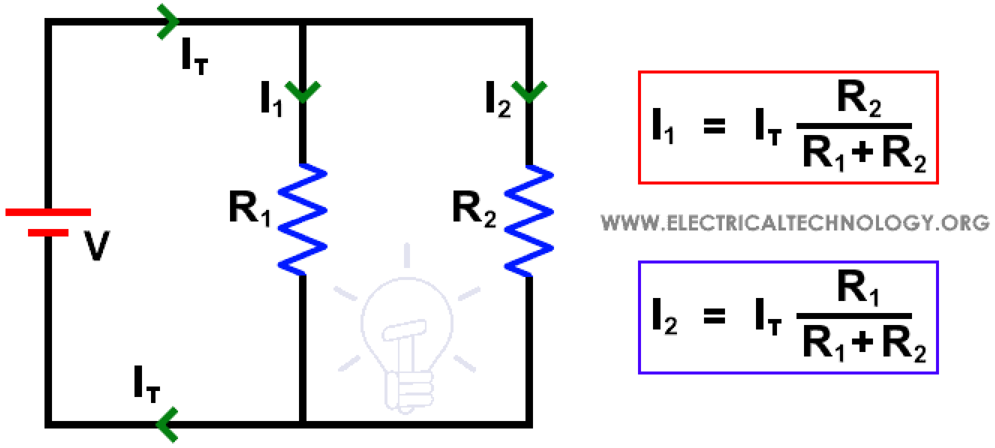
Norton’s Theorem

YORK COLLEGE & UNIVERSITY CENTRE

Recap – Current Divider

- The current divider rule can be used to work out the current through separate branches if we know the overall (total) current

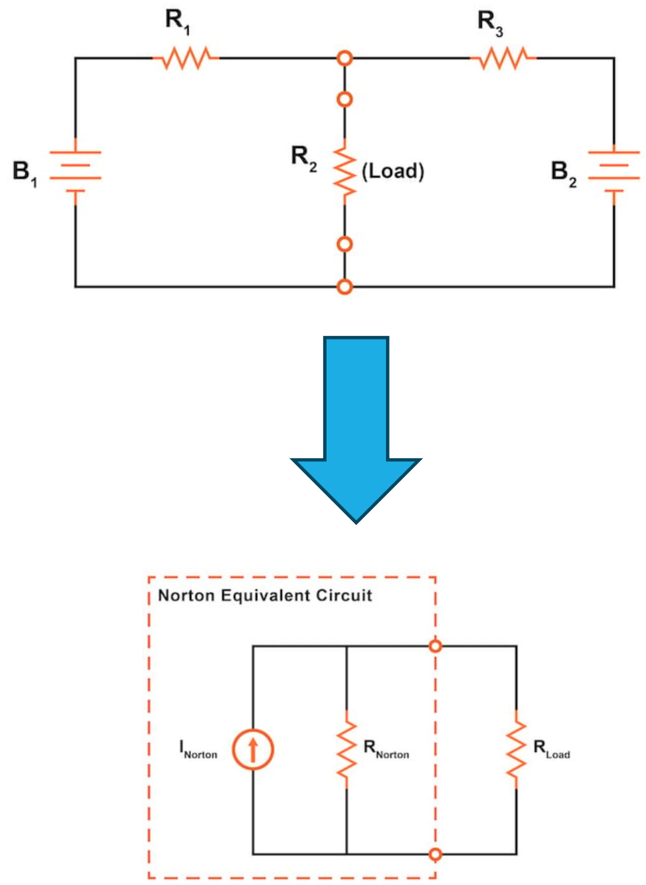


$$\boxed{I_1 = I_T \frac{R_2}{R_1 + R_2}}$$

$$\boxed{I_2 = I_T \frac{R_1}{R_1 + R_2}}$$

What is Norton's Theorem

- Norton's Theorem says that **any linear circuit** (a network of resistors, voltage sources, and current sources) can be simplified to a **single current source in parallel with a single resistor**, as seen from two output terminals.



