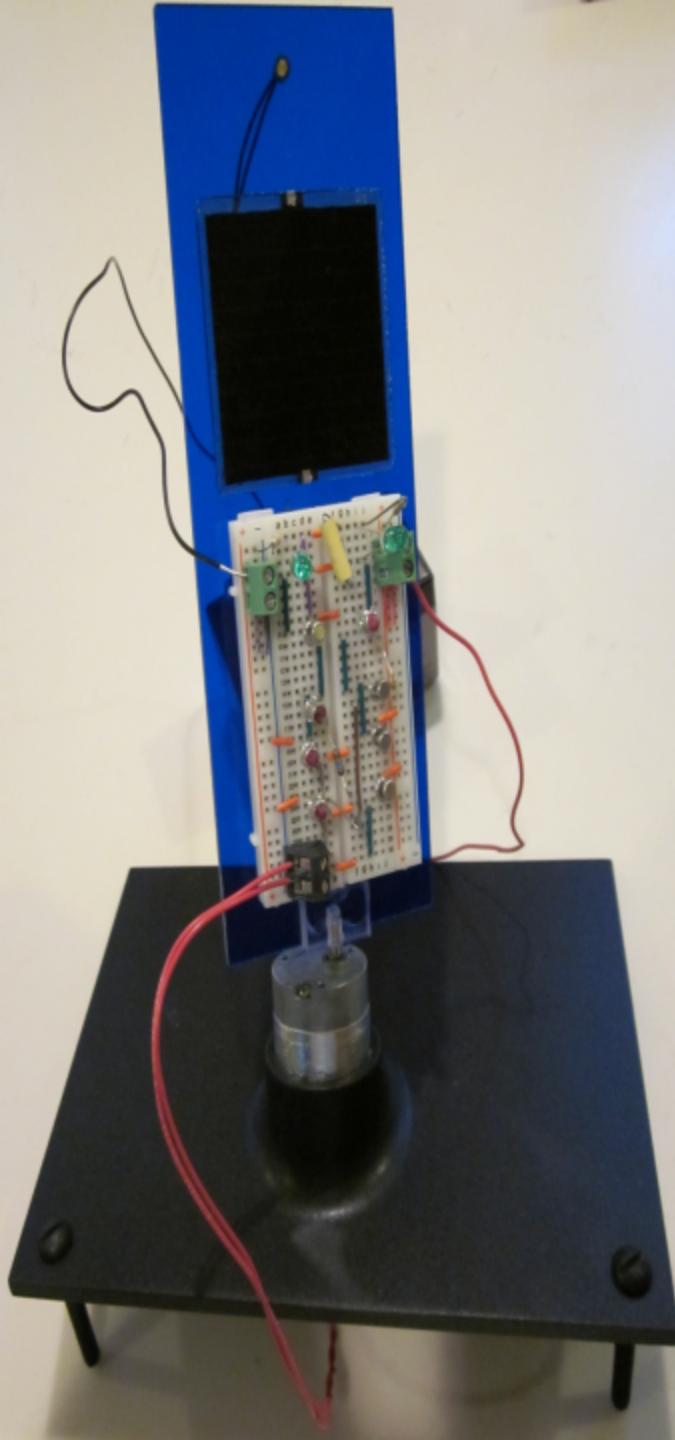


SVEL's Ohms Law Workshop Curriculum

For Middle & High Schools

A great way to introduce students to electricity



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Developed in participation with Stanford University' Solar & Wind Energy Program (SWEP) through EPA P3 grant

Agenda

Ohm's Law Workshop

- ❑ Classroom Teaching Slides
 - ❑ Story about applying Ohm's law in real world
 - ❑ Familiarity with electrical parameters (Current, Voltage Resistor)
- ❑ Electronics Parts Familiarity
 - ❑ Battery, Resistors, Multimeter, Light Bulb, Wires Breadboard
- ❑ Ohm's Law Hands on Exercises
 - ❑ Build a circuit to power on a light bulb
 - ❑ Exercise 1: Investigating voltage and current
 - ❑ Follow up exercise
 - ❑ Exercise 2: Investigating resistance and current
 - ❑ Follow up exercise
 - ❑ Summary of Ohm's law
- ❑ Appendix
 - ❑ Theory of electrical current
 - ❑ How to identify resistor value
 - ❑ Documents required to complete this workshop

Story: Pak-Pak & Tiny



Tiny, the baby elephant, and her mother, Pak-Pak, are going on a mission.

