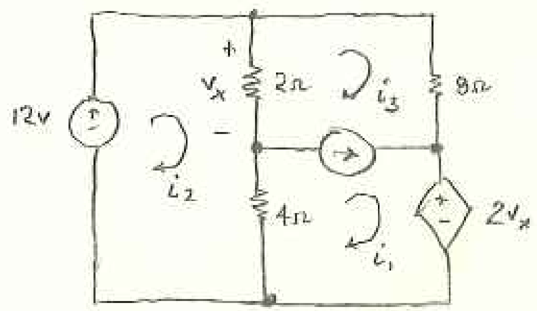
Question 1



Mesh i_2:
$$-12 + 2(i_2 - i_3) + 4(i_2 - i_1) = 0$$
$$6i_2 - 4i_1 - 2i_3 = 12 \quad (1)$$

Supermesh i_1, i_3:
$$4(i_1 - i_2) + 2(i_3 - i_2) + 8i_3 + 2V_x = 0$$
$$4i_1 - 4i_2 + 2i_3 - 2i_2 + 8i_3 + 2V_x = 0$$
$$4i_1 - 6i_2 + 10i_3 + 2V_x = 0 \quad (2)$$

The controlling voltage $V_x = 2(i_2 - i_3)$

Substituting this into (2) gives: $4i_1 - 6i_2 + 10i_3 + 4(i_2 - i_3) = 0$
$$-2i_2 + 4i_1 + 6i_3 = 0 \quad (3)$$

Supermesh dependence: $i_1 - i_3 = 3$
so $i_3 = i_1 - 3 \quad (4)$

Substituting (4) into (3) gives: $-2i_2 + 4i_1 + 6(i_1 - 3) = 0$
$$-2i_2 + 4i_1 + 6i_1 - 18 = 0$$
$$-2i_2 + 10i_1 = 18$$

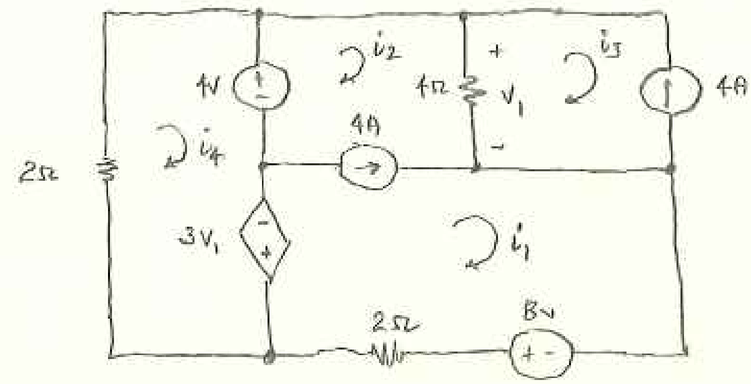
or, rearranging, $-2i_2 = 18 - 10i_1$
$$i_2 = -9 + 5i_1 \quad (5)$$

Now substitute (5) and (4) into (1)

$$6(-9 + 5i_1) - 4i_1 - 2(i_1 - 3) = 12$$
$$-54 + 30i_1 - 4i_1 - 2i_1 + 6 = 12$$
$$24i_1 = 60$$

Therefore, $\boxed{i_1 = 2.5\text{ A}}$ Also, $i_2 = 3.5$ A
$i_3 = -0.5$ A

Question 2



Here we note that $i_3 = -4A$ and i_1 and i_2 form a supermesh.

Supermesh i_1, i_2 : $\underbrace{-4 + 4(i_2 - i_3)}_{\text{mesh } i_2} \underbrace{- 8 + 2i_1 + 3V_1}_{\text{mesh } i_1} = 0$ (1)

where we have the controlling voltage $V_1 = 4(i_2 - i_3)$. Substitute this into (1) :

$$-4 + 4i_2 - 4i_3 - 8 + 2i_2 + 12i_2 - 12i_3 = 0$$
$$2i_1 + 16i_2 - 16i_3 = 12$$