Norton’s vs Thevenin’s

Feature	Thevenin’s Theorem	Norton’s Theorem
Equivalent form	Voltage source in series with a resistor	Current source in parallel with a resistor
Source type	Voltage source ($V_{t}h$)	Current source (I_{n})
Resistance	Thevenin resistance ($R_{t}h$)	Norton resistance (R_{n}) — same value as $R_{t}h$
Relationship	—	$I_{n} = V_{t}h / R_{t}h$
Useful when	The load is easier to analyse with a voltage source	The load is easier to analyse with a current source

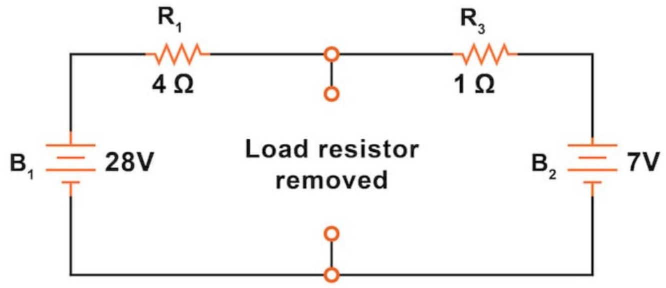
Steps to solving Norton's Theorem

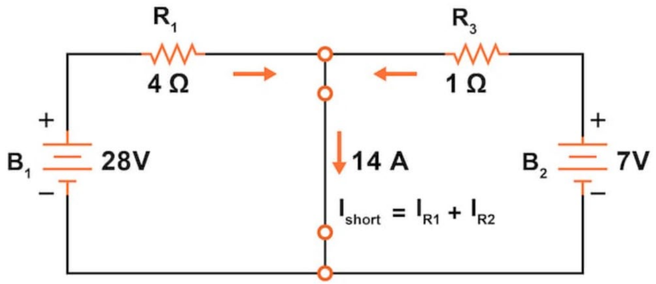
1. Remove the load resistor (the part you're focusing on).

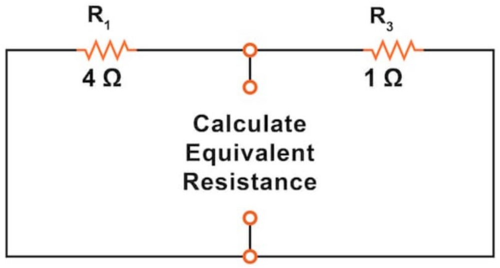
2. Find the short-circuit current between the two terminals — that's I_n.

3. Turn off all power sources and find the equivalent resistance between the terminals — that's R_n.

4. Draw a simple equivalent: a current source (I_n) in parallel with a resistor (R_n), and then reconnect your load to it.