Story: Pak-Pak & Tiny



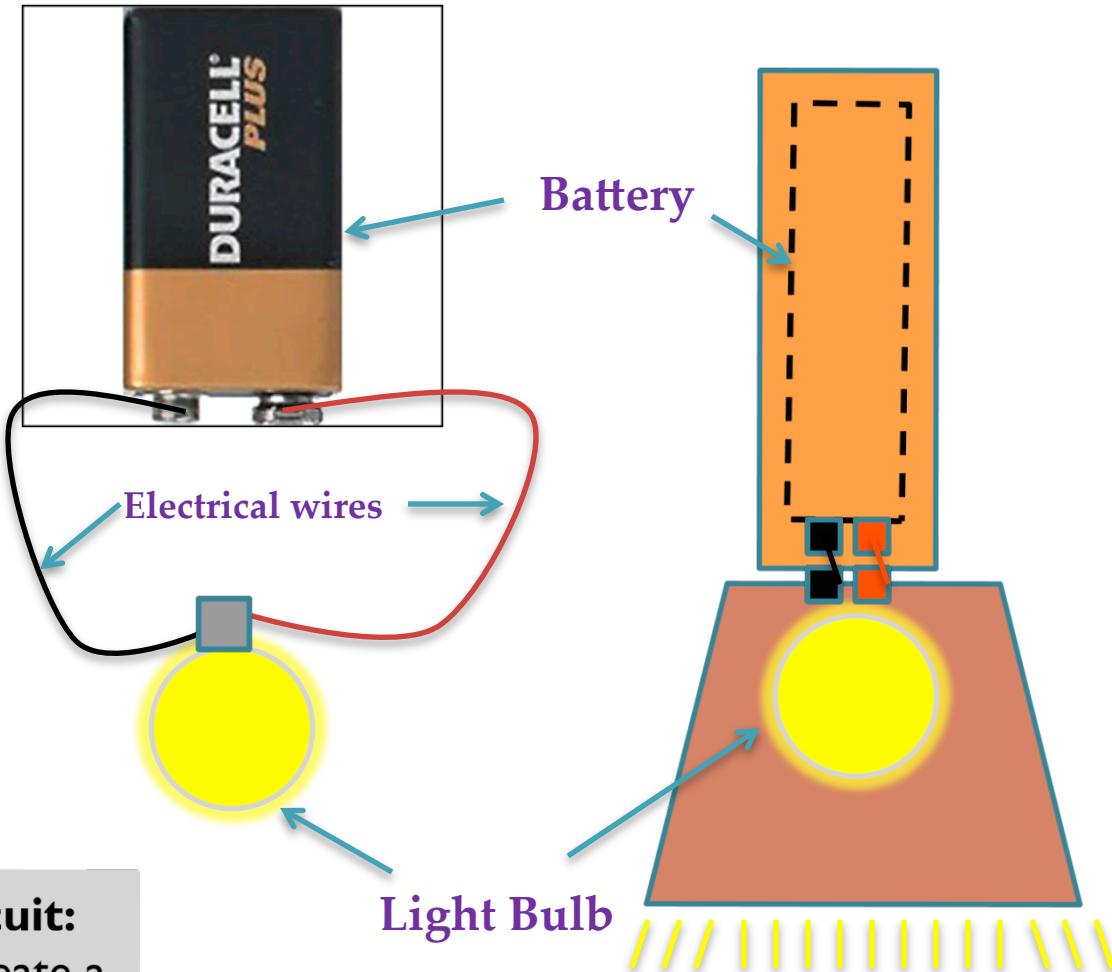
Tiny wants to get her best friend out of a dark cave that has no electricity. Can you suggest a way to Tiny?

Solution: Tiny's Problems

If you came up with an idea that Tiny can take a flashlight inside the cave, you guessed it correctly!

What is a flashlight?

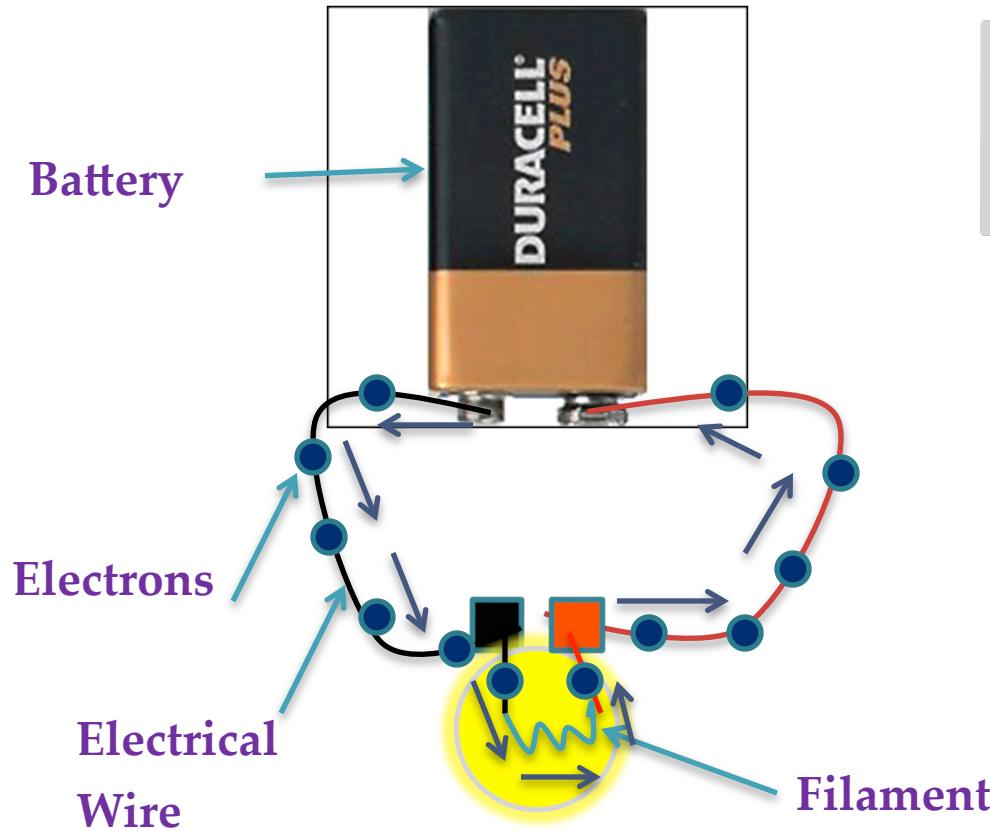
Flashlight



Electrical Circuit:
Electrical wires create a loop connecting battery with the bulb.

