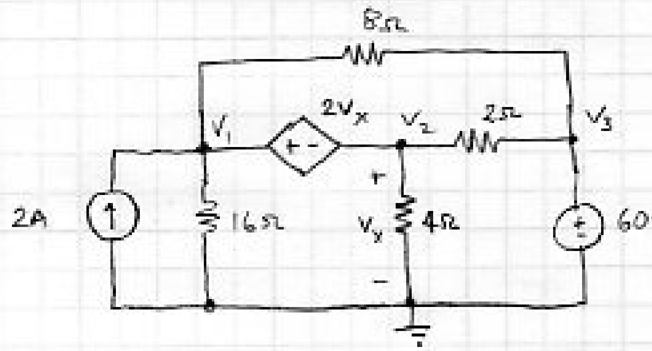
Question 1

(a)



Solving for node voltages, so set up the node-voltage method.

Node V_3 : $V_3 = 60$

Supernode V_1/V_2 : $-2 + \frac{V_1}{16} + \frac{V_1 - V_3}{8} + \frac{V_2}{4} + \frac{V_2 - V_3}{2} = 0$

or $-32 + V_1 + 2V_1 - 2V_3 + 4V_2 + 8V_2 - 8V_3 = 0$

so $3V_1 + 12V_2 - 10V_3 = 32$

Substitute $V_3 = 60$ and this simplifies to

$$3V_1 + 12V_2 - 600 = 32$$
$$3V_1 + 12V_2 = 632 \qquad (1)$$

Within the supernode :

$$V_1 - V_2 = 2V_x \text{ , where } V_x = V_2$$

$$V_1 - V_2 = 2V_2$$
$$V_1 = 3V_2 \qquad (2)$$

Substitute (2) into (1)

$$9V_2 + 12V_2 = 632$$
$$21V_2 = 632$$

so $V_2 = 30.1$ v

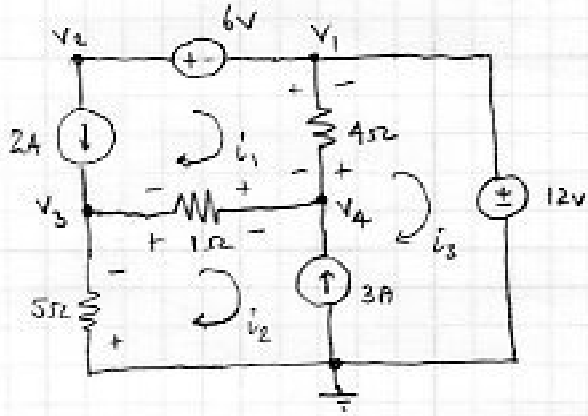
and from (2), $V_1 = 90.3$ v

(b) Using the passive reference convention for power

$$p = -2V_1 = -180.6 \text{ W}$$

Question 2

(a)



Solving for mesh currents, so set up for the mesh-current method

Loop 1: $i_1 = -2A$

Supermesh i_2/i_3: $5i_2 + (i_2 - i_1) + 4(i_3 - i_1) + 12 = 0$

$$6i_2 - 5i_1 + 4i_3 = -12$$

Substitute $i_1 = -2$

$$6i_2 + 10 + 4i_3 = -12$$

$$6i_2 + 4i_3 = -22 \quad (1)$$

And within the supermesh

$$i_3 - i_2 = 3$$

$$i_3 = 3 + i_2 \quad (2)$$

Substitute (2) into (1)

$$6i_2 + 4(3 + i_2) = -22$$

$$6i_2 + 12 + 4i_2 = -22$$

$$10i_2 = -34$$

$$i_2 = -3.4\ A$$

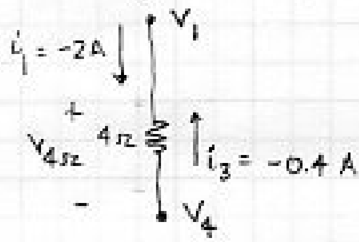
and substitute back into (2)

$$i_3 = 3 + (-3.4) = -0.4\ A$$

(b) Note that $V_1 = 12v$.
Note also that node V_2 is simply 6 volts <u>higher</u> than V_1, since the two nodes are joined by a voltage source.

