Electricity and Magnetism
Lab 5-6
Resistors and Voltage Drops

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Overview

- reminder about Ohm's Law
- potential drops in circuits
- reminder about ammeters and voltmeters
- using a breadboard

Ohm's Law

Ohm's law is the principle used to measure resistance in the first and second labs.

We found last time that Ohm's law held for the resistors we are using at room temperature. We can now assume it holds for each component resistor.

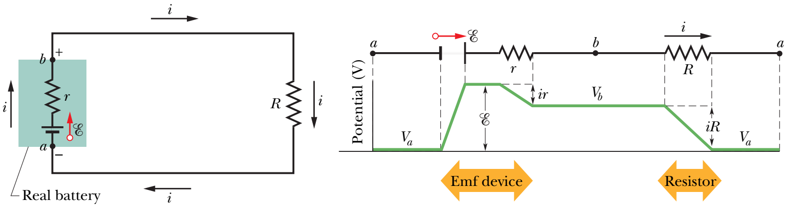
Remember, Ohms Law:

$$V = IR$$

where R is constant.

In this lab, we can use Ohm's law to figure out the potential drop across or current through resistors that are just one part of a larger circuit.

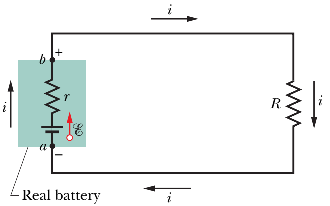
Current and Potential Difference in a Circuit

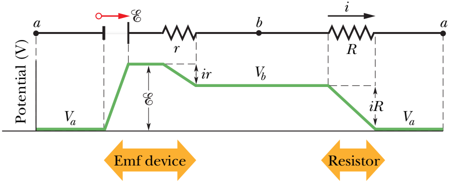


Here, resistances are in series.

What do we know about the current through each resistor?

Current and Potential Difference in a Circuit





Here, resistances are in series.

What do we know about the current through each resistor? It must be the same for both!

The "resistor" of value r has a voltage drop of $V_r = ir$.

The R resistor has a voltage drop of $V_R = iR$.

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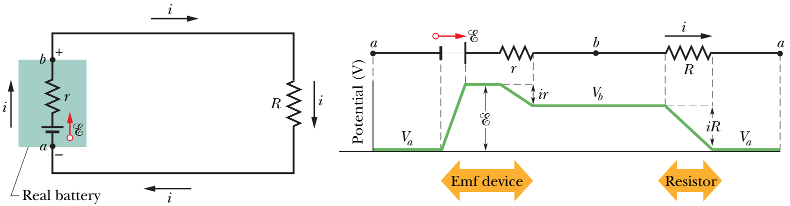

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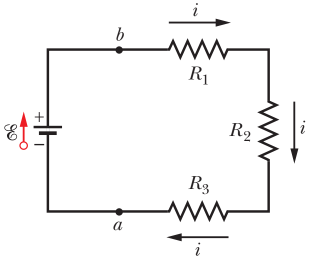
How could we find i? What is the effective resistance of r and R together?

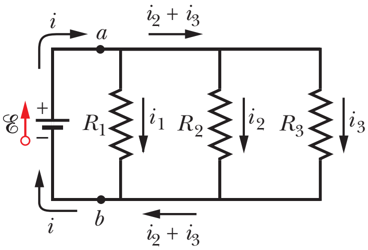
Series and Parallel

Example

Resistors in series:



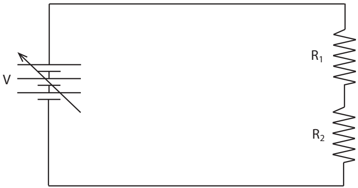
Resistors in parallel:



Series and Parallel

So for resistors in series, we can use that the current i is the same across both resistors to find:

1. the potential drop across each resistor
2. the effective resistance of the two resistors together



Resistors in Series

The current though resistors in series in a loop is the same.

Let the total potential difference across two resistors be ΔV, then

$$\Delta V = IR_1 + IR_2 = I(R_1 + R_2)$$

Then the effective equivalent resistance of both together is just the sum

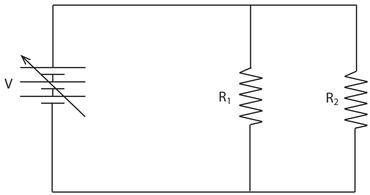
$$R_{\text{eq}} = R_1 + R_2$$

For n resistors in **series**:

$$R_{\text{eq}} = R_1 + R_2 + \ldots + R_n = \sum_{i=1}^{n} R_i$$

Series and Parallel

What about two resistors in parallel? What is the same across both resistors?