Why does a bulb light up when it is connected to a battery?

Battery



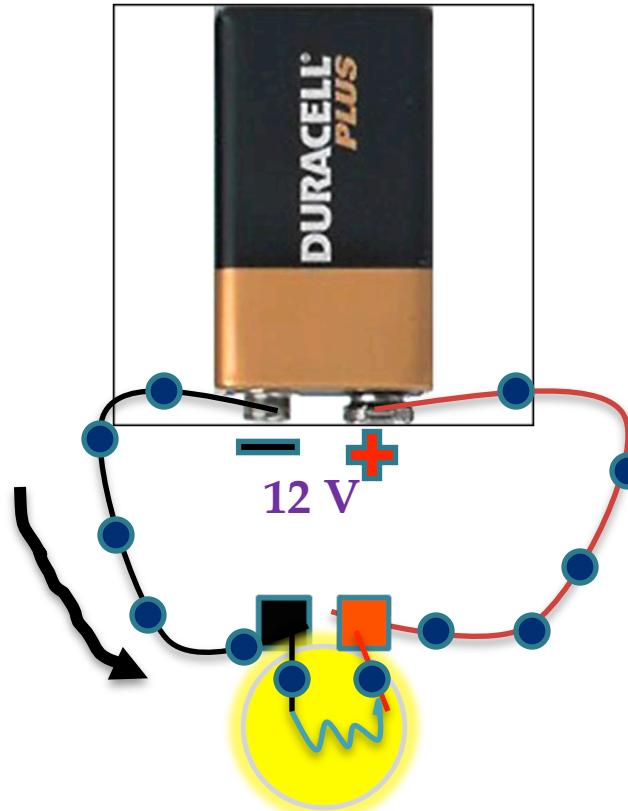
Electrons:
Electrons travel through the circuit wires.

- Battery stores energy. Stored energy is carried out by **electrons**.
- Electrons flow out of the battery through the **circuit**.
- Filament in the bulb is heated by electrons.
- Heated bulb filament produces visible light.

But, what makes electrons flow out of the battery in the first place?

Voltage

Electrons
are negatively
charged



Voltage:

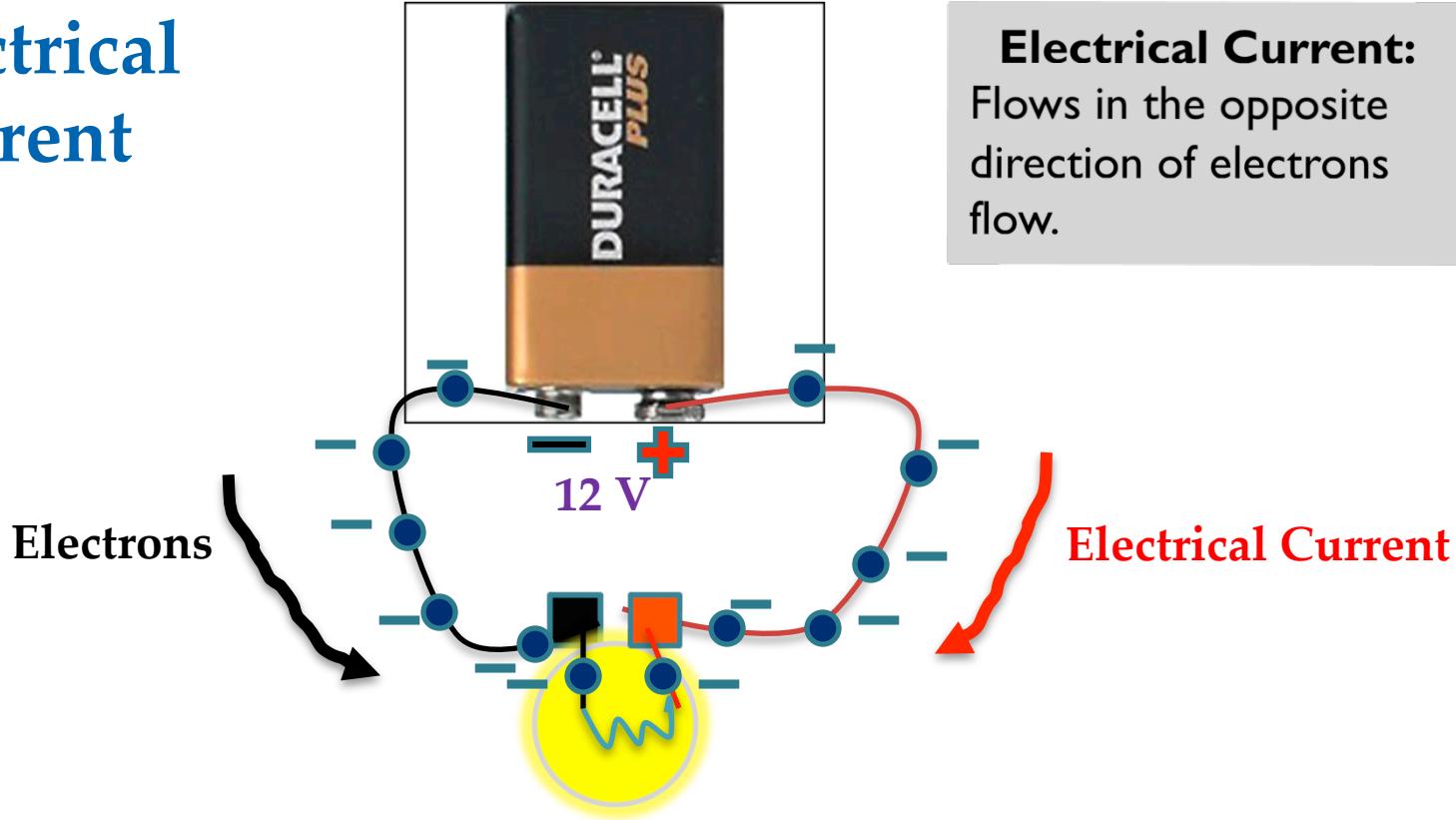
Voltage forces electrons to travel in the wire from battery “-” to “+.”