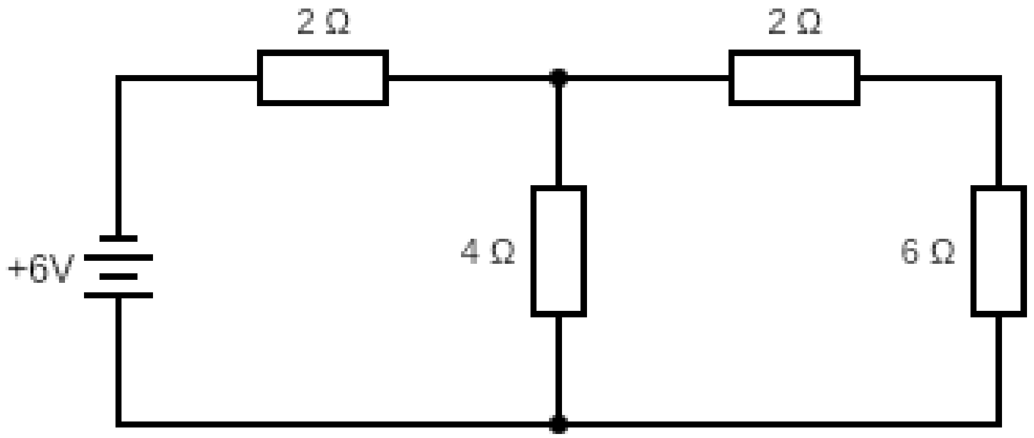






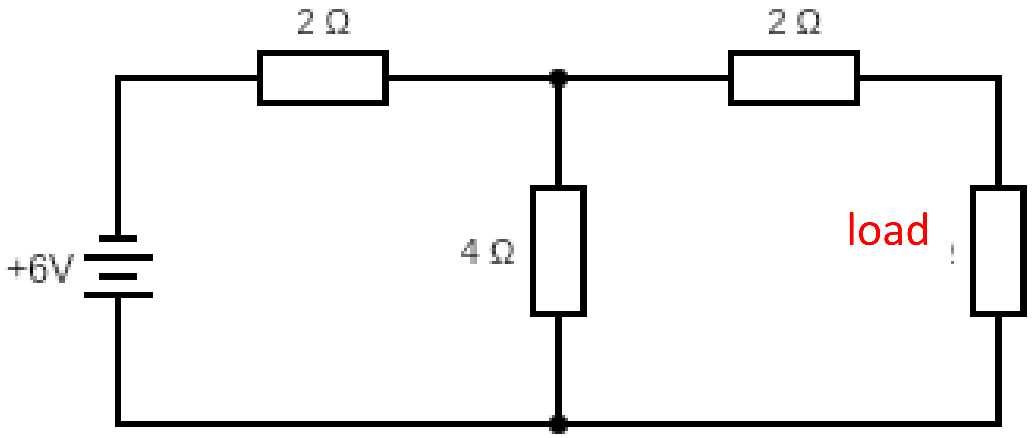
Example Solve

- Our first step is to decide which resistor is our load (often this is given to us but not always)
- For this we are using the 4-ohm resistor as our load



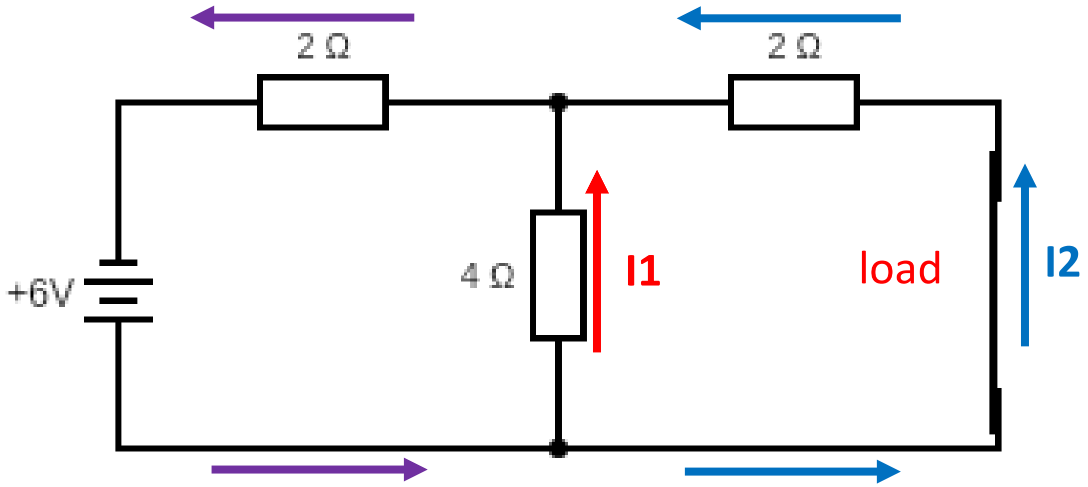
Example Solve

- We will start by working out our (I_n)
- To do this we must keep the voltage source and other components and just short the load
- Then we will work out the current flowing over the load



