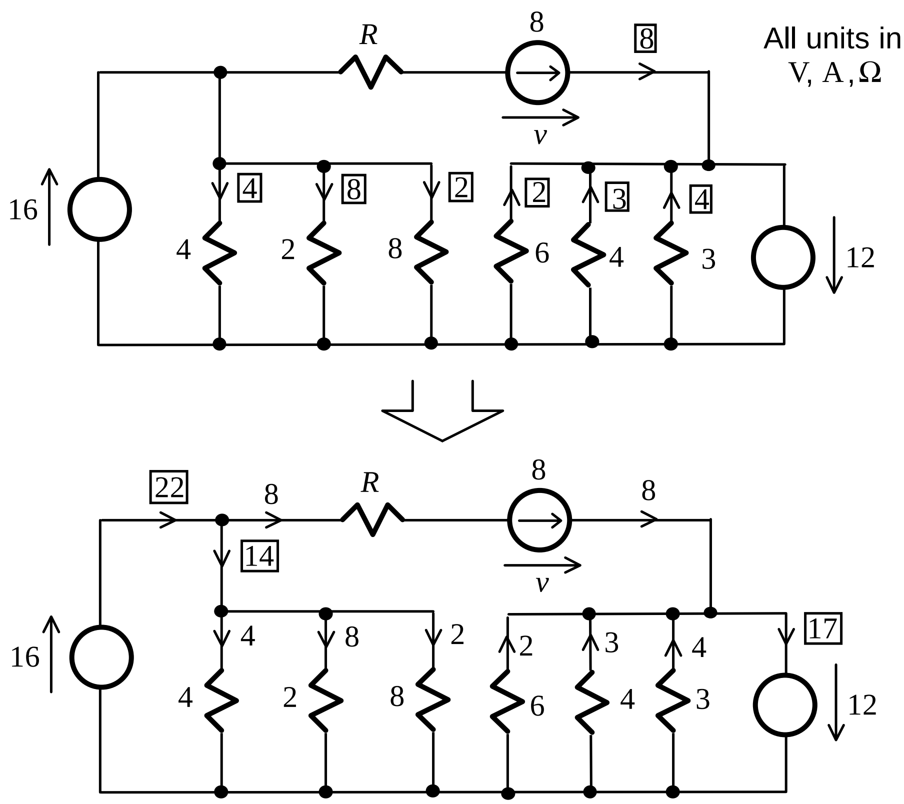
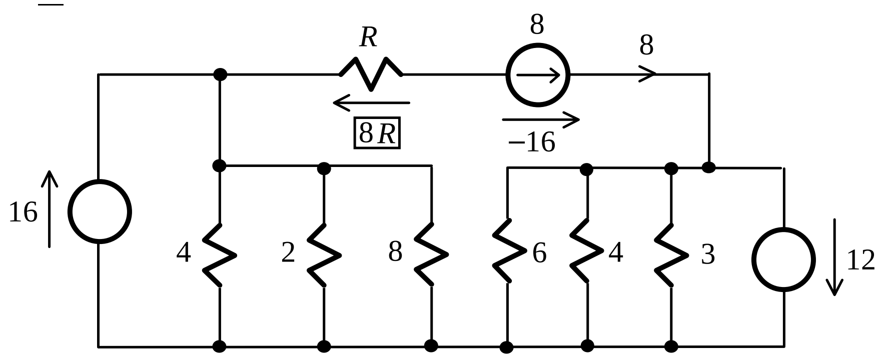
F.2 Probleme Cir El c.c.: Kirchhoff, Legare la pământ

Q.1

Currents



Value for $\underline{R}$

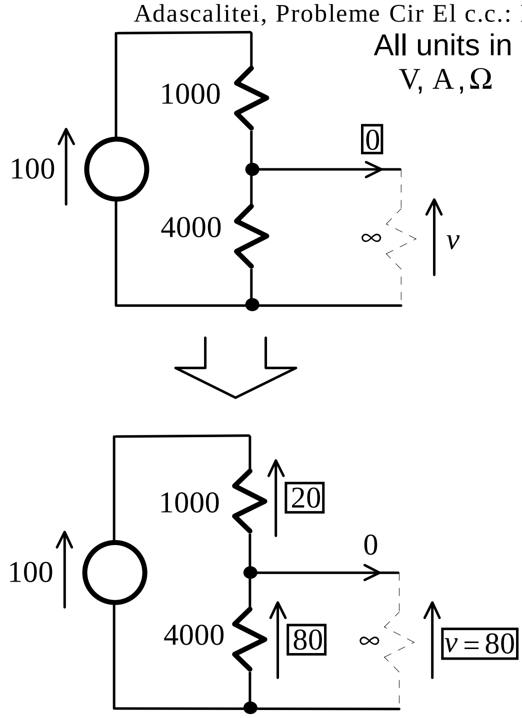


Applying KVL to the loop with the sources and R:

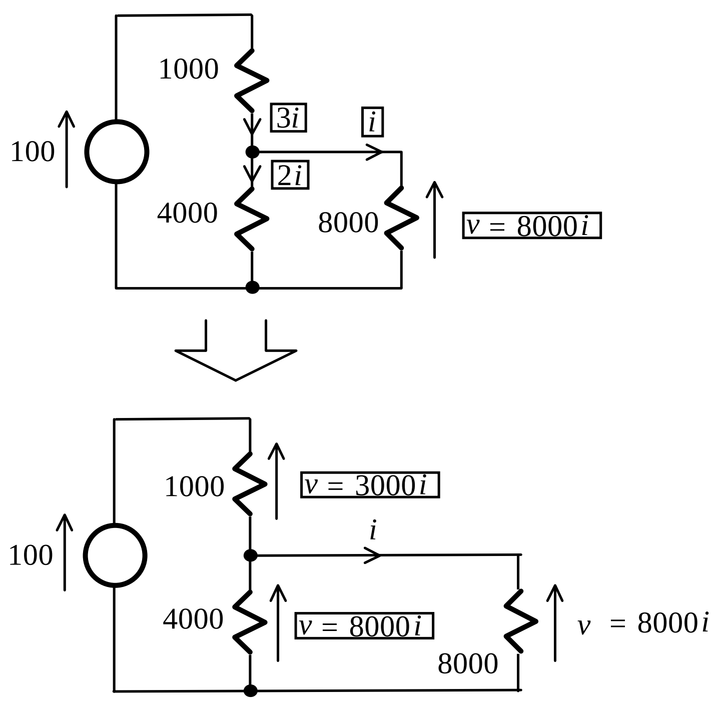
$$16 - 8R - 16 + 12 = 0 \;\Rightarrow\; R = 1.5$$