$$V_1 = 12$$
$$V_2 = 18$$

At node V_4,



↓ branch current $i = i_1 - i_2$
$= -2 - (-0.4)$
$= -1.6$ A

so $V_{4\Omega}$ as shown $= i \times 4\Omega = -6.4v$

Therefore, $V_1 - V_4 = V_{4\Omega} = -6.4v$

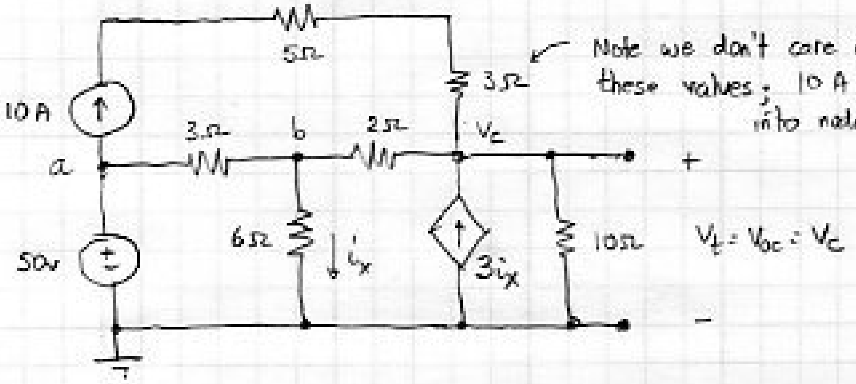
$$12 - V_4 = -6.4$$
$$V_4 = 12 + 6.4 = 18.4v$$

At node V_3, use loop i_2 (easiest)

$$V_3 = -i_2 \times 5$$
$$= -(-3.4) \times 5$$
$$= 17v$$

Question 3

(a) Let's begin with the Thevenin voltage $V_t = V_{oc}$.



Note we don't care about these values; 10 A flows into node c anyway!

Setting up for the node-voltage method.

Node a: $V_a = 50v$

Node b: $\frac{V_b - V_a}{3} + \frac{V_b}{6} + \frac{V_b - V_c}{2} = 0$

$2V_b - 2V_a + V_b + 3V_b - 3V_c = 0$

$-2a + 6V_b - 3V_c = 0$ (1)

Node c: $-10 - 3i_x + \frac{V_c - V_b}{2} + \frac{V_c}{10} = 0$

$\longrightarrow$ note that $i_x = \frac{V_b}{6}$, so

$-10 - 0.5V_b + \frac{V_c - V_b}{2} + \frac{V_c}{10} = 0$

$-100 - 5V_b + 5V_c - 5V_b + V_c = 0$

$-10V_b + 6V_c = 100$ (2)

From (1) with $V_a = 50$,

$-100 + 6V_b - 3V_c = 0$

$6V_b - 3V_c = 100$ (3)

From (2), $V_b = \frac{100 - 6V_c}{-10} = 0.6V_c - 10$

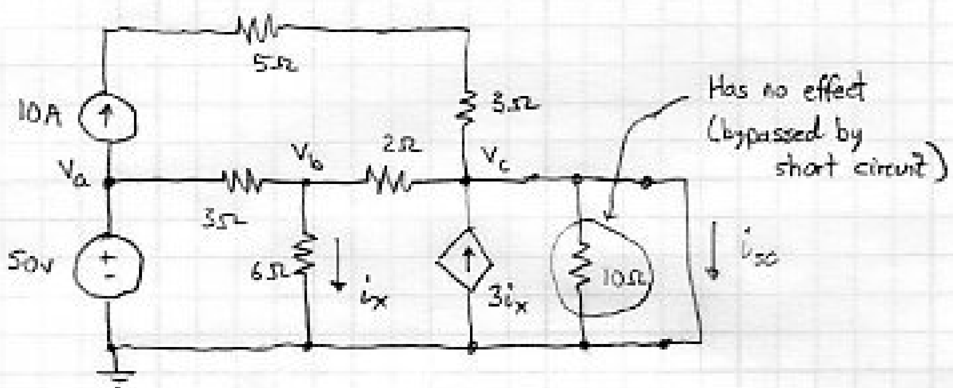
Substitute into (3)

$$6\left(0.6V_c - 10\right) - 3V_c = 100$$
$$3.6V_c - 60 - 3V_c = 100$$

$$0.6V_c = 160$$

Hence, $V_c = \frac{160}{0.6} = \boxed{266.67}$ THEVENIN VOLTAGE V_t

Next find R_t. Unfortunately, no short-cuts thanks to the dependent source.



Node voltage method.

Node a: $V_a = 50$, as before

Node b: $\frac{V_b - V_a}{3} + \frac{V_b}{6} + \frac{V_b - V_c}{2} = 0$

⟶ We know $V_a = 50$ and $V_c = 0$ (thanks to short circuit)

$$\frac{V_b - 50}{3} + \frac{V_b}{6} + \frac{V_b}{2} = 0$$
$$2V_b - 100 + V_b + 3V_b = 0$$
$$6V_b = 100$$

so $V_b = 16.67$ V

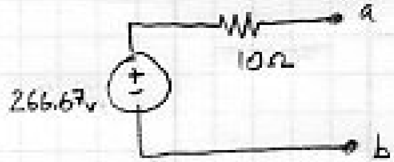
Node c: $-10 - 3i_x + \frac{\cancel{V_c}^{0} - V_b}{2} + \cancel{\frac{V_c}{10}}^{0} + i_{sc} = 0$