Why do electrons flow out of the battery?

- Battery has positive (+) & negative (-) terminals which represent the energy stored in it.
- Energy difference of the terminals is called **potential difference or Voltage**.
- Electrons are negatively charged so as soon as circuit is formed, they escape from battery “-” terminal and go to the “+” terminal.

I heard that battery discharges Current. But you are saying that battery discharges electrons. I am confused!

Electrical Current



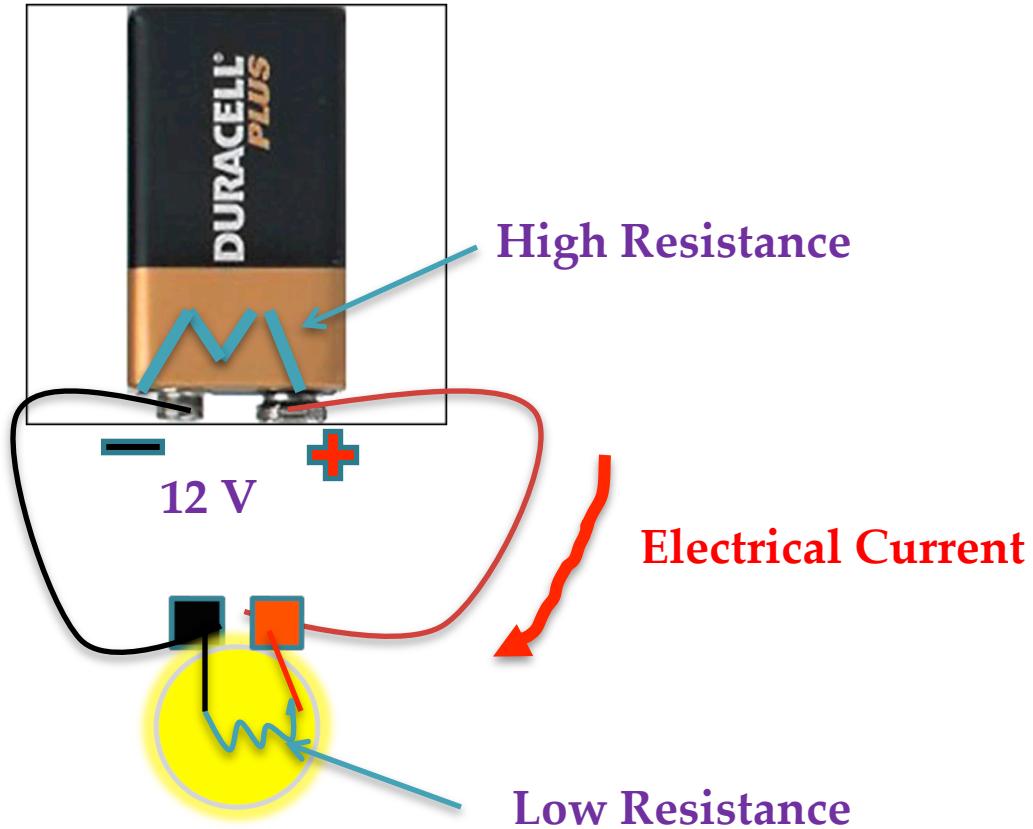
Electrons or Electrical Current?

- Electrons move from “-” to “+” terminal of the battery.
- **Electrical Current** flows in the opposite direction of the flow of electrons.
- From now on, we will only talk about Electrical Current & not electrons.

Why does the electrical current flow through the bulb filament and not through the battery itself?

Electrical Current:
Flows in the opposite direction of electrons flow.

Resistance



- Resistance reduces the current flow in a circuit.
- Electrical current flows through the least resistive path.
- Bulb filament is resistive but battery resistance is much more, so current flows through the bulb filament.

Summary: Voltage, Electrical Current, Resistance

Voltage (Potential Difference):

- Difference in energy between “+” & “-” terminals
- Causes flow of electrons out of battery

Electrical Current:

- Flow of electrons (from “-” to “+” terminal)
- Current is denoted to flow from “+” to “-”

Resistance:

- Electrical current flows to the least resistive path
- Resistance reduces the current flow in a circuit

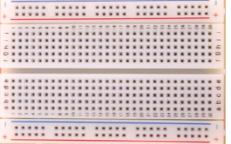
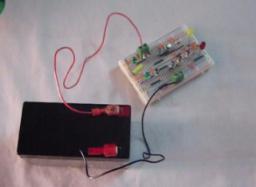
Electrical Circuit:

- Electrical wires create a loop that connects electrical
- Current will only flow if the circuit is a complete loop

Let's build a cool apparatus that will enable Tiny to light up the cave.