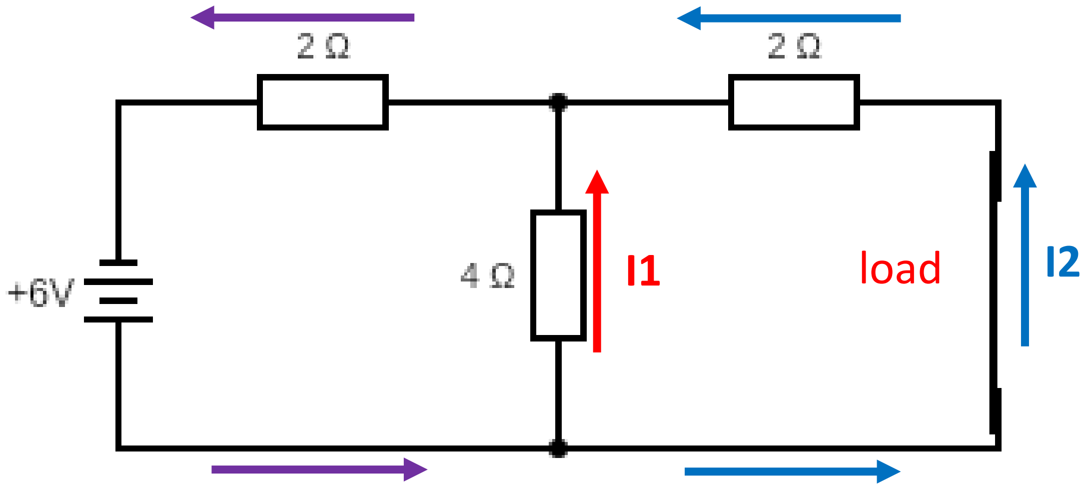
Example Solve

- To work out the current over the load we will first work out the current throughout the whole circuit
- The current through the whole circuit is equivalent to the $\frac{v_{source}}{R_{eq}}$
- We can work out the R_{eq} by doing $2 + \frac{1}{\frac{1}{4}+\frac{1}{2}} = \frac{10}{3}$



Example Solve

- $R_{eq} = \frac{10}{3}$
- $\frac{v_{source}}{R_{eq}} = \frac{6}{10/3} = 1.8$ (total current)
- So the purple arrows are 1.8A