With $i_3 = -4$, $-4 + 16i_2 + 64 = 12$
$$2i_1 + 16i_2 = -52 \quad (2)$$

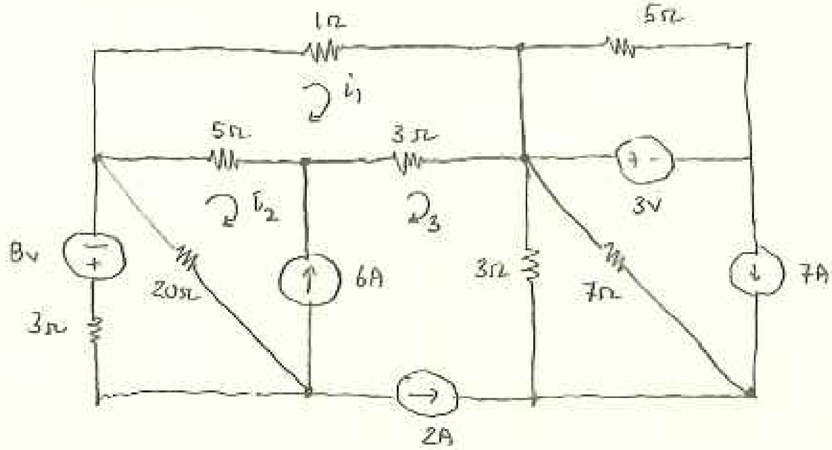
Supermesh dependence : $i_1 - i_2 = 4$, so $i_2 = i_1 - 4$

Substitute into (2) : $2i_1 + 16(i_1 - 4) = -52$
$$18i_1 - 64 = -52$$
$$18i_1 = 12$$

giving $\boxed{i_1 = 0.6667 \text{ A}}$ and $i_2 = -3.333$ A

NOTE : Notice that i_4 was never needed in this calculation! The other mesh currents are independent of i_4 thanks to the voltage sources (4V, $3V_1$).

Question 3



As the hint mentions, not all meshes are needed to find i_1. Looking at mesh i_1, it shares mesh currents i_2 and i_3, and no other mesh.

Furthermore, by inspection, $i_3 = -2A$.

Meshes i_2 and i_3 form a supermesh where the currents are related by the dependence equation

$$i_3 - i_2 = 6$$
$$\text{so} \quad i_2 = i_3 - 6$$

Since $i_3 = -2A$, $i_2 = -8A$

Then, mesh i_1:
$$5(i_1 - i_2) + i_1 + 3(i_1 - i_3) = 0$$
$$5i_1 - 5i_2 + i_1 + 3i_1 - 3i_3 = 0$$
$$9i_1 - 5i_2 - 3i_3 = 0$$

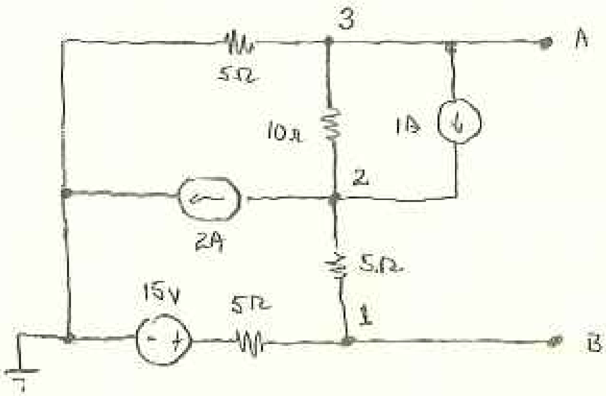
giving:
$$9i_1 - 5(-8) - 3(-2) = 0$$
$$9i_1 = -46$$

$$\boxed{i_1 = -5.111\,A}$$

Question 4

We don't have any dependent sources, so we may use the short-cut method to find the Thevenin resistance.

First, find V_t.



With the reference node chosen as shown, there are three unknown node voltages. When we're done,

$$V_A = V_3 \quad \text{and} \quad V_B = V_1, \quad \text{so} \quad V_t = V_A - V_B$$

Node 1: $\dfrac{V_1 - 15}{5} + \dfrac{V_1 - V_2}{5} = 0$

(x5) $V_1 - 15 + V_1 - V_2 = 0$

$2V_1 - V_2 = 15$ (1)

Node 2: $\dfrac{V_2 - V_1}{5} + 2 + \dfrac{V_2 - V_3}{10} - 1 = 0$

(x 10) $2V_2 - 2V_1 + 20 + V_2 - V_3 - 10 = 0$

$3V_2 - 2V_1 - V_3 = -10$ (2)

Node 3: $\dfrac{V_3}{5} + \dfrac{V_3 - V_2}{10} + 1 = 0$

(x 10) $2V_3 + V_3 - V_2 = -10$

$3V_3 - V_2 = -10$ (3)

