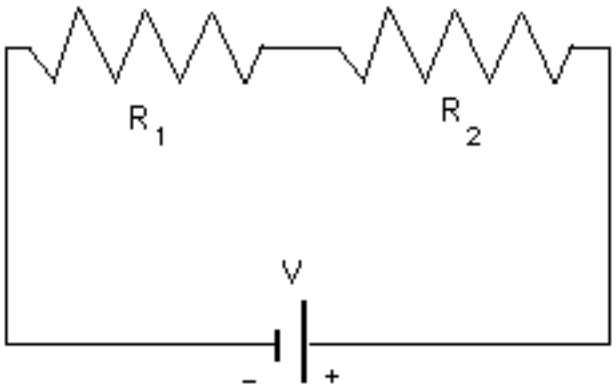
Electronics Lab #2

Simple Series and Parallel Circuits

The definitions of series and parallel circuits will be given in this lab. Also, measurements in very simple series and parallel circuits will be discussed.

Two Resistors in Series

A circuit having two resistors R_1 and R_2 in **series** is indicated below:



If two resistors are in **series**, then same current i flow through each resistor. Suppose for example, the voltage source V=12 volts and the resistors have values $R_1 = 10,000\,\Omega$ and $R_2 = 20,000\,\Omega$. (You should repeat this experiment using two resistors in your parts box. Make sure the resistors are large enough so that the current is smaller than 1 milliampere otherwise you might blow a fuse in your ammeter, "fry" (burn out) a resistor, or meltdown your power supply.)

IMPORTANT NOTE: If you use an ohmmeter to measure the values of the resistors, do NOT have the battery attached while making the measurement otherwise you will get incorrect measurement for the resistance.

Since the two resistors are in series, the total resistance is

$$R_{Total} = R_1 + R_2 \qquad (1)$$

and numerically you have

$$R_{Total} = 10,000\,\Omega + 20,000\,\Omega = 30,000\,\Omega \qquad (2)$$

Check that the total resistance of two resistors in series is indeed correct using an ohmmeter with the

battery not attached.

The current i in this series circuit is given by Ohm's law as

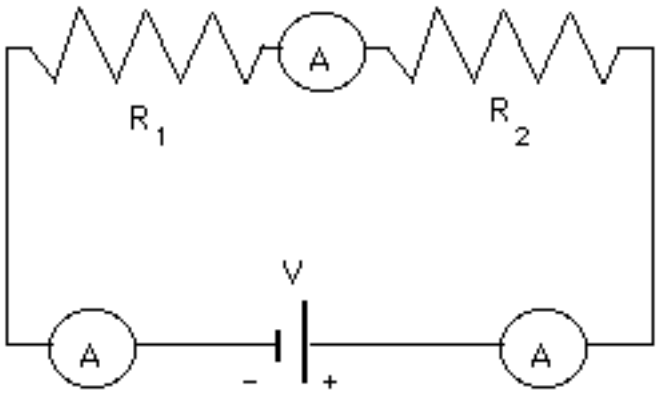
$$i = \frac{V}{R_{Total}} = \frac{12\ \text{Volts}}{30,\ 000\ \Omega} = 0.4 \times 10^{-3}\ \text{A} \qquad (3)$$

or 0.4 milliamps. You can have *Mathematica* does the calculation obtaining

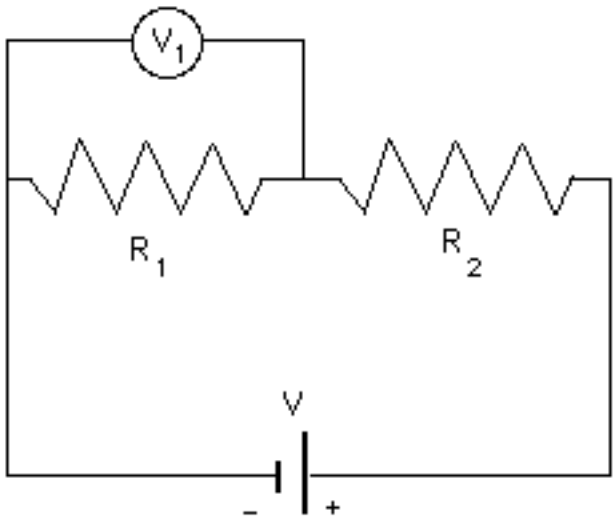
```
12
--------
30 000.

0.0004
```

If you place an ammeter in each spot indicated in the circuit below, you should get the same value of the current i.