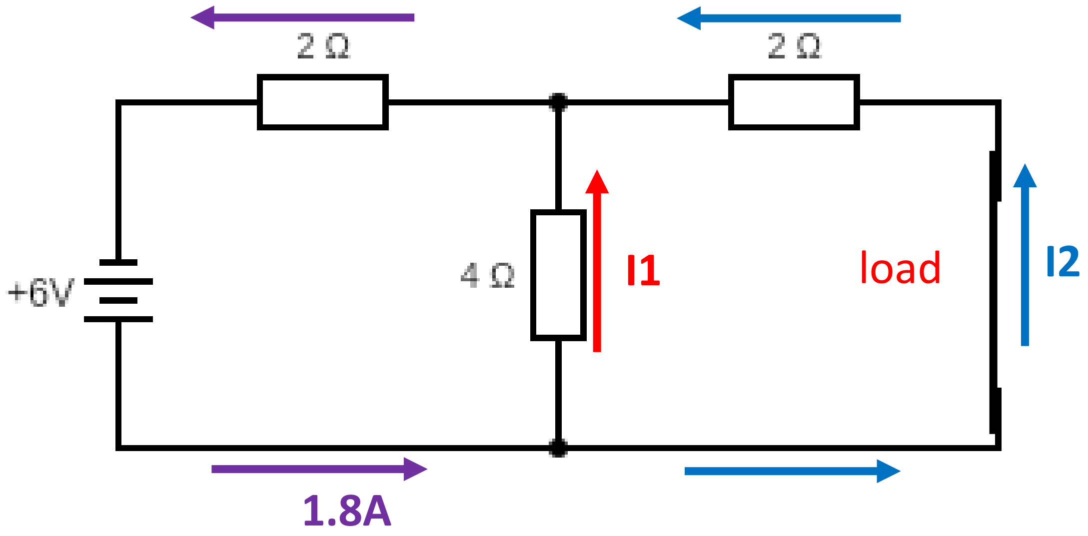
Example Solve

$$I_2 = I_T \frac{R_1}{R_1 + R_2}$$

- We can then apply the current divider rule to find the current through I2

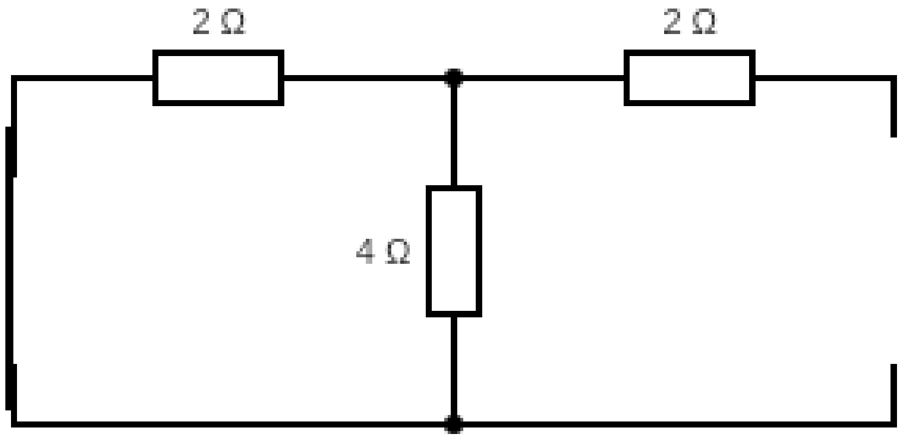
- $I_2 = 1.8 * \left(\frac{4}{4+2}\right) = 1.2$

- Therefore, the current over the load (I_n) is **1.2**



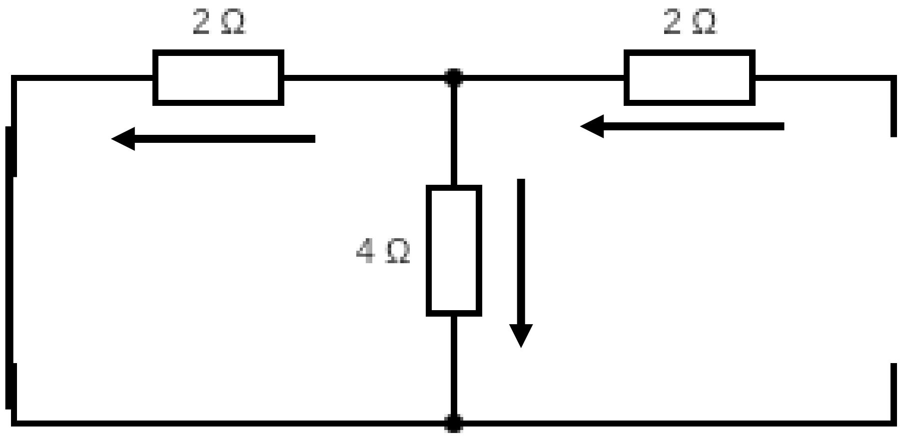
Example Solve

- Next we calculate the Norton's Resistance
- To do this we take out the load (treat it as an open circuit) and turn sources into short circuits
- We then look at the equivalent resistance from the perspective of the open circuit



Example Solve

- So we have one resistor in series with 2 parallel resistors
- $R_n = 2 + \frac{1}{\frac{1}{2}+\frac{1}{4}} = \frac{10}{3} \approx 3.33$
- So we now have I_n and R_n
- All that's left to do is draw our equivalent



Example Solve

- $R_n \approx 3.33$
- $I_n = 1.2$