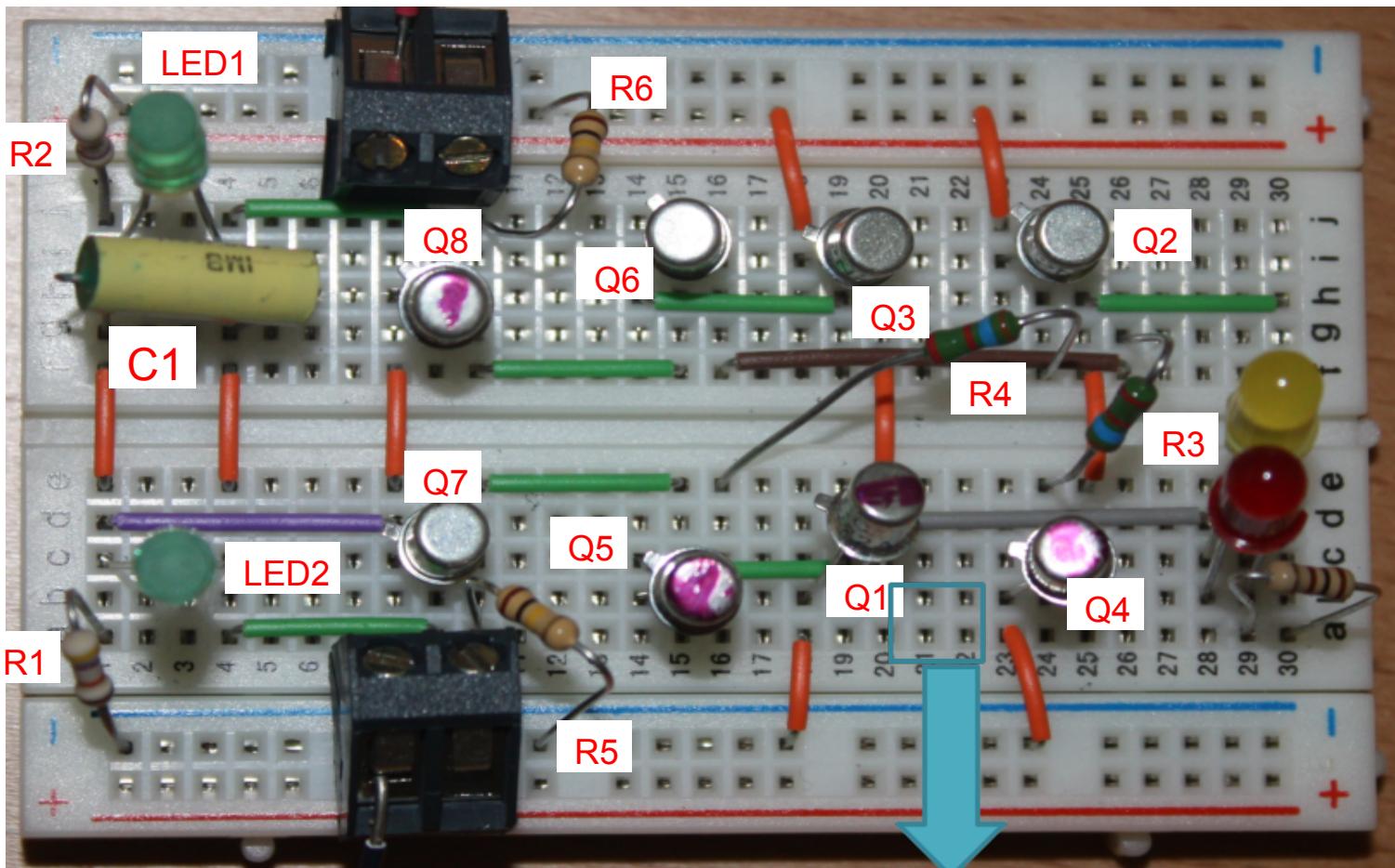
Can you guess all the parts required for the experiments?

Electronics Parts Familiarity

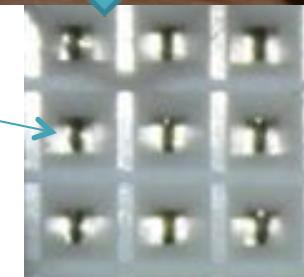
	Picture	Symbol	Description
Electronic components			<ul style="list-style-type: none"> ▪ Resistors have no polarity (can be connected either way) ▪ Resistor “RESISTS” flow of electric current through a circuit ▪ Stripes on the resistor shows the value of resistor
			<ul style="list-style-type: none"> ▪ Light bulb has no polarity (can be connected either way) ▪ It has a resistive filament
			<ul style="list-style-type: none"> ▪ A battery has “+” and “-” terminals, denoted by red and black. ▪ A battery stores charges (which generates electric current) when connected to an appliance or electric circuit.
			Breadboard is used to hold electronic parts in a circuit.
			Wire & Connectors connect battery to the breadboard power lines
Others			Jumper wire connects components in the breadboard