The voltage across each resistor is **different** for the case of resistors in series. For example, the voltage across resistor R_1 is determined with a voltmeter as indicated below:



It is also easy to calculate the voltage V_1 since we already know the current i is resistor R_1. In general,

$$V_1 = i\, R_1 \tag{4}$$

and for the particular example at hand

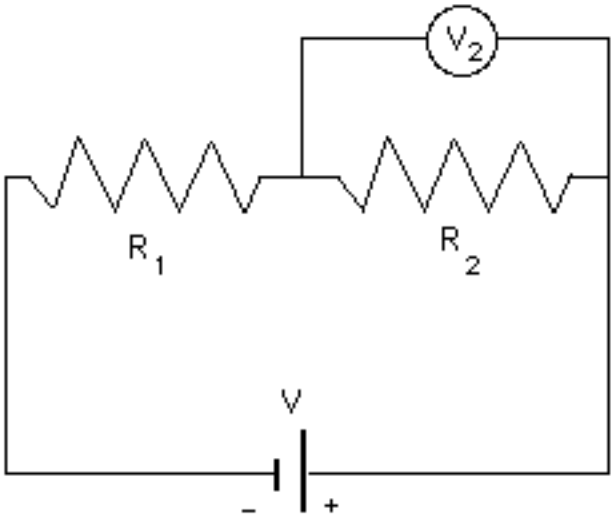
$$V_1 = \left(0.4 \times 10^{-3}\ \text{A}\right) \times (10,000\ \Omega) = 4\ \text{Volts} \tag{5}$$

since using *Mathematica* we obtain

```
(0.4 × 10^-3) × (10 000)
```

```
4.
```

Similarly the voltage V_2 across the resistor R_2 is measured as indicated below:



The voltage V_2 is calculated as below:

$$V_2 = i\, R_2 \tag{6}$$

since the same current flows through both resistors since they are in series. For the particular example at hand

$$V_2 = \left(0.4 \times 10^{-3}\ \text{A}\right) \times (20,\ 000\ \Omega) = 8\ \text{Volts} \tag{7}$$

since using *Mathematica* we obtain

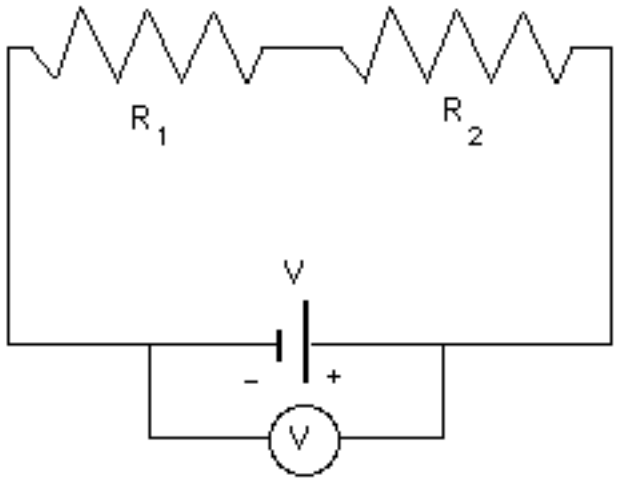
```
(0.4 × 10^-3) × (20 000)
```

```
8.
```

Notice the sum of the voltages across the resistors

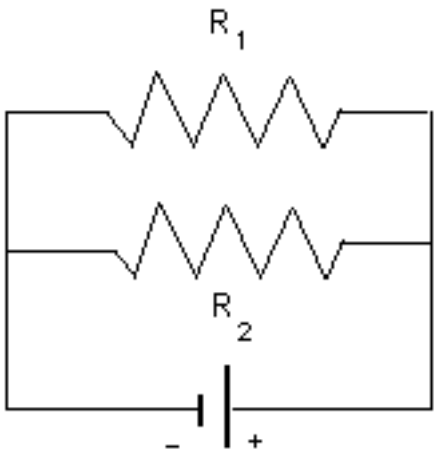
$$V = V_1 + V_2 = 4\ \text{V} + 8\ \text{V} = 12\ \text{V} \tag{8}$$

is just the battery voltage. To measure this voltage attach the voltmeter as indicated below:



Two Resistors in Parallel

A circuit having two resistors R_1 and R_2 in **parallel** is indicated below:



If two resistors are in **parallel**, then same **voltage** is across each resistor. The total resistance of two resistors in parallel is given by

$$\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2} \tag{9}$$

Suppose the same two resistors as before, $R_1 = 10,\ 000\,\Omega$ and $R_2 = 20,\ 000\,\Omega$ are in parallel, then

$$\frac{1}{R_{Total}} = \frac{1}{10,\ 000\,\Omega} + \frac{1}{20,\ 000\,\Omega} \tag{10}$$

Using *Mathematica* we obtain

```
1/10000. + 1/20000
```

```
0.00015
```

and thus

$$R_{Total} = \frac{1}{0.00015} = 6,\ 667\,\Omega \tag{11}$$

since *Mathematica* yields

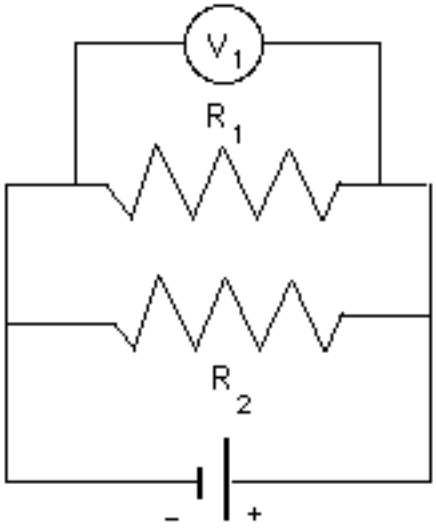
```
1/0.00015
```

```
6666.67
```

IMPORTANT NOTE: Once again, when you work on your own laboratory circuit, make sure the resistance measurement using the ohmmeter is done without the battery source attached.

