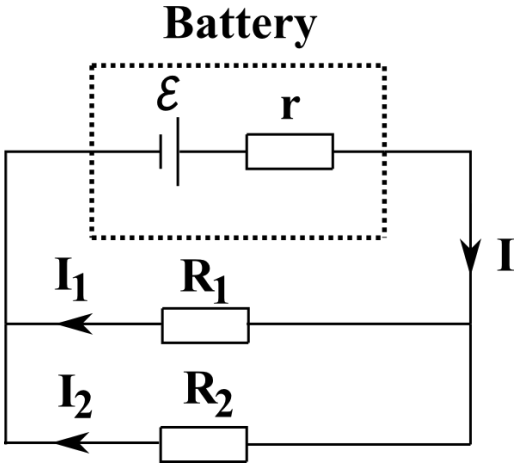
Answer on Question 58886, Physics, Electric Circuits

Question:

A 3 V battery with internal resistance 0.5 Ω is connected across a parallel combination of 1 Ω and 2 Ω resistances. The current in the 2 Ω resistance is___?

Solution:

Here's the sketch of our task:



We have a battery with electromotive force of $\mathcal{E} = 3\ V$; the internal resistance of the battery is $r = 0.5\ \Omega$. That battery is connected across a parallel combination of $R_1 = 1\ \Omega$ and $R_2 = 2\ \Omega$ resistances, as shown in the picture above. Our task is to find the current in the resistance R_2.

Let's first find the equivalent resistance of combination of resistances $R_1 = 1\ \Omega$ and $R_2 = 2\ \Omega$ that connected in parallel (let's call it the equivalent load resistance):

$$R_{eq(load)} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{R_1 R_2}{R_1 + R_2} = \frac{1\ \Omega \cdot 2\ \Omega}{1\ \Omega + 2\ \Omega} = 0.66(6)\ \Omega.$$

The combination of these two resistances is in series with the internal resistance of the battery, r. Let's find the equivalent resistance of the internal resistance of the battery, r, and the equivalent load resistance, $R_{eq(load)}$:

$$R_{eq} = r + R_{eq(load)}.$$

Then, from the Ohm's law we can find the current in the circuit:

$$I = \frac{\mathcal{E}}{R_{eq}} = \frac{\mathcal{E}}{r + R_{eq(load)}} = \frac{3\ V}{0.5\ \Omega + 0.66(6)\ \Omega} = 2.57\ A.$$

So, the terminal voltage of the battery will be:

$$V = \mathcal{E} - Ir = 3\ V - 2.57\ A \cdot 0.5\ \Omega = 1.715\ \text{V}.$$

Finally, from the Ohm's law we can find the current in the $R_2 = 2\ \Omega$ resistance:

$$I_2 = \frac{V}{R_2} = \frac{1.715\ V}{2\ \Omega} = 0.86\ A.$$

Answer:

$I_2 = 0.86\ A.$