$$-10 - 0.5V_b - 0.5V_b + i_{sc} = 0$$

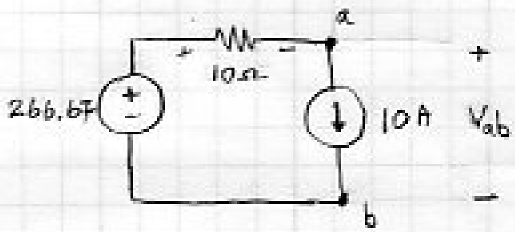
so $i_{sc} = 10 + V_b$

$= \boxed{26.67 \text{ A}}$ SHORT-CIRCUIT CURRENT

Therefore, $R_t = \dfrac{V_t}{i_{sc}} = \dfrac{266.67}{26.67} = 10\Omega$



(b)

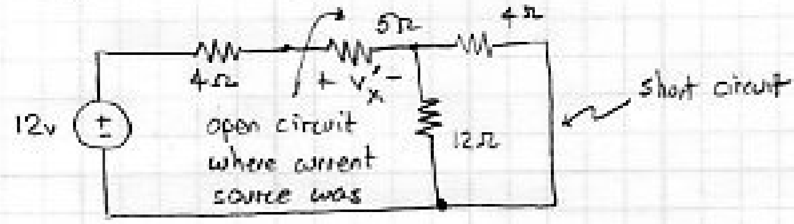


KVL around this loop gives $-266.67 + 10(10) + V_{ab} = 0$

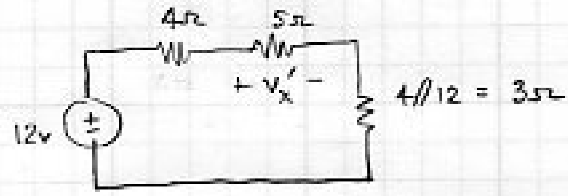
$V_{ab} = 166.67 \text{ v}$

Question 4

(i) 12-volt source acting alone

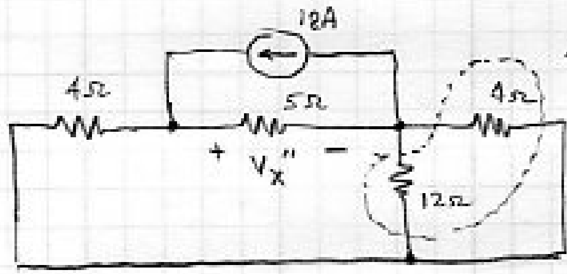


Redrawing



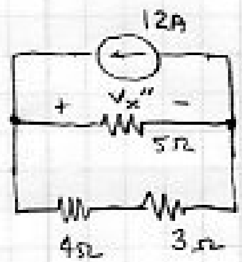
Voltage divider : $V_x' = \dfrac{5}{4+5+3} \times 12 = 5\text{v}$

(ii) 2-amp source acting alone



4//12 = 3Ω

Redrawing

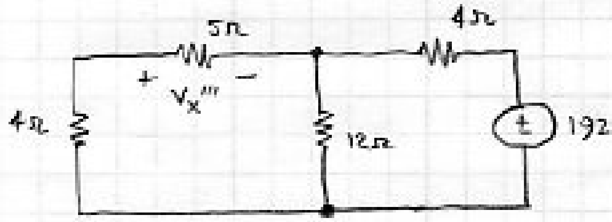


Total Req across current source

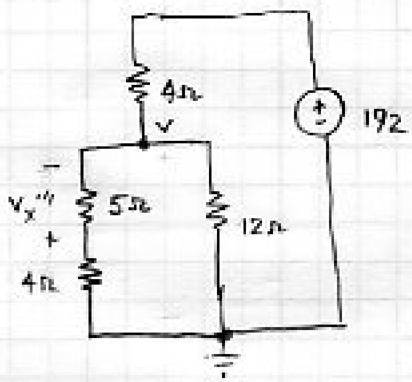
$R_{eq} = 7 // 5$
$= 2.9167\ \Omega$
$= \dfrac{35}{12}\ \Omega$

Therefore, $V_x'' = 12 \times \dfrac{35}{12}$
$= 35\text{v}$

(iii) 19-volt source acting alone



Redraw



Voltage dividers again: $V = \dfrac{(4+5)/\!/12}{(4+5)/\!/12 + 4} \times 192$

$= 108\text{ v}$

And $V_x''' = \dfrac{-5}{5+4} \times V = -60\text{v}$

Finally,

$$V_x = V_x' + V_x'' + V_x'''$$

$$= 5 + 35 - 60$$

$$= -20\text{v}$$