Breadboard

Breadboard is used to hold electronic components



Electronic components lock in



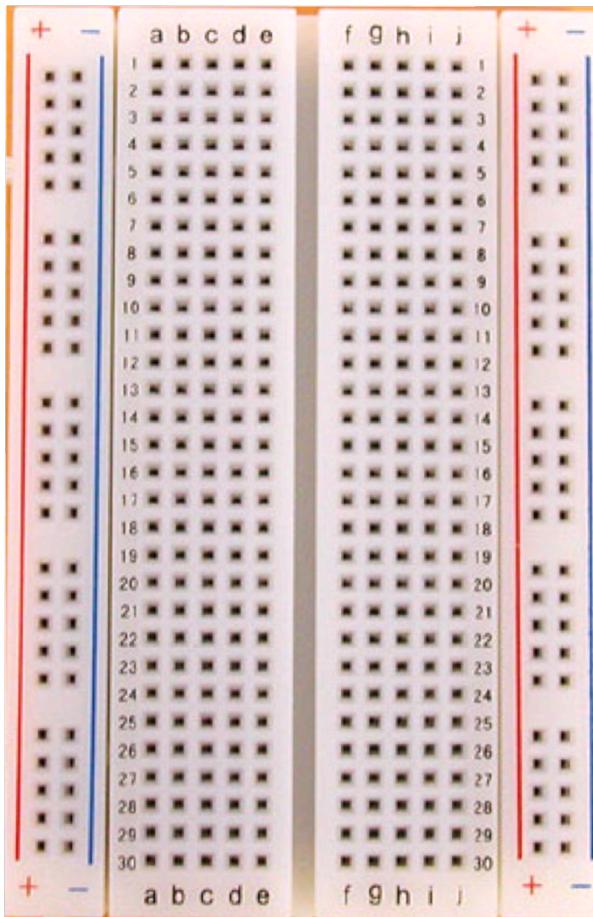
Breadboard Connections

Markings

- Rows are marked 1 to 30.
- Columns are marked A to J.

Power

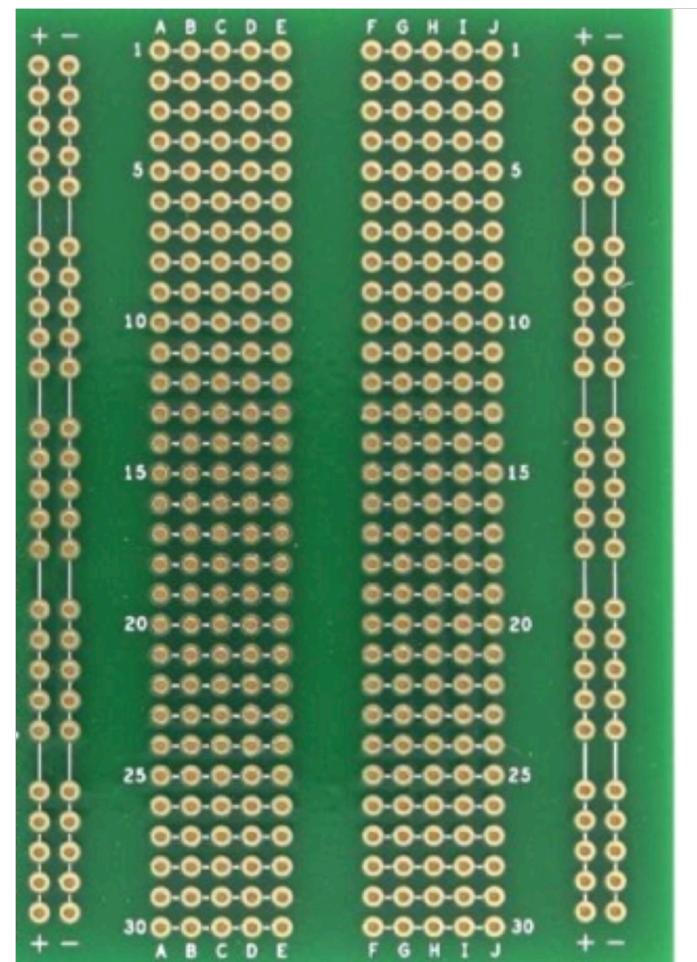
- On either side are connections to the battery marked with + & -.



Breadboard connection

Breadboard connection

- 5 points in each row are connected
 - i.e.: Insertion points A1 to E1 are connected
- None of the rows are connected to each other
 - i.e.: Columns E and F are not connected
- Insertion points in columns + are connected.
- Insertion points in columns - are connected.



Components lock in



Multimeter: How To Use It?

- Multimeter can measure: voltage, current or resistance (electrical parameters)
- How to select multimeter range to measure a parameter? Example: To measure-
 - 47K ohm resistor, set the knob at 200K ohm setting.
 - 5 mA current, set the knob at 20 mA.
 - 12V voltage, set the knob at 20V setting.