When you attach the battery and measure the voltage across the resistor R_1 you should get V=12 Volts

the same as the battery voltage and this measurement is done as indicated below:



The voltmeter can be attached across resistor R_2 in a similar way and again you should get V=12 Volts.

The current in each resistor is different. For example, the current in resistor R_1 is given via Ohm's law as

$$i_1 = \frac{V}{R_1} \tag{12}$$

The numerical value of this current for the above example is

$$i_1 = \frac{12\ V}{10,\ 000\ \Omega} = 1.2\ ma \tag{13}$$

```
  12
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10 000.

0.0012
```
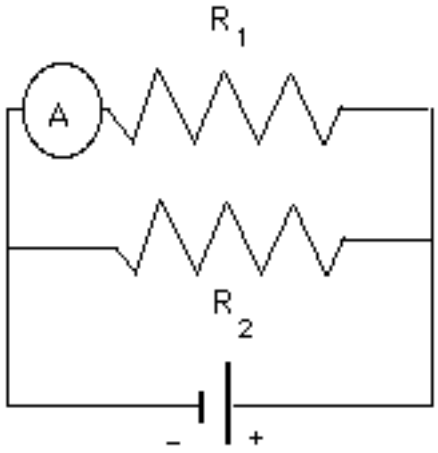

and the ammeter should be attached as indicated below:



Similarly the current in resistor R_2 is given via Ohm's law as

$$i_2 = \frac{V}{R_2} \tag{14}$$

The numerical value of this current for the above example is

$$i_2 = \frac{12\ V}{20,\ 000\ \Omega} = 0.6\ ma \tag{15}$$

```
  12
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20 000.

0.0006
```
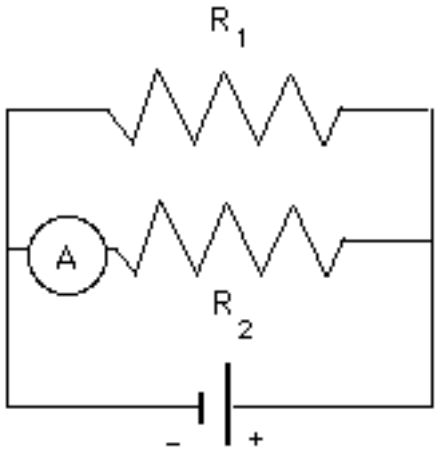

and the ammeter should be attached as indicated below:



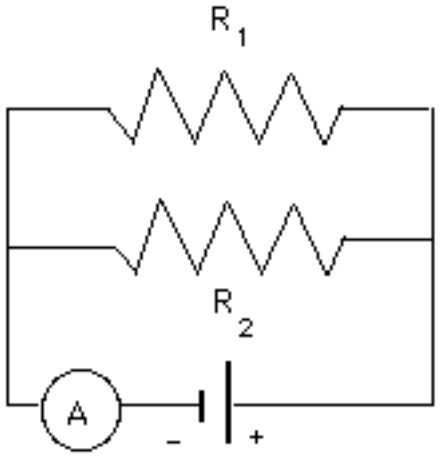
The total current supplies by the battery is the sum of the currents through the resistors.

$$i = i_1 + i_2 \tag{16}$$

The numerical value of the total current is

$$i = 1.2\ ma + 0.6\ ma = 1.8\ ma \tag{17}$$

and this current is measured with ammeter attached as indicated below:



Experiments You Should Do

Series Circuit: Pick two resistors from your parts box in the 10,000Ω range. Measure the resistances using the Ohmmeter and make sure the values agree with the color code. Connect the resistors in series and measure the total resistance and see that this resistance agrees with what you expect from numerical calculation. Calculate the current using Ohm's law. Measure the value of the current in each resistor and make sure this agrees with the theoretical numerical value of the current. Calculate the voltage across each resistor using Ohm's law. Verify that these voltages are correct using the voltmeter attached to the circuit in the proper manner described above.

Parallel Circuit: Again, pick two resistors from your parts box in the 10,000Ω range. Measure the resistances using the Ohmmeter and make sure the values agree with the color code. Connect the resistors in parallel and measure the total resistance and see that this resistance agrees with what you expect from numerical calculation. Calculate the total current supplied by the battery using Ohm's law. Measure the value of the total current and make sure this agrees with the theoretical numerical value of the current. Calculate the current through each resistor using Ohm's law. Verify that these currents are correct using the ammeter attached to the circuit in the proper manner described above. Also, make sure the total current supplied by the battery is the sum of the currents through the resistors.