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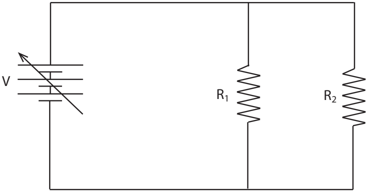


The potential difference!

Resistors in Parallel

The potential difference across two resistors in parallel is the same. (Loop rule.)

Let I be the total current that flows through both resistors: $I = I_1 + I_2$. (Junction rule.)

$$I = \frac{\Delta V}{R_{eq}} = \frac{\Delta V}{R_1} + \frac{\Delta V}{R_2}$$

Dividing the equation by ΔV:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

For n of resistors in **parallel**:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n} = \sum_{i=1}^{n} \frac{1}{R_i}$$

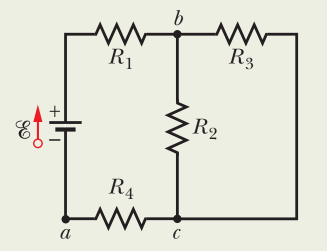
Resistors vs. Capacitors

Table of equivalent capacitances and resistances for series and parallel.

	resistors	capacitors
series	$R_{\text{eq}} = \sum R_i$	$\frac{1}{C_{\text{eq}}} = \sum \frac{1}{C_i}$
parallel	$\frac{1}{R_{\text{eq}}} = \sum \frac{1}{R_i}$	$C_{\text{eq}} = \sum C_i$

Example

Consider the circuit pictured with $\mathcal{E} = 12$ V, and the following resistor values: $R_1 = 20\ \Omega$, $R_2 = 20\ \Omega$, $R_3 = 30\ \Omega$, and $R_4 = 8.0\ \Omega$.



What is the current through the battery?

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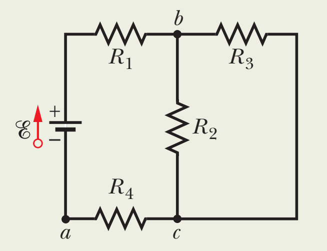

What is the current through the battery?
answer: $I = 0.30$ A

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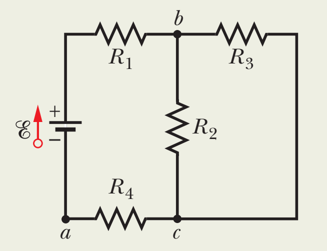

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What is the current through resistor R_2?

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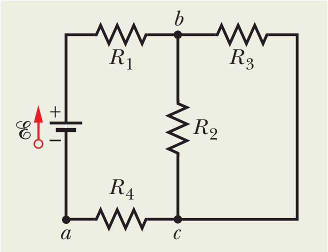


What is the current through the battery?
answer: $I = 0.30$ A

What is the current through resistor R_2?
answer: $I_2 = 0.18$ A

Lab Report

This is a 2-week lab. You will need to prepare a lab report.

Style of the lab report: pretend you are a scientist. Your goals:

- clearly communicate precisely what you did, and the results you got
- let others know exactly how to repeat your experiment, confirm your results
- give an introduction to the reader of any theory involved

Lab report

What to assume about the reader:

- they do not know what was on the instruction sheet
- they do not know what precise equipment you used
- they already know how to use all of the equipment
- they are skeptical

Lab report

The lab report should contain:

- an introduction: what are you investigating in this experiment
- the hypothesis: the theoretical predictions you are trying to test
- a description of the experimental procedure and all equipment used
- your data / measurements
- analysis: how well did your data agree with the predictions? Were there any sources of experimental error? Were they systematic or random? What would you do differently in the future to improve this experiment?
- conclusion: Does the theory seem correct? Does your data support it? If not, why not? If there are a few data points that deviate from predictions, try to explain what may have occurred. What other related questions could you investigate in similar experiments?

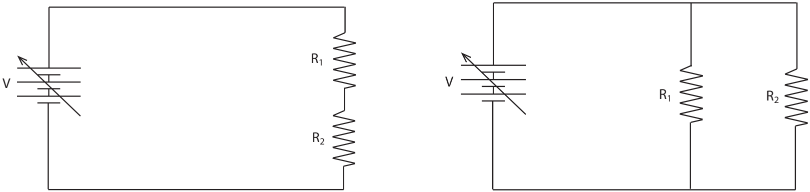
Lab report

Other things:

- diagrams and tables are often very helpful
- do not make statements without evidence
- do error analysis or give percentage differences where appropriate
- do not copy word-for-word from the instruction sheet!

