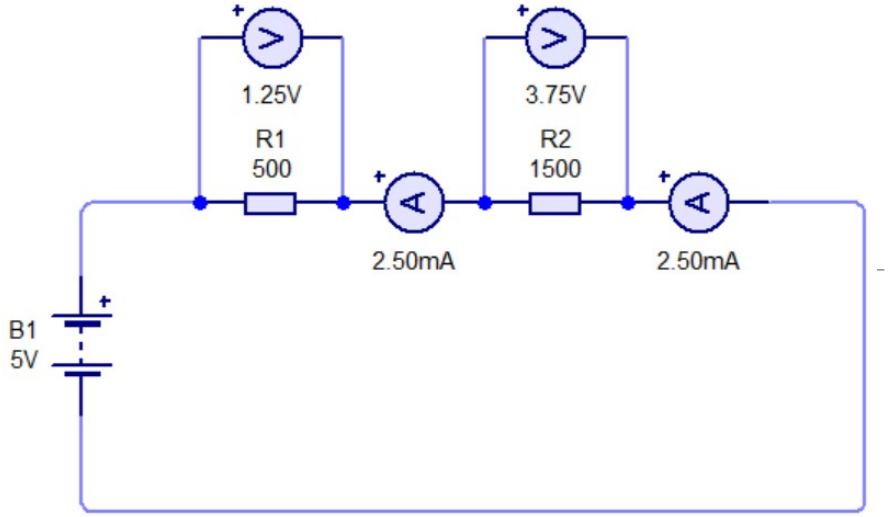
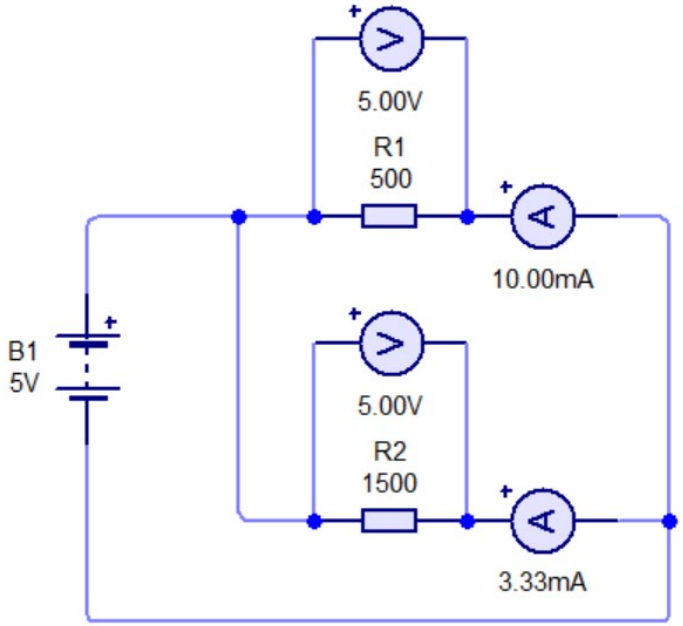
Kirchoff’s Laws