From (1), $V_2 = 2V_1 - 15$. Substitute into (2)

$$3(2V_1 - 15) - 2V_1 - V_3 = -10$$
$$6V_1 - 45 - 2V_1 - V_3 = -10$$
$$4V_1 - V_3 = 35 \quad (4)$$

From (3), $3V_3 - (2V_1 - 15) = -10$

$-2V_1 + 3V_3 = -25$ (5)

From (3) and (5), $-2V_1 + 3(4V_1 - 35) = -25$

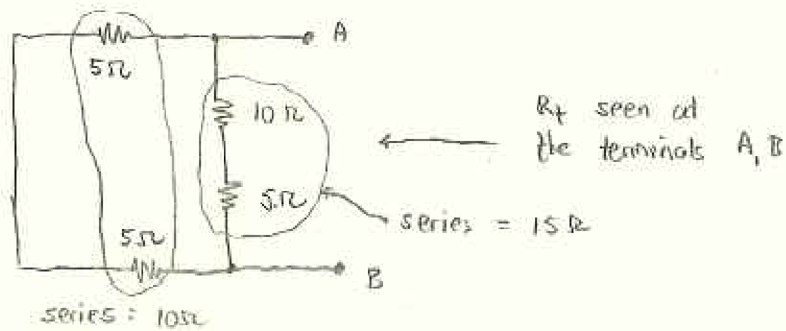
$$10V_1 - 150 = -25$$
$$10V_1 = 80$$

so $V_1 = 8V$, and also $V_3 = -3V$ and $V_2 = 1V$.

Finally $V_t = V_3 - V_1 = \boxed{-11\,v}$

Question 5

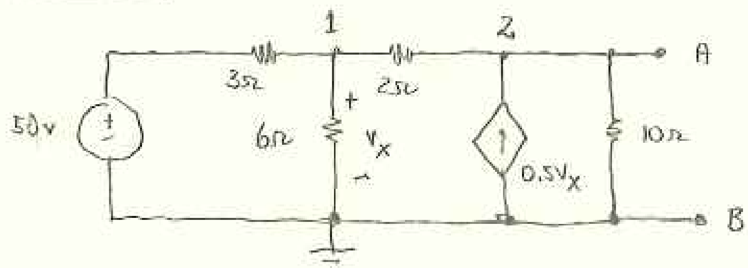
Zeroing the sources gives



Finally, 10Ω is in parallel with 15 Ω

$$R_t = 10 /\!/ 15 = \boxed{6\Omega}$$

Question 6



Node 1 : $\frac{V_1 - 50}{3} + \frac{V_1}{6} + \frac{V_1 - V_2}{2} = 0$

(x6) $2V_1 - 100 + V_1 + 3V_1 - 3V_2 = 0$

$6V_1 - 3V_2 = 100$ (1)

Node 2 : $-0.5V_x + \frac{V_2 - V_1}{2} + \frac{V_2}{10} = 0$

where we observe that $V_x = V_1$.

$$-0.5V_1 + \frac{V_2 - V_1}{2} + \frac{V_2}{10} = 0$$

(x 10) $-5V_1 + 5V_2 - 5V_1 + V_2 = 0$

$$-10V_1 + 6V_2 = 0, \quad \text{so} \quad V_1 = 0.6V_2 \qquad (2)$$

Substitute this into (1) giving:

$$6(0.6V_2) - 3V_2 = 100$$
$$3.6V_2 - 3V_2 = 100$$
$$0.6V_2 = 100$$

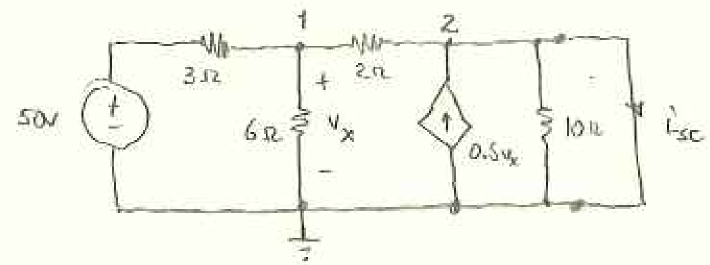
and $V_2 = 166.67\,v$

Since $V_B = 0$ and $V_A = V_2$, the Thevenin voltage is

$$\boxed{V_t = 166.67v}$$

Question 7

The circuit has a dependent source, so we must calculate i_{sc}



Node 1: $\frac{V_1 - 50}{3} + \frac{V_1}{6} + \frac{V_1 - V_2}{2} = 0$

$$6V_1 - 3V_2 = 100 \qquad [\text{same equation}]$$

However, $V_2 = 0$, so $6V_1 - 0 = 100$

$$V_1 = 16.67\ V$$

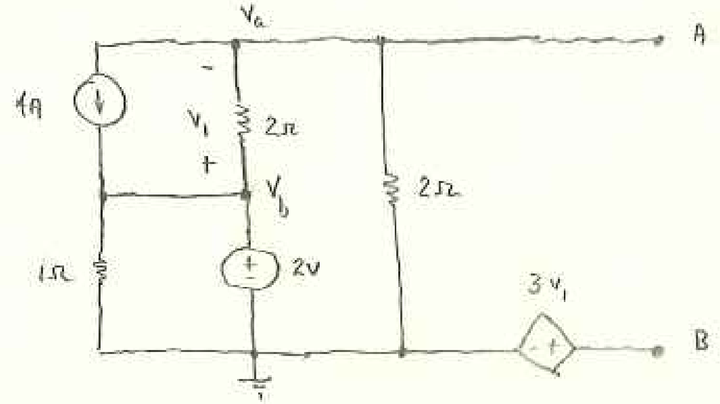
Node 2: $\frac{V_2 - V_1}{2} - 0.5V_1 + i_{sc} = 0$

$$0 - \frac{V_1}{2} - 0.5V_1 + i_{sc} = 0$$

$$i_{sc} = V_1$$

so $\boxed{i_{sc} = 16.67\ A}$

Question 8



We see that $V_b = 2V$, and that $V_A = V_a$, and $V_B = 3V_1$.
When we're ready, $V_t = V_A - V_B$.

At V_a: $4 + \frac{V_a - 2}{2} + \frac{V_a}{2} = 0$

$(\times 2)$ $8 + V_a - 2 + V_a = 0$
$2V_a = -6$

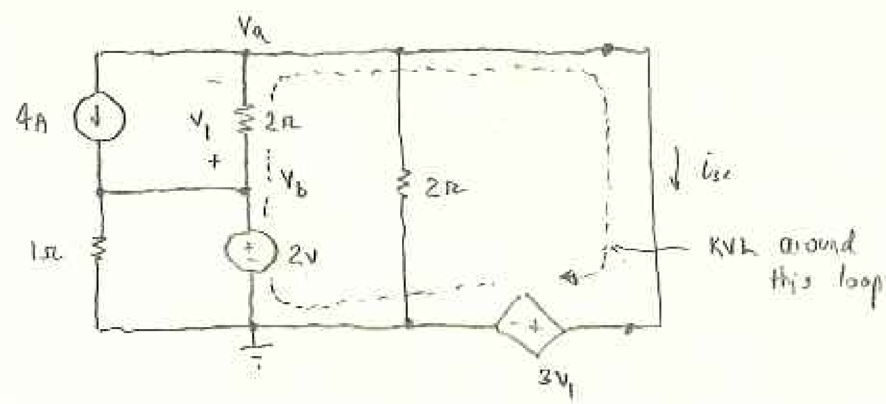
Therefore, $V_A = V_a = -3\,V$

The dependent voltage source uses $V_1 = V_b - V_a = 2 - (-3)$
$V_1 = 5V$

so $V_B = 3V_1 = 3(5) = 15V$

Finally, $V_t = V_A - V_B = -3 - 15 = \boxed{-18V}$

Question 9



Following the hint given, KVL around the loop shown gives

$$-2 + V_1 + 3V_1 = 0$$
$$4V_1 = 2$$

so $V_1 = \frac{1}{2}$ V

With the short circuit applied,

$$V_a = 3V_1 = 1.5\text{ V}$$

At node a: $\frac{V_a - 2}{2} + 4 + \frac{V_a}{2} + i_{sc} = 0$

(×2) $V_a - 2 + 8 + V_a + 2i_{sc} = 0$

$$2V_a + 6 + 2i_{sc} = 0$$

With $V_a = 1.5$, $2(1.5) + 6 + 2i_{sc} = 0$

$$2i_{sc} = -9$$

$$i_{sc} = \boxed{-4.5\text{ A}}$$

Alternatively, one may use the mesh-current method using two mesh equations. One of the mesh currents is i_{sc}!