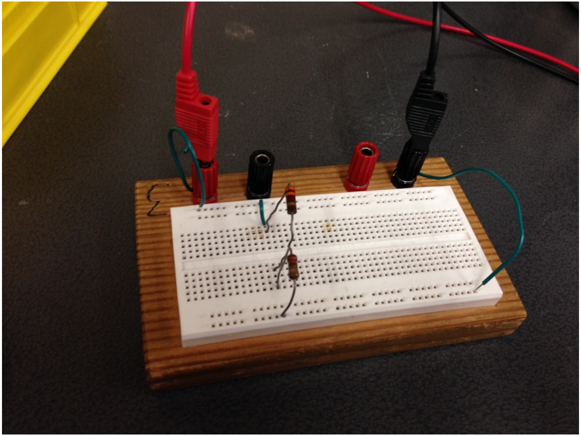
Procedure

We will construct these circuits:



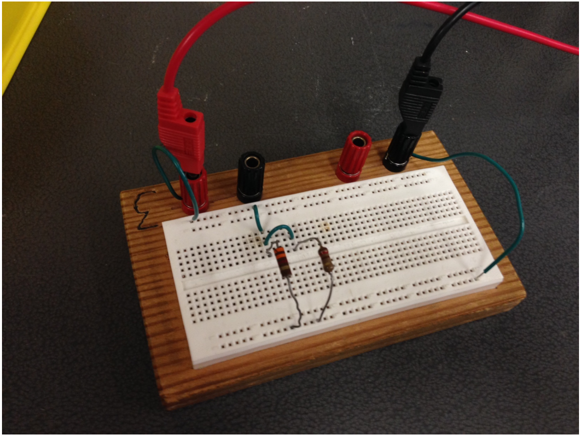
Procedure

On your table that will look like:



Procedure

and:



Procedure

You will use the Simpson VOM as a voltmeter in this experiment and the HP-DMM as an ammeter to measure the current through each resistor and the potential difference across each.

Meters

Ammeter

A device for measuring **current** in a circuit.

The ammeter must be connected in series in the part of the circuit where you want to test the current.

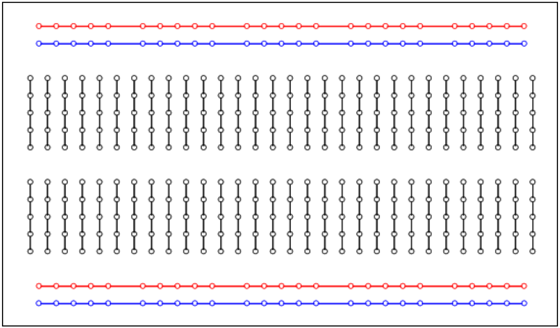
Voltmeter

A device for measuring **potential difference** across a component of a circuit.

The voltmeter must be connected in parallel across the component where you wish to measure the potential drop.

Breadboards

You will be using a breadboard. The internal wiring of the breadboard looks like this:

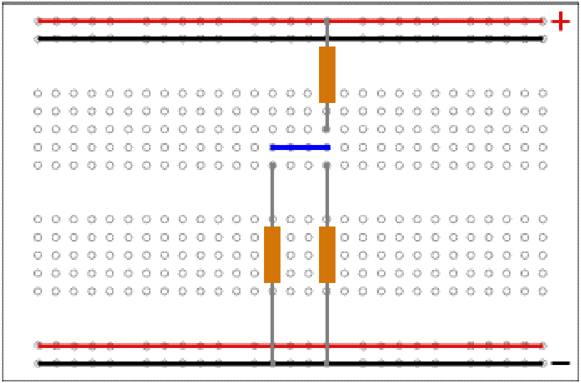


The top and bottom two rows are connected across the board.

Columns are connected downward up until the gap. There are no connections across the central gap. That is a good place to put components.

[1]Image from http://ecee.colorado.edu/ mathys/ecen2250/myDAQ01/

Example Breadboard Circuit

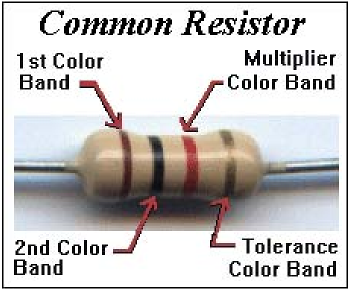


Reading the Value of Resistors

Color guide:

Resistor Color Code

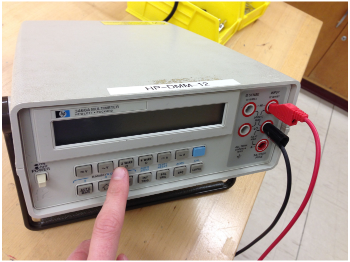
	Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Gray	White
	0	1	2	3	4	5	6	7	8	9
Multiplier	1	10	100	1,000	10,000	100,000	1,000,000	10,000,000	100,000,000	--



[1]Images from orcadxcc.org.

HP DMM wiring

To measure resistance:



To measure current (ammeter):