Recap on DC Circuits

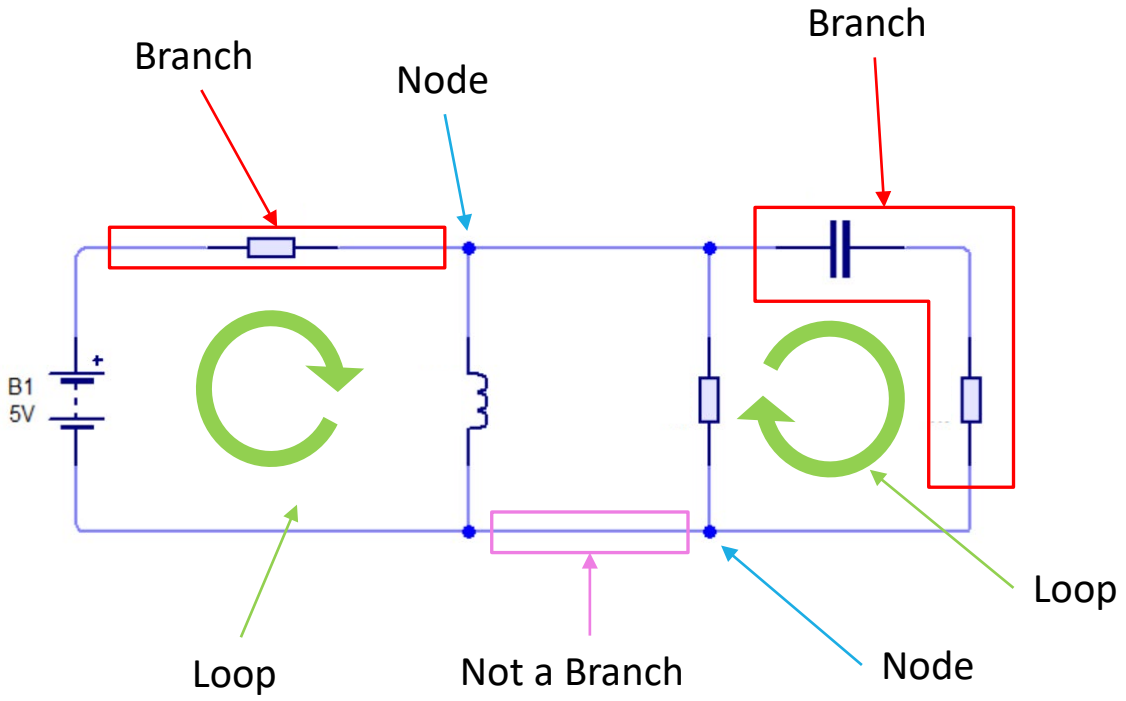
- Ohms law (V=IR)
- **Series connection:** Current is the same through all components, voltages split
- **Parallel connection:** Voltage is the same across branches, currents split





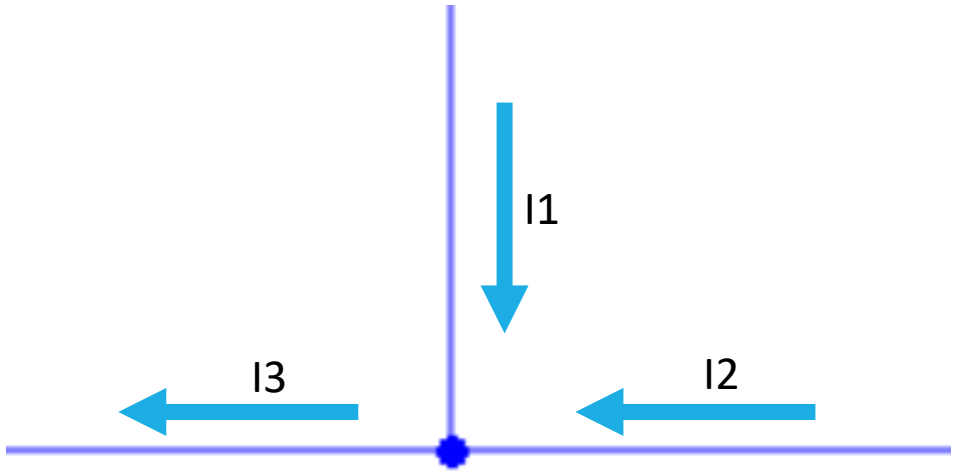
Parts of DC Circuits

- **Node**: A point in a circuit where two or more components are connected.
- **Branch**: A single path connecting two nodes that contains a circuit element (e.g., resistor, voltage source).
- **Loop/Mesh**: Any closed conducting path in a circuit where you can start at one point, travel through elements, and return to the starting point without retracing.



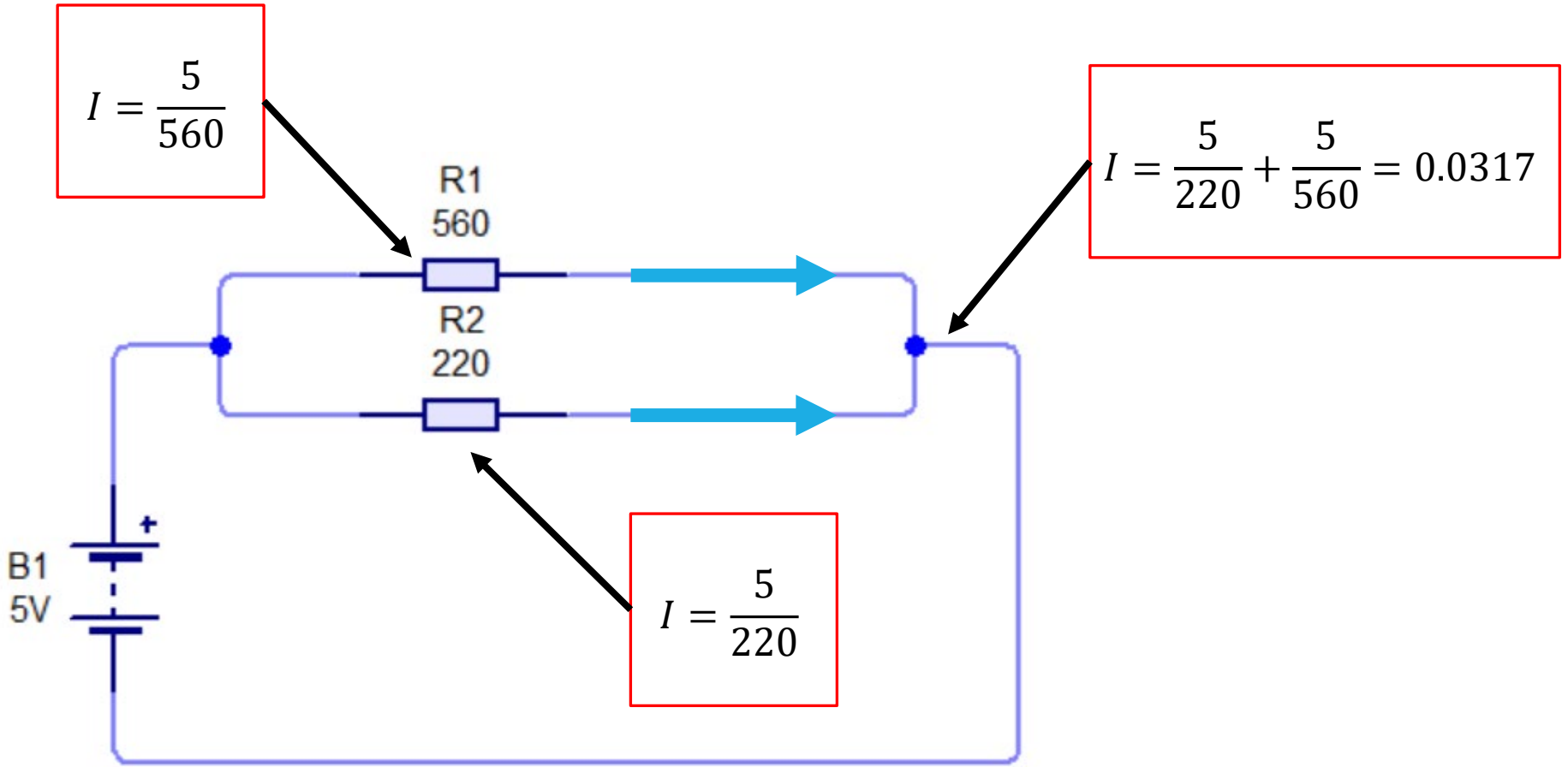
Kirchoff's Current Law

- **Definition:** At any junction, the total current entering = total current leaving
- **Equation form:** $\sum I_{in} = \sum I_{out}$
- **Basis:** Conservation of charge



$$I1 + I2 = I3$$

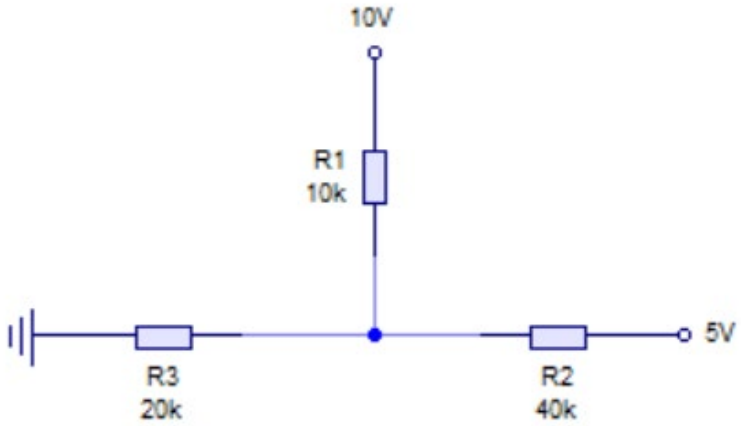
KCL Example


$I = \frac{5}{560}$
$I = \frac{5}{220} + \frac{5}{560} = 0.0317$
R1
560
R2
220
B1
5V
+
$I = \frac{5}{220}$

Example Solving a Kirchoff's Current Question

- Find the voltage at the node
- We know that $I = \frac{V}{R}$
- We only need to look at the voltage at the node so we need to know the voltage drop across the resistors

$$I = \frac{V_{\text{node}} - V_{\text{other side}}}{R}$$



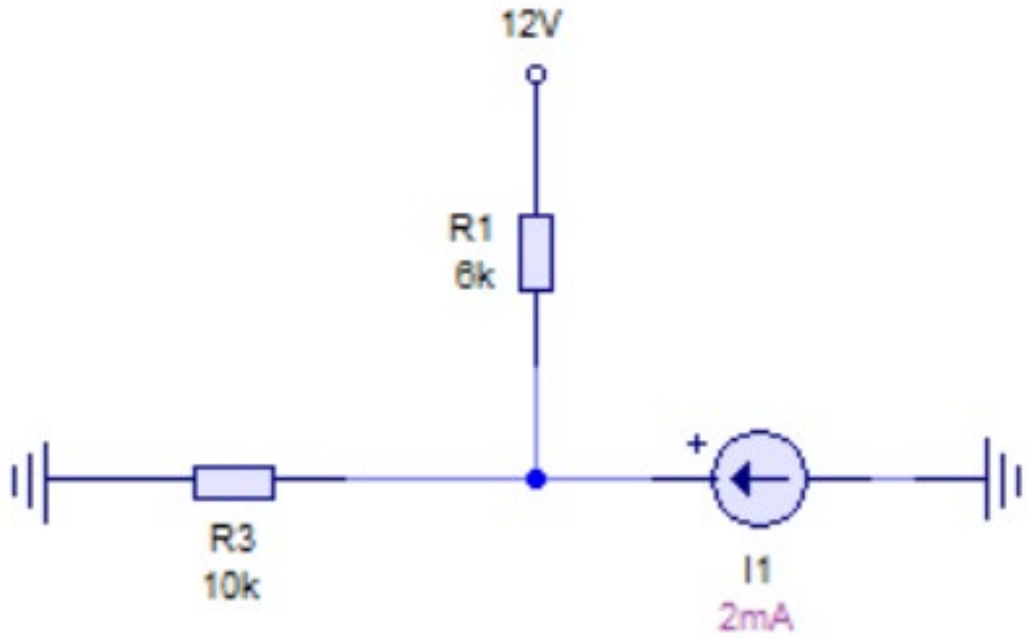
- We know due to KCL all the currents going into and out of the node must equal 0

$$\frac{V_x - 0}{20k} + \frac{V_x - 10}{10k} + \frac{V_x - 5}{40k} = 0$$

- Then we can rearrange to get V_x

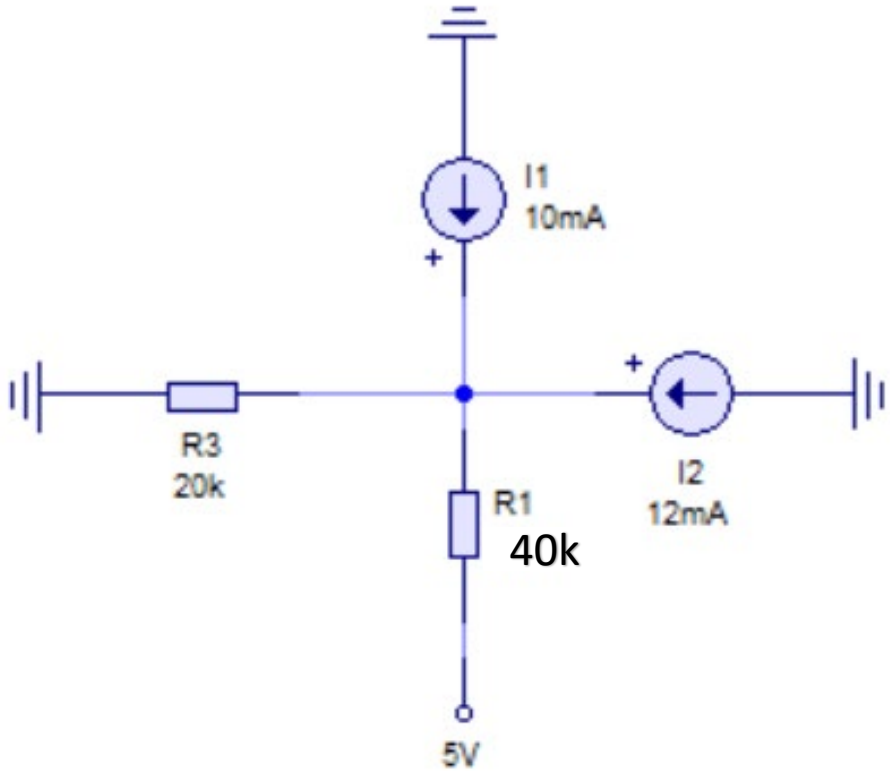
Your Turn

- Write the KCL formula values at that joint
- What is the voltage at the node
- Work out the current through R1 and R2



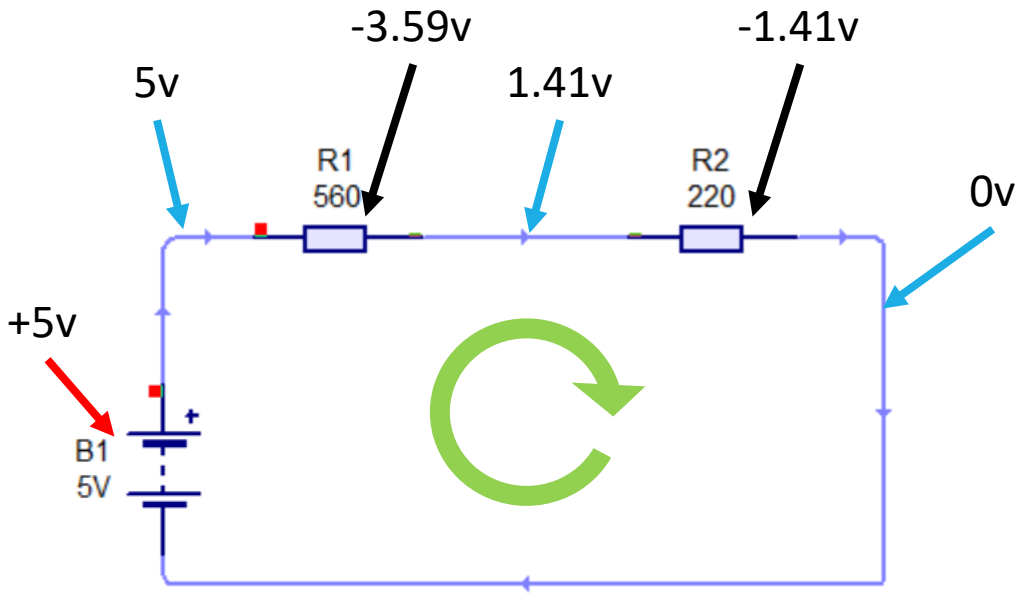
Your Turn

- Write the KCL formula values at that joint
- What is the voltage at the node
- Work out the current going to ground



Kirchoff's Voltage Law

- **Definition:** The sum of all voltages around any closed loop in a circuit is zero.
- **Equation form:** $\sum V = 0$
- **Meaning:** Energy is conserved—voltage rises (sources) are balanced by voltage drops (loads).
- **Rule of thumb:** When you go around a loop, add rises as positive, drops as negative.

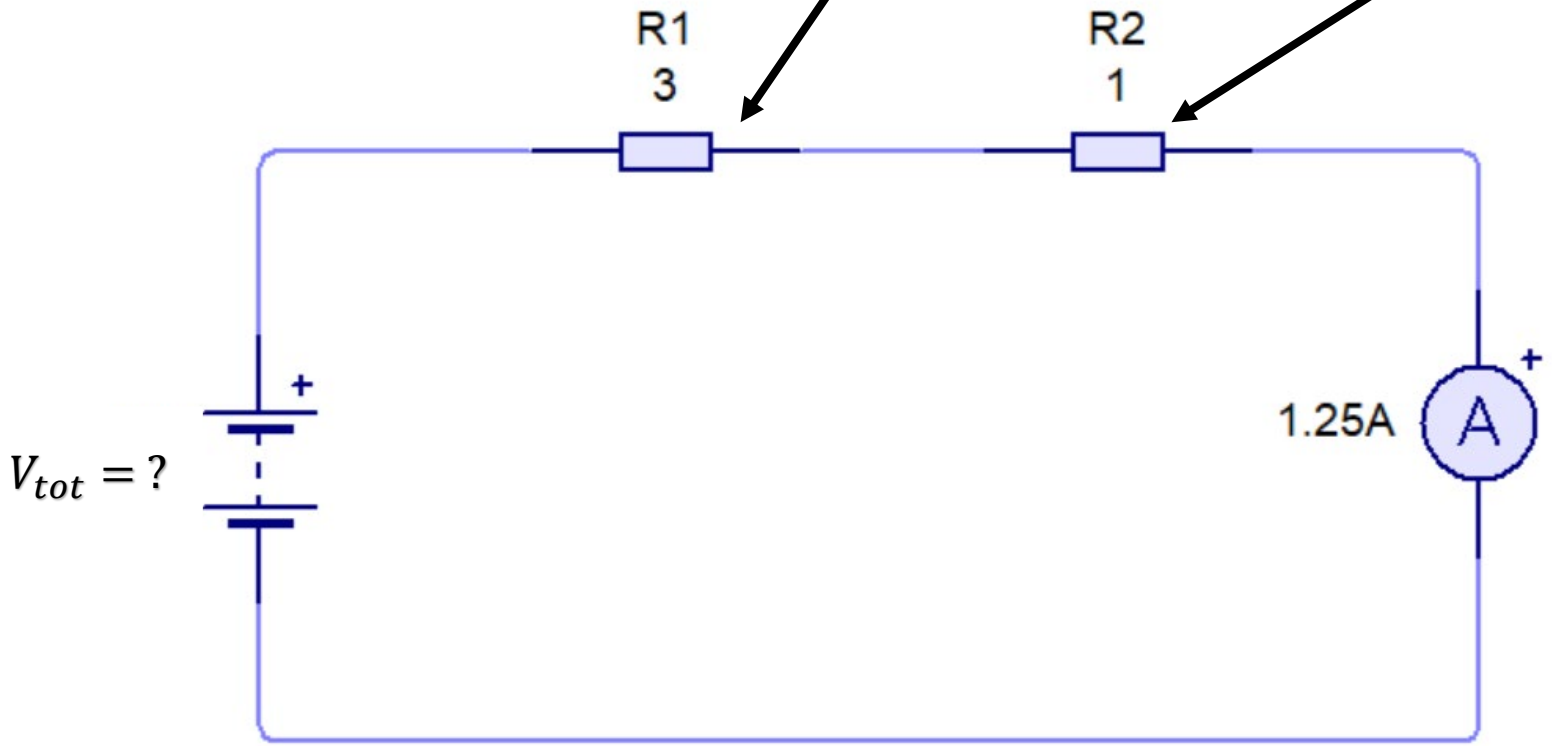


$$5v - 3.59v - 1.41v = 0v$$

KVL Example

$V_1 = 1.25 * 3 = 3.75$

$V_2 = 1.25 * 1 = 1.25$

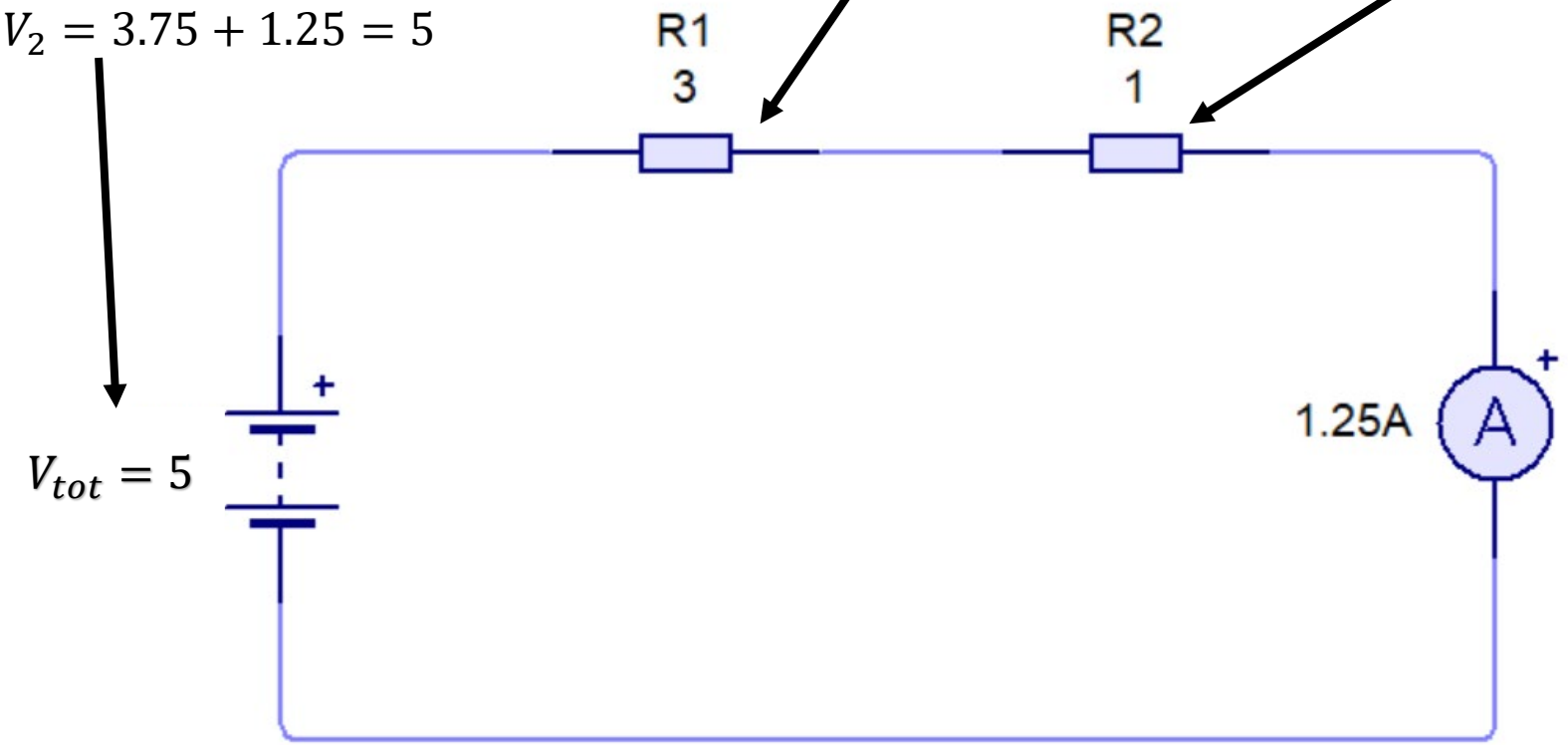


KVL Example

$V_1 = 1.25 * 3 = 3.75$

$V_2 = 1.25 * 1 = 1.25$

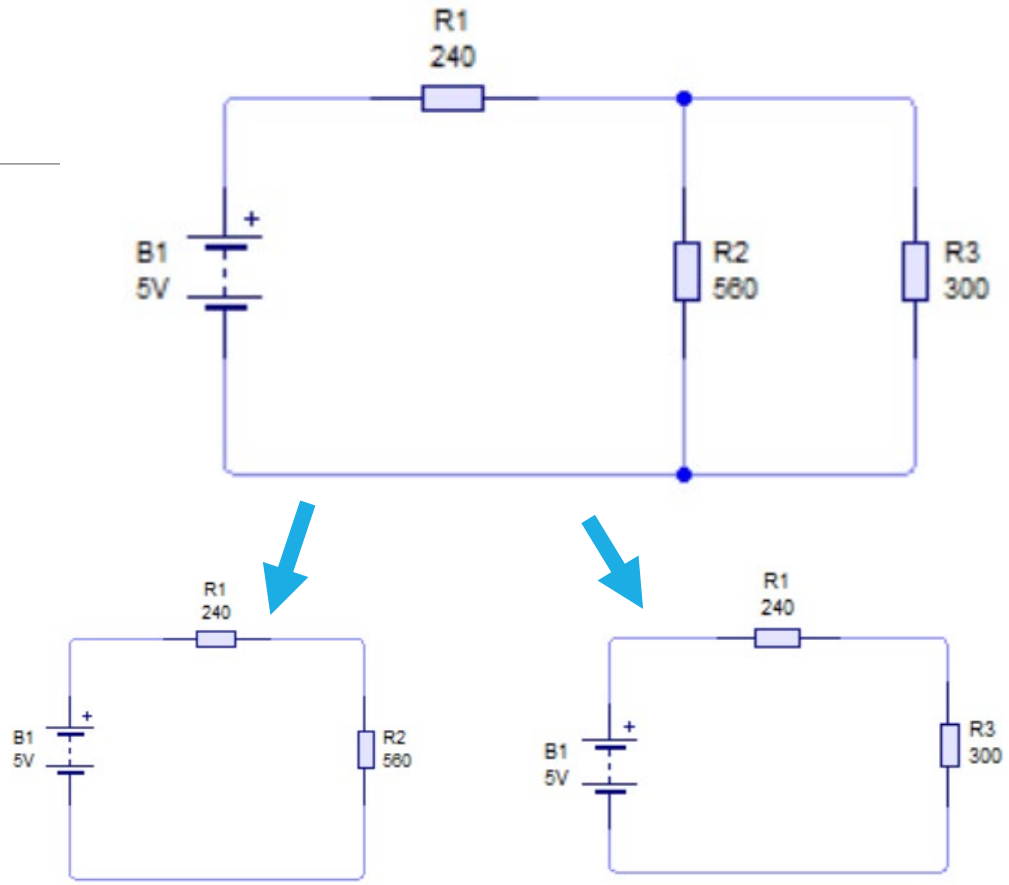
$V_{tot} = V_1 + V_2 = 3.75 + 1.25 = 5$



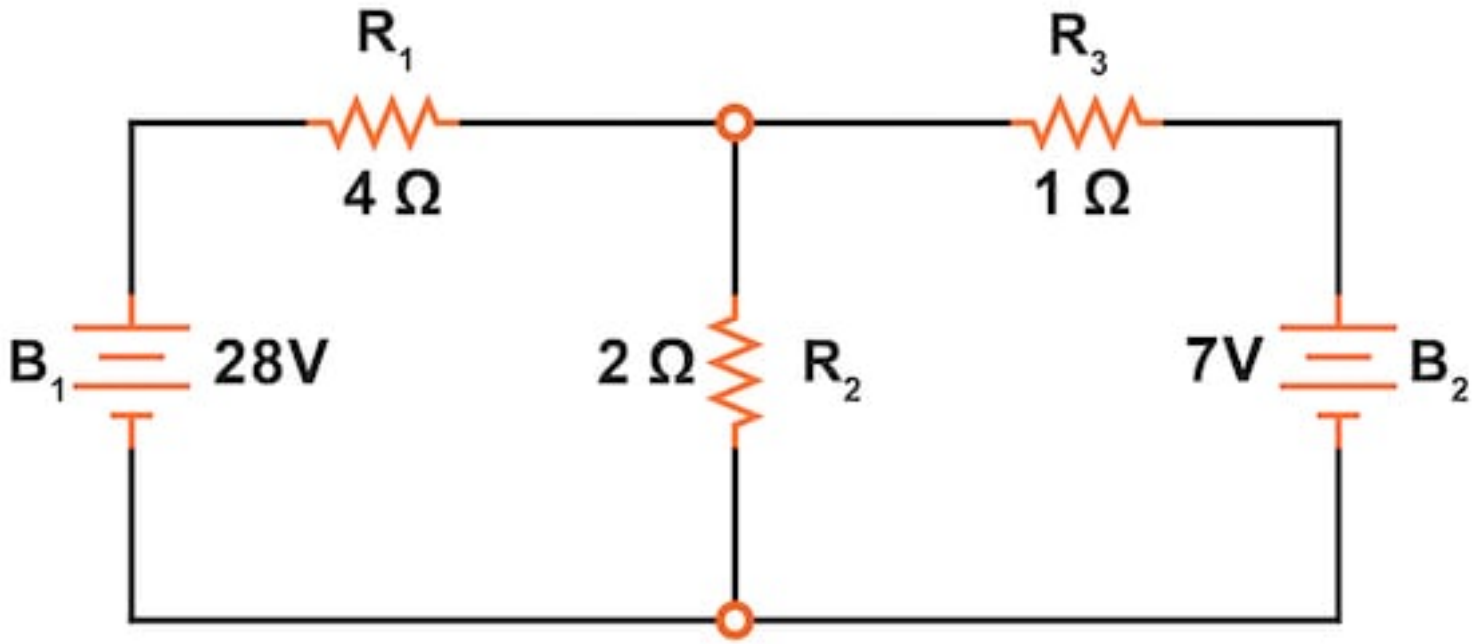
$V_{tot} = 5$

Mesh/Loop Analysis

- We mainly use Kirchoff's Laws in Mesh Analysis
- Mesh Analysis allows us to look at voltage and current values all around the circuit
- We do this by dividing our circuit into "meshes" or loops and then doing KCL and KVL analysis



Let's Solve this together



Let's Solve this together