Note: If you choose the range that is lower than the parameter being measured, display will blink.
- How to connect multimeter in the circuit?
 - To measure voltage across a resistor: Connect the multimeter across the resistor
 - To measure resistance across a resistor: Connect the multimeter across the resistor
 - To measure current passing through a circuit: Connect multimeter in series with the circuit

Hands-on Exercises

- ◆ Let's connect the light bulb to the battery
- ◆ Learn about how Electrical Current, Voltage, and Resistance are related to each other

Voltage & Current: Observation Exercise-1

Experiments

- Step 1: Setup the light bulb circuit as described in the activity guide: OL01 (1.0A). Use **Resistor=100 ohm**
- Step 2: Setup the battery connection to the light bulb circuit as described in the activity guide: OL01 (1.0B). Use a **12V battery**.
- Step 3: Observe the glow of the light bulb
- Step 4: Remove **12V battery** from breadboard & connect a **6V battery**
- Step 5: Observe the glow of the light bulb again

Observation

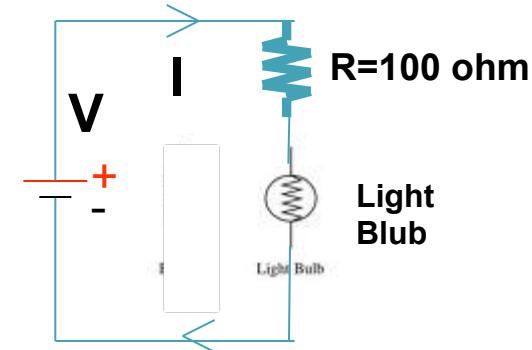
- Do you see any differences in the glow of the light bulb in the two cases - Step 1 & Step 4?
- Why does the light bulb glow brighter when connected to a 12V battery in comparison to a 6V battery?

Explanation

Higher voltage results in more current supplied to the light bulb filament

Point To Remember

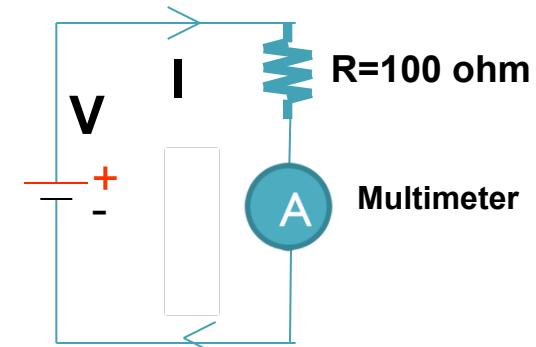
Current is proportional to Voltage



Further Explanation (Current & Voltage)

Experiment: Measure Current

- Step 1: Set multimeter knob to measure Current 200 mA
- Step 2: Connect 12V battery to breadboard
- Step 3: Connect 100 ohm resistor
- Step 4: Ask students:
 - To measure current, should the ammeter (multimeter) be connected in parallel or series?
 - Ask students if the Current in the circuit can be predicted? (Answer to be given later)
- Step 5: Remove light bulb and replace it with a multimeter
- Step 6: Take the Current reading
- Step 7: Replace 12V battery with a 6V battery
- Step 8: Take the Current reading again



Circuit For Current/Voltage

Measurement Table: Enter your current readings

Battery Voltage	Current
12 V	
6 V	

Note: Resistance is 100 ohm

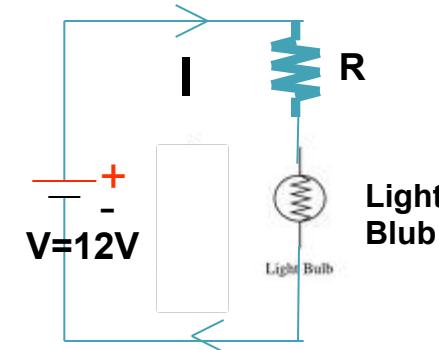
Observation: More current flows through the circuit with higher battery voltage

Explanation: Higher voltage (like high pressure in the water faucet) pushes more electron through the circuit (like water in the pipe)

Resistance & Current: Observation Exercise-2

Experiments

- Step 1: Setup the light bulb circuit as described in the activity guide: OL01 (1.0A). Use **Resistor=100 ohm**
- Step 2: Setup the battery connection to the light bulb circuit as described in the activity guide: OL01 (1.0B). Use a **12V battery**.
- Step 3: Observe the glow of the light bulb
- Step 4: Replace **100 ohm resistor** from the breadboard & replace it with a **200 ohm resistor**
- Step 5: Observe the glow of the light bulb again



Observation

- Do you see any differences in the glow of the light bulb in the two cases - Step 1 & Step 4?
- Why does the light bulb glow brighter when series resistor is small?

Explanation

Higher resistor impedes the flow of current through the circuit thereby reducing the glow of the light bulb

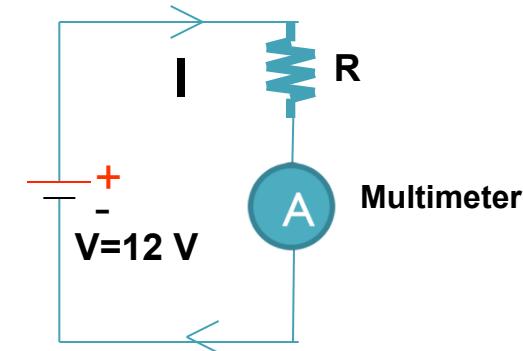
Point To Remember

Current is inversely proportional to Resistance

Further Explanation (Current & Resistance)

Experiment: Measure Current

- Step 1: Set multimeter knob to measure current 200 mA
- Step 2: Connect 12V battery to breadboard
- Step 3: Connect 100 ohm resistor
- Step 4: Remove light bulb and replace it with a multimeter
- Step 5: Replace 100 ohm resistor with a 200 ohm resistor
- Step 6: Take the Current reading



Measurement Table: Enter Current readings

Resistor value	Current
100 ohm	
200 ohm	

Observation: More Current flows through the circuit when resistor is smaller

Explanation: Higher resistance impedes the flow of current

What is Ohm's Law?

