boxed{i_3 = -2\text{ A}}$$

Then, $\boxed{\begin{aligned} i_4 &= 12 + 6i_3 \\ &= 0\text{ A} \end{aligned}}$

From (4),

$$8i_2 - 4i_3 = -10$$
$$8i_2 - 4(-2) = -10$$
$$8i_2 + 8 = -10$$
$$8i_2 = -18, \qquad \boxed{i_2 = -2.25\text{ A}}$$

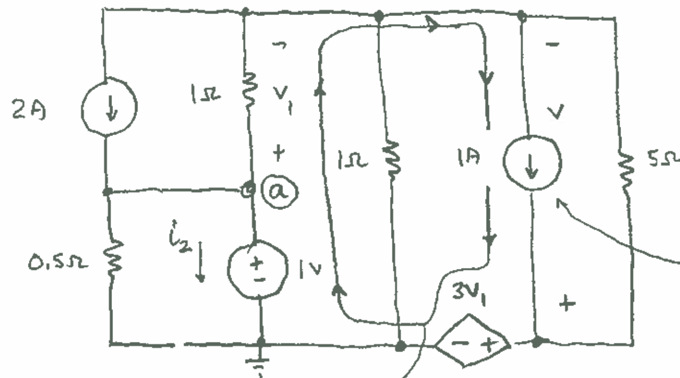
From (3),

$$i_1 - i_3 = 2$$
$$i_1 = i_3 + 2, \qquad \boxed{i = 0\text{ A}}$$

GAH!

Question 3

(a) With the load circuit attached



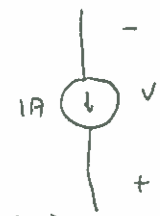
This is delivering 5 W of power, so $p = -5\text{W}$

KVL around this loop gives

$$-V + 3V_1 - 1 + V_1 = 0$$
$$-5 + 3V_1 - 1 + V_1 = 0$$
$$4V_1 = 6$$

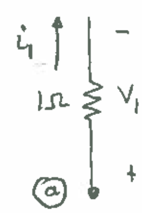
$$\therefore \boxed{V_1 = 1.5\text{ V}}$$

This implies the voltage polarity indicated $\longrightarrow$



$$V = \frac{-p}{i} = \frac{-(-5)}{1\text{A}} = 5\text{V}.$$

Node equation at a: $\frac{V_a}{0.5} - 2 + i_2 + i_1 = 0$



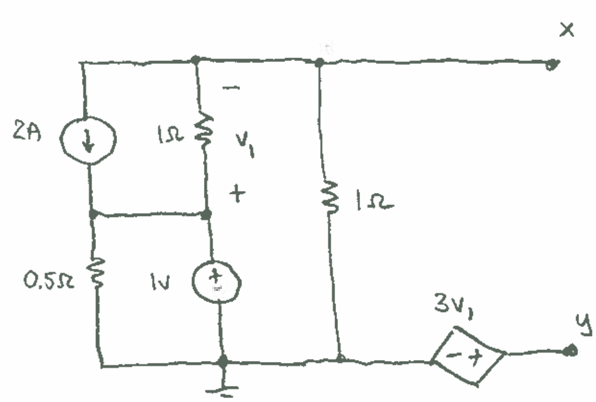
With $V_a = 1$, $V_1 = 1.5$, $\frac{1}{0.5} - 2 + i_2 + V_1 = 0$

where $i_1 = \frac{V_1}{1\Omega} = 1.5$

$$2 - 2 + i_2 + 1.5 = 0$$

$$\therefore \boxed{i_2 = -1.5\text{A}}$$

(b) With the load disconnected,



Thevenin voltage: Only one node equation required

Node x: $\frac{V_x}{1} + \frac{V_x - 1}{1} + 2 = 0$

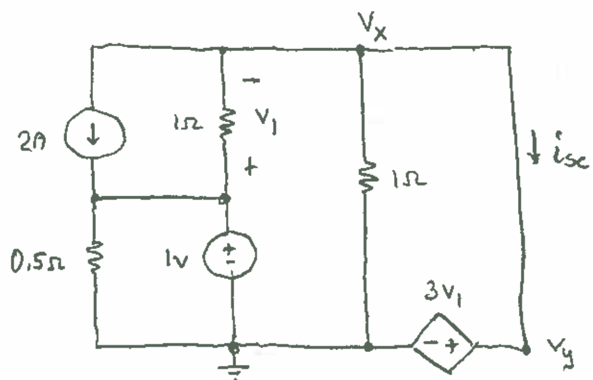
$$V_x + V_x - 1 + 2 = 0$$
$$2V_x = -1$$
$$V_x = -0.5$$

We also know $V_1 = 1 - V_x = 1.5\text{ v}$

Hence, $V_y = 3V_1 = 4.5\text{v}$

and $\boxed{V_t = V_{oc} = V_x - V_y = -5\text{v}}$

Now, need i_{sc}



We now have $V_x = V_y = 3V_1$

At node x: $\frac{V_x}{1} + \frac{V_x - 1}{1} + 2 + i_{sc} = 0$ (1)

where $V_x = 3V_1$

We know $V_1 = 1 - V_x$, so

$$V_x = 3(1 - V_x)$$
$$= 3 - 3V_x$$

$4V_x = 3$, so $V_x = \frac{3}{4}$

Substitute into (1): $\frac{3}{4} + \left(\frac{3}{4} - 1\right) + 2 + i_{sc} = 0$

$\frac{1}{2} + 2 = -i_{sc}$, so $i_{sc} = -2.5\text{ A}$

Finally, $R_t = \dfrac{V_t}{i_{sc}} = \dfrac{-5}{-2.5} = 2\Omega$