Q.2

(a) $R = \infty$ *(open circuit or no load situation)*



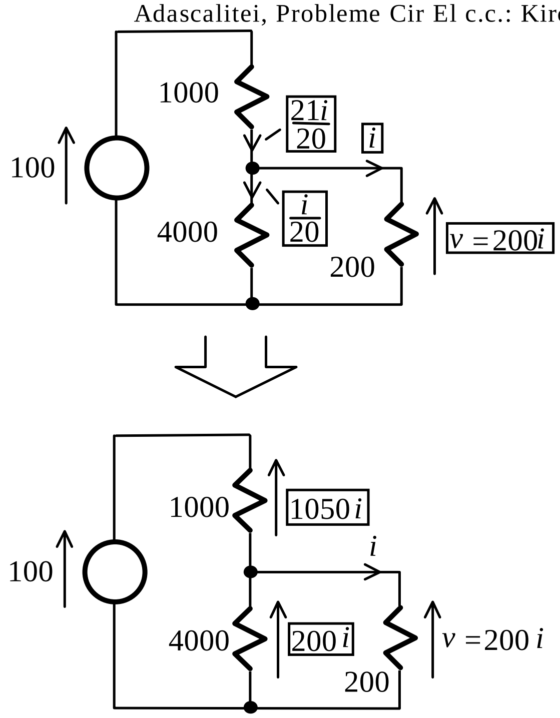
(b) $R = 8000\Omega$



$$100 = 3000i + 8000i \;\Rightarrow\; i = \frac{1}{110}\,\mathrm{A}$$

$$v = 8000i = 72.73\mathrm{V}$$

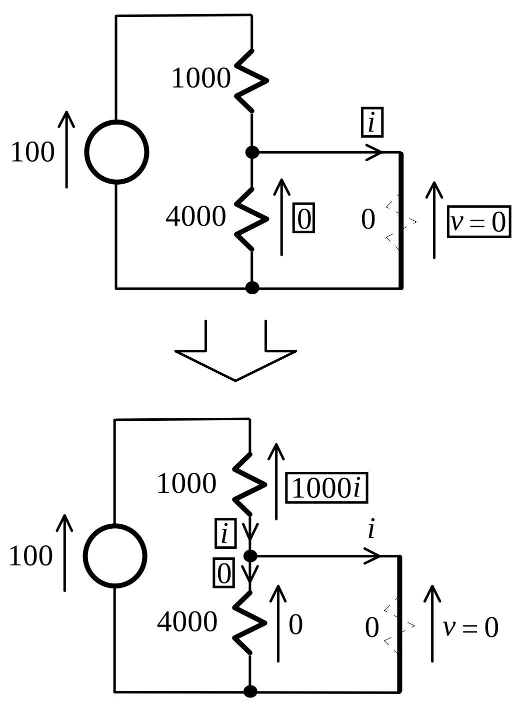
(c) $R = 200\Omega$



$$100 = 1050i + 200i \;\Rightarrow\; 100 = 1250i \;\Rightarrow\; i = \frac{2}{25}\,\text{A}$$

$$v = 200i = 16\,\text{V}$$

(d) $R = 0$ *(short circuit)*



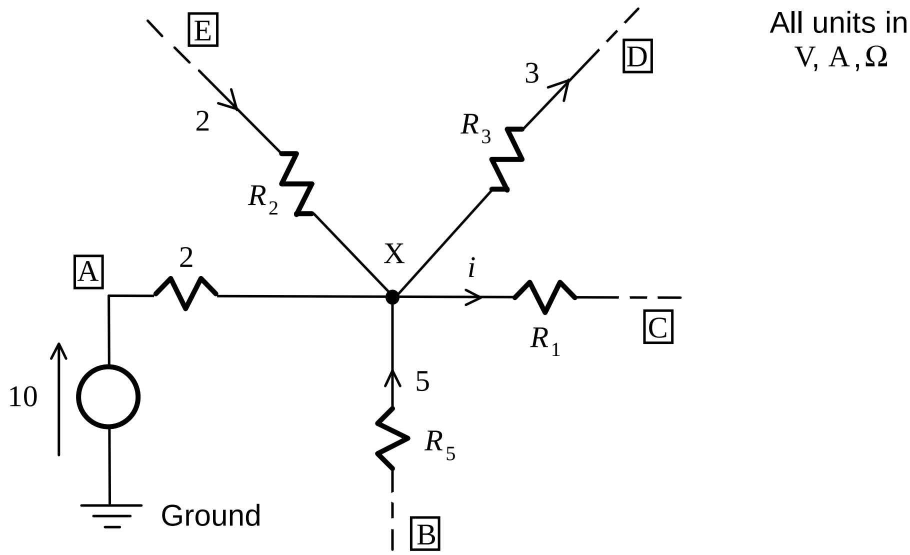
$$100 = 1000i \;\Rightarrow\; i = 0.1\,\text{A}$$

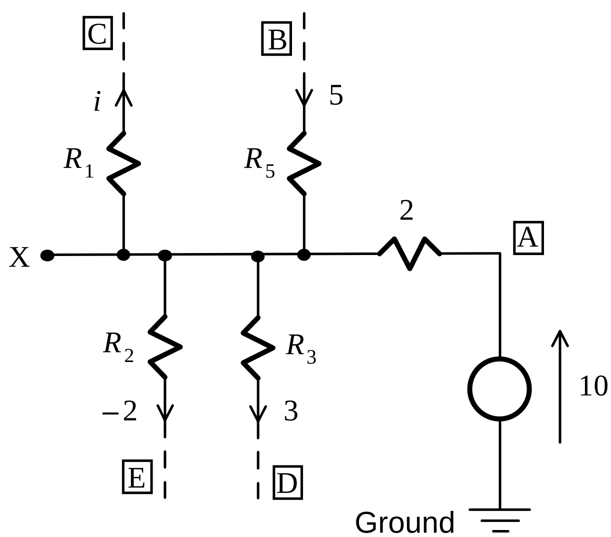
It may be slightly faster to derive two general formulas for v and i and then substitute the values for R.