Ohm's Law Summary

- Current (I) is proportional to voltage (V): $(I \propto V)$
- Current (I) is inversely proportional to resistance R: $(I \propto 1/R)$
- This is ohm's law $I = V/R$ or $V = IR$

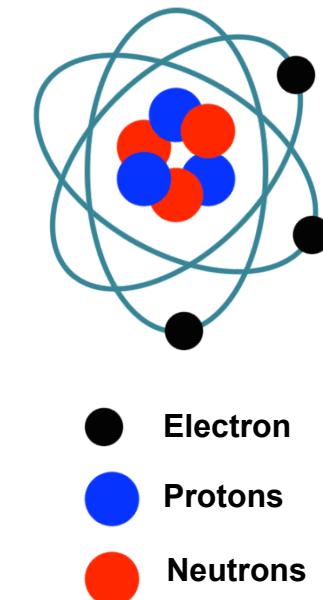
Significance of Ohm's Law ($V=IR$)

- Ohm's law is used to predict current when voltage and resistance in the circuit is known
- It can also be used to predict either voltage or resistance if the other two quantities are known

Appendix

Electrical Theory: What is Electrical Current?

- Flow of electrons constitutes electrical current (in reverse direction).
- Every thing around us is made up of an element or group of elements.
- There are 118 known elements.
- Atoms are made up of small particles:
 - Protons (with Positive charges)
 - Electrons (with Negative charges)
 - Neutrons (with no charges)
- Each element is made of atoms having a particular number of protons and neutrons.
 - The number of electrons may vary.
 - Electrons may move from one atom to another. When this occurs, an electrical current forms.
 - Electrons must gain energy, move to a higher energy state, before they will jump between atoms.

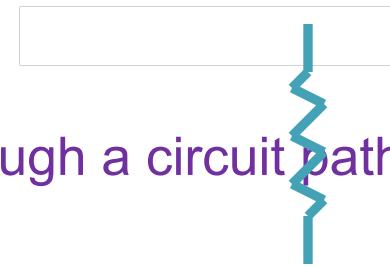


How Are Voltage & Resistance Relevant To Electrical Current?

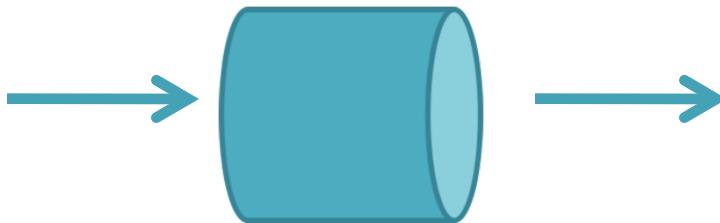
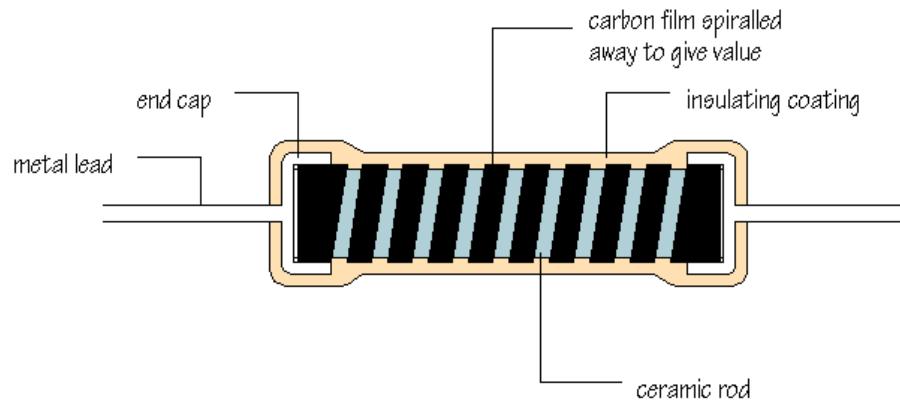
- **Electrical Voltage:**
 - Voltage makes electrical current flow – from higher voltage (or potential) to a lower voltage – just like water flows from a higher altitude (or potential) to a lower altitude
 - Voltage increases the energy state of electrons
 - Electrons gain energy when a battery creates an electrical potential
- **Resistance:**
 - Resistance drains energy away from electrons.
 - Electrons lose energy when they pass through wires and resistors.

Resistor

□ Resistor RESISTS the flow of current through a circuit path

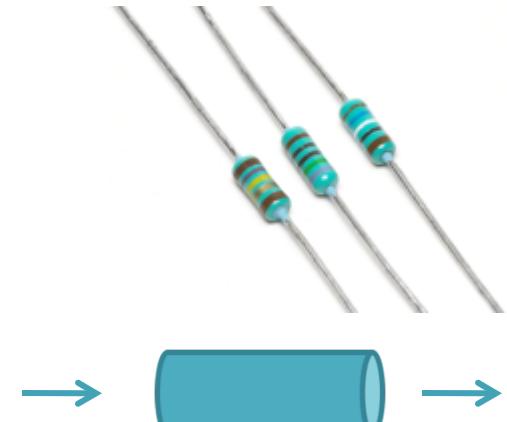


Resistor symbol
Resistor unit: Ohm



Large pipe-> More water can flow through
Large wire-> More current can flow through
(Less resistance)

