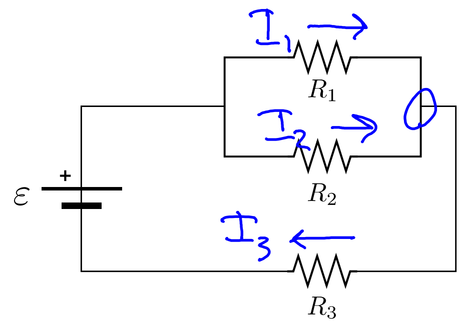


Problem C1.1 (☆): the diagram to the left depicts a circuit where the components have $R_1 = 2\ \Omega$, $R_2 = 6\ \Omega$, and $R_3 = 4\ \Omega$. The current through R_2 is $I_2 = 0.8\ A$.

(a) What are the currents I_1 and I_3?

(b) What is the EMF of the battery?

Some equations we may need:

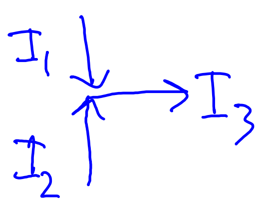
- Ohm's law: $V = IR$
- Kirchoff's Junction rule: $\sum_k I_k = 0$
- Kirchoff's loop rule: $\sum_k V_k = 0$

(a) R_1 & R_2 in parallel. $\therefore V_1 = V_2$

$$\therefore I_1 R_1 = I_2 R_2 \Rightarrow I_1 = \frac{I_2 R_2}{R_1} = \frac{(0.8\ A)(6\ \Omega)}{2\ \Omega}$$

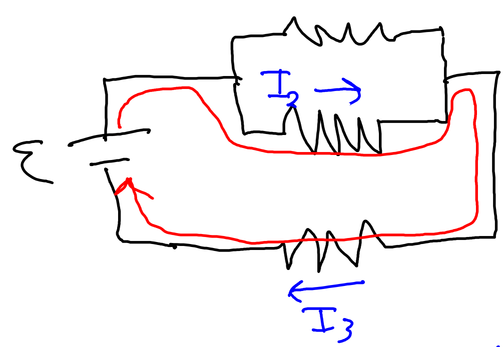
$$= \underline{2.4 A}$$

For I_3, we can use Kircheff's Junction rule:



$$\Rightarrow I_3 = I_1 + I_2 = \underline{3.2\ A}$$

(b) Drawing a Kirchoff loop law:



$$\varepsilon - I_2 R_2 - I_3 R_3 = 0$$

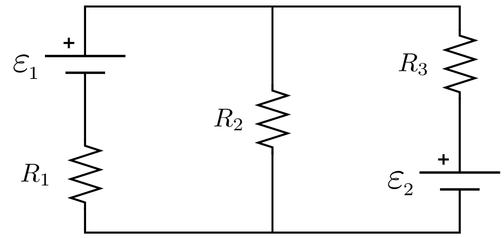
$$\varepsilon = I_2 R_2 + I_3 R_3$$

$$= (0.8A)(6\Omega) + (3.2A)\cdot(4\Omega) = \underline{17.6\ V}$$

Unit check:

$V = IR \Rightarrow V = A\Omega$ ✓

Problem C1.2 (☆): the diagram to the left depicts a circuit with where the components have resistance $R_1 = 4\ \Omega$, $R_2 = 8\ \Omega$, and $R_3 = 6\ \Omega$ and batteries have emf $\varepsilon_1 = 12\ V$ and $\varepsilon_2 = 6\ V$.

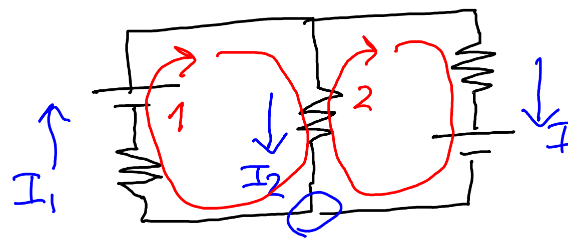


- **(a)** What is the current through resistor R_2?
- **(b)** Are both batteries discharging, or is one charging the other? If so which one?

Some equations we may need:

- Kirchoff's loop rule: $\sum_k V_k = 0$
- Kirchoff's junction rule: $\sum_k I_k = 0$

(a) To work out how the batteries combine, we need to use 3 Kirchoff laws to determine 3 unknowns: the branch currents.



We can guess their directions:

KLR #1: $\mathcal{E}_1 - I_2 R_2 - I_1 R_1 = 0$ (1)

KLR #1: $+I_2 R_2 - I_3 R_3 - \mathcal{E}_2 = 0$ (2)

KJR: $I_2 + I_3 = I_1$ (3)

From (1): $I_1 = \frac{1}{R_1}(\mathcal{E}_1 - I_2 R_2)$ From (2): $I_3 = \frac{1}{R_3}(I_2 R_2 - \mathcal{E}_2)$

Sub (3): $\therefore I_2\left(1 + \frac{R_2}{R_3} + \frac{R_2}{R_1}\right) - \frac{\mathcal{E}_1}{R_1} - \frac{\mathcal{E}_2}{R_3} = 0$

$$I_2 = \frac{\left(\frac{12\cancel{V}\,A}{4\cancel{\Omega}} + \frac{6\cancel{V}\,A}{6\cancel{\Omega}}\right)}{\left(1 + \frac{8\cancel{\Omega}}{6\cancel{\Omega}} + \frac{8\cancel{\Omega}}{4\cancel{\Omega}}\right)} \checkmark = \underline{0.923\ A}$$

A positive answer means we guessed right for I_2.

Problem C1.2 cont:

(b) To determine whether the batteries are charging, we need to work out the direction of I_2 & I_3:

From (1): $I_1 = \frac{1}{R_1}\left(\mathcal{E}_1 - I_2 R_2\right) = \frac{1}{4\Omega}\left(12V - (0.923A)(8V)\right) = 1.15\ A$

From (2): $I_3 = \frac{1}{R_3}\left(I_2 R_2 - \mathcal{E}_2\right) = \frac{1}{6\Omega}\left((0.923A)(8V) - 6V\right) = 0.231\ A$

Thus we guessed right for both I_1 and I_3 because our answers are positive.

Thus $\mathcal{E}_1$ is discharging because current is flowing from +ve to −ve terminal.

However $\mathcal{E}_2$ is charging, as current is flowing into the +ve terminal.