Q.3

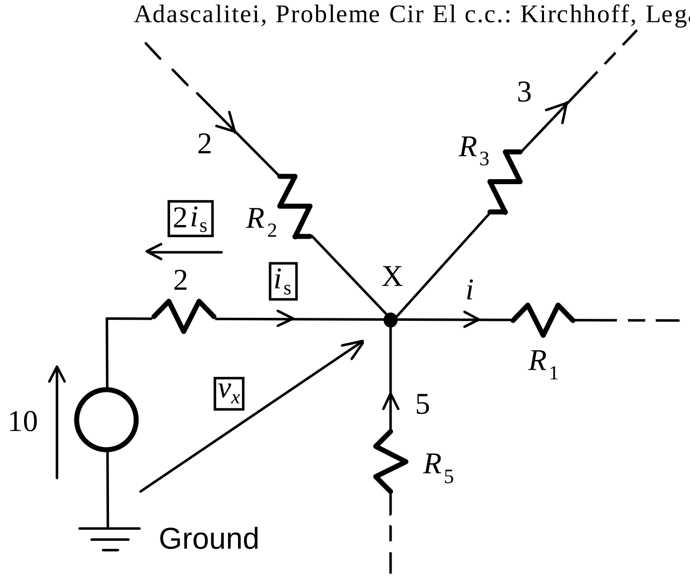
Equivalence of circuits

The two circuits are equivalent because the connections (topology), elements and currents between the various nodes are identical:





Current and voltage



Applying KCL to node X and then KVL:

$i_s = i + 3 - 2 - 5 = i - 4$

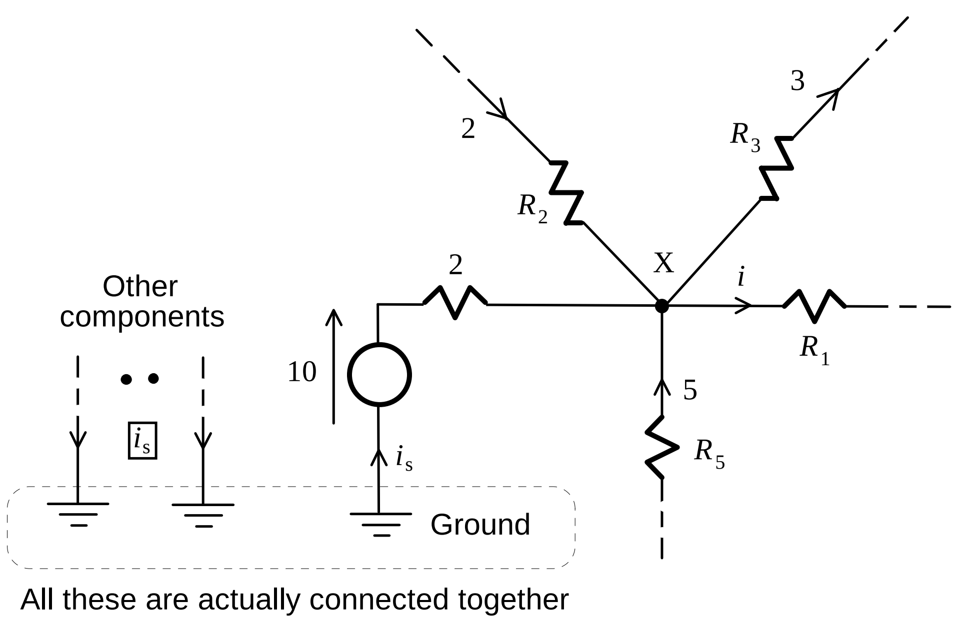
$v_x = 10 - 2i_s = 10 - 2(i - 4) = 18 - 2i$

When $i = 2$, $i_s = -2\,\text{A}$ and $v_x = 14\,\text{V}$

When $i = -3$, $i_s = -7\,\text{A}$ and $v_x = 24\,\text{V}$

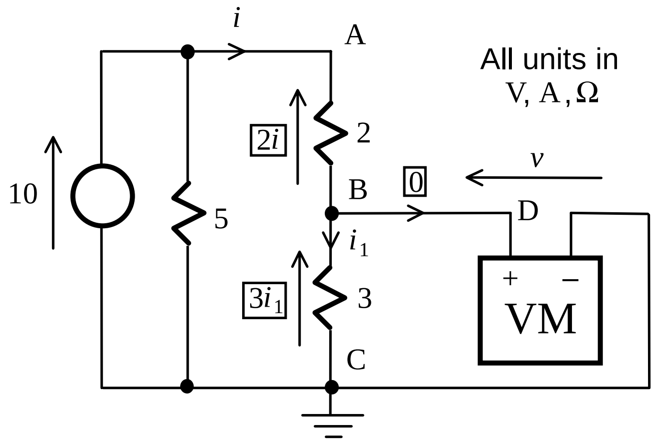
KCL for ground node

Since there may be other components connected to ground, the application of KCL must include all the other connections not shown in the original diagram. The implication is that all these other components must be delivering a combined current of i_s to ground:



Q.4

(a) Point C *grounded and Point* B *connected to Point* D



Applying KCL to node B:

$$i_1 = i - 0 = i$$

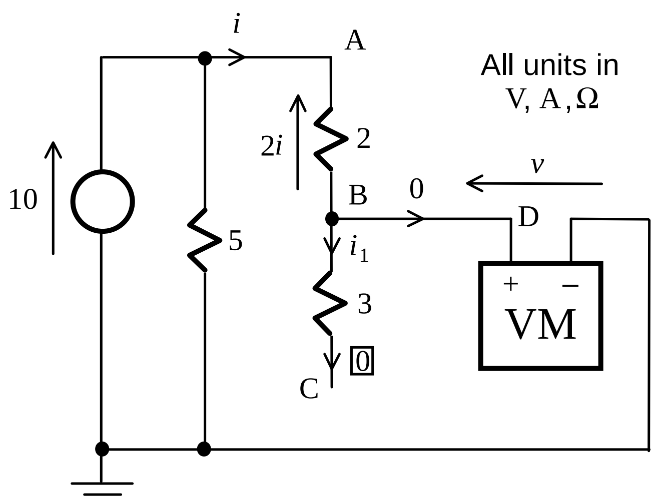
Applying KVL to loop with voltage source, A, B and C:

$$10 = 2i + 3i_1 = 5i \Rightarrow i = 2\,\mathrm{A}$$

Applying KVL to loop with B, C and VM:

$$v = 3i_1 = 3i = 6\,\mathrm{V}$$

(b) No connection for Point C *and Point* B *connected to Point* D



Applying KCL to node C and then to node B:

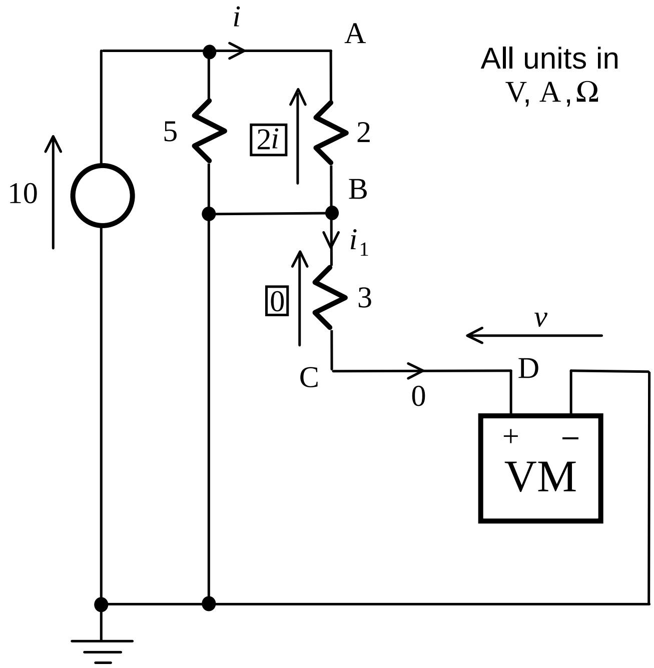
$$i_1 = 0\,\mathrm{A}$$

$$i = i_1 + 0 = 0\,\mathrm{A}$$

Applying KVL to loop with voltage source, A, B and VM:

$$10 = 2i + v \Rightarrow v = 10\,\mathrm{V}$$

(c) Point B *grounded and Point* C *connected to Point* D



Applying KVL to loop with voltage source, A and B:

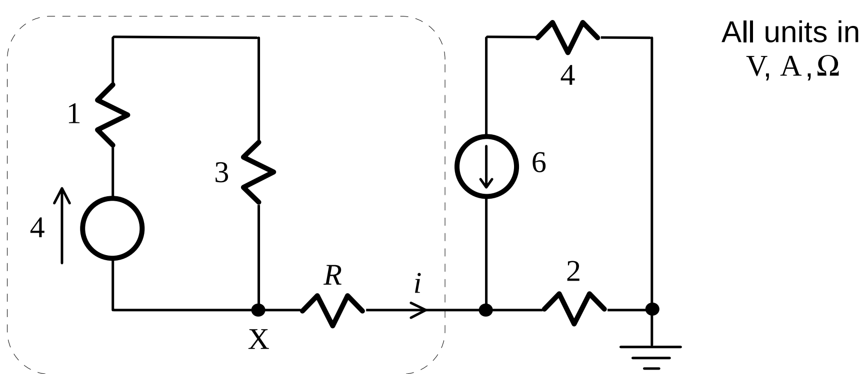
$$10 = 2i \;\Rightarrow\; i = 5\text{A}$$

Applying KVL to loop with B, C, D and VM:

$$v + 3i_1 = 0 \;\Rightarrow\; v = 0\text{V}$$

Q.5

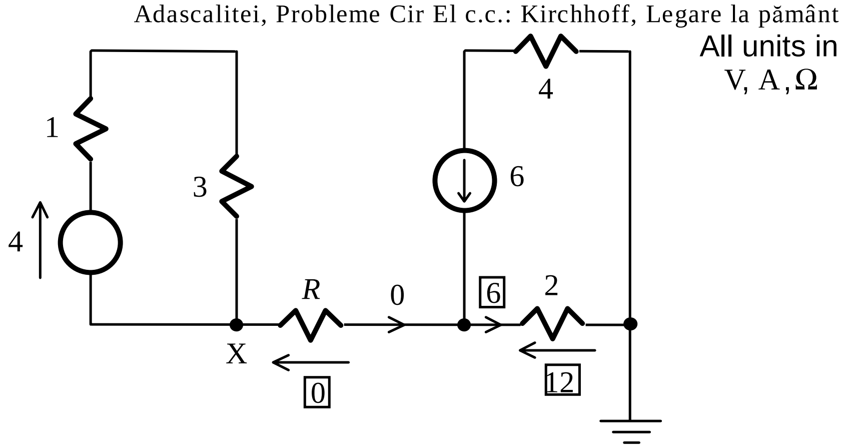
Original circuit



Applying KCL to the dotted surface:

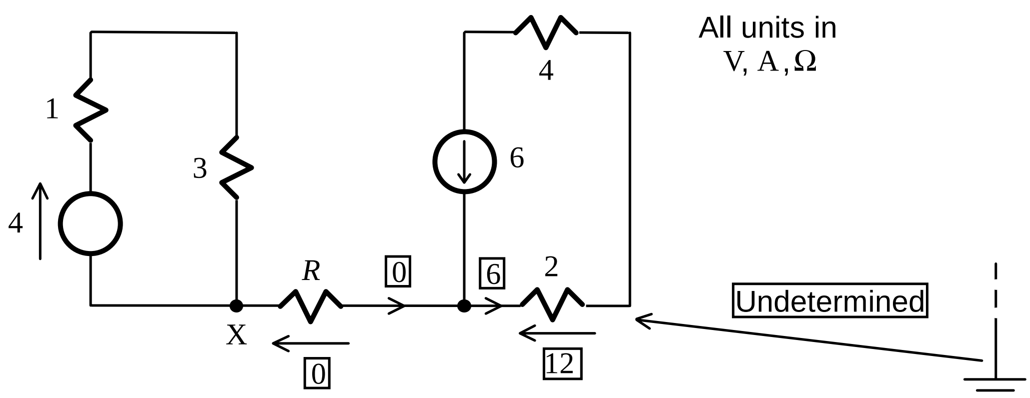
$$i = 0$$

Thus:



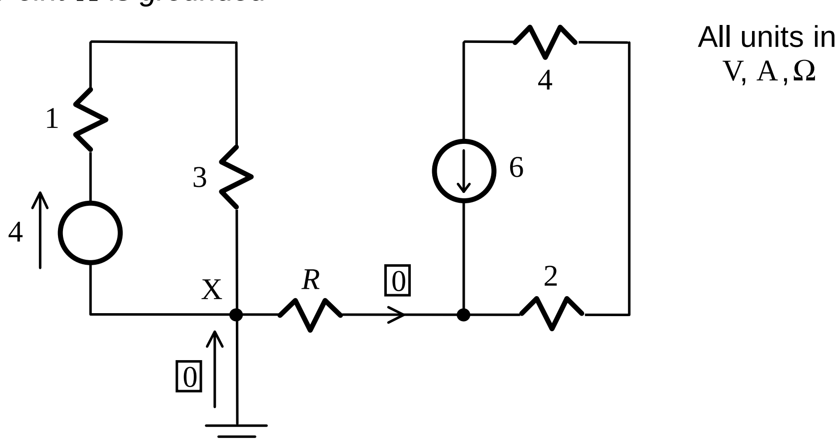
Potential of node X wrt ground = 12 V

When the circuit is not grounded



The potential of node X wrt ground cannot be determined. In practice, its value will depend on factors such as the existence of static charges and other electrical and magnetic effects.

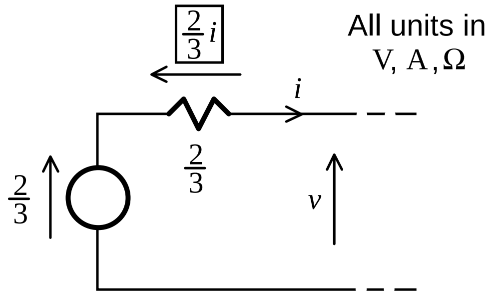
When Point X is grounded



The potential of node X wrt ground is now 0.

Q.6

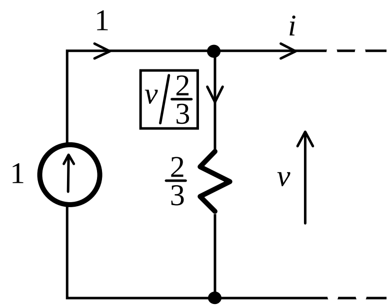
First circuit



Applying KVL:

$$\frac{2}{3} = v + \frac{2i}{3}$$

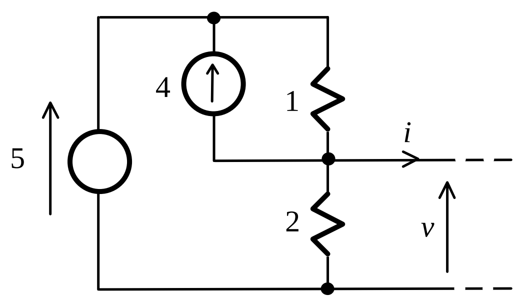
Second circuit

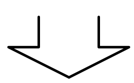


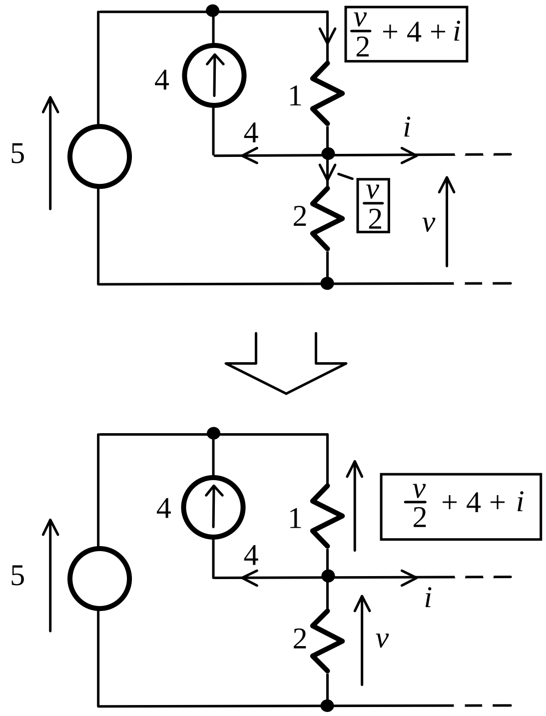
Applying KCL:

$$1 = \frac{v}{2/3} + i \;\Rightarrow\; \frac{2}{3} = v + \frac{2i}{3}$$

Third circuit







From KVL:

$$5 = \frac{v}{2} + 4 + i + v = \frac{3v}{2} + 4 + i$$

$$1 = \frac{3v}{2} + i \;\Rightarrow\; \frac{2}{3} = v + \frac{2i}{3}$$

Equivalence

The three circuits are different in circuit topology and the components used. However, they have the same voltage-current relationship and are electrically equivalent from a voltage-current point of view. It is impossible for an external circuit connected to the outputs of these circuits to tell which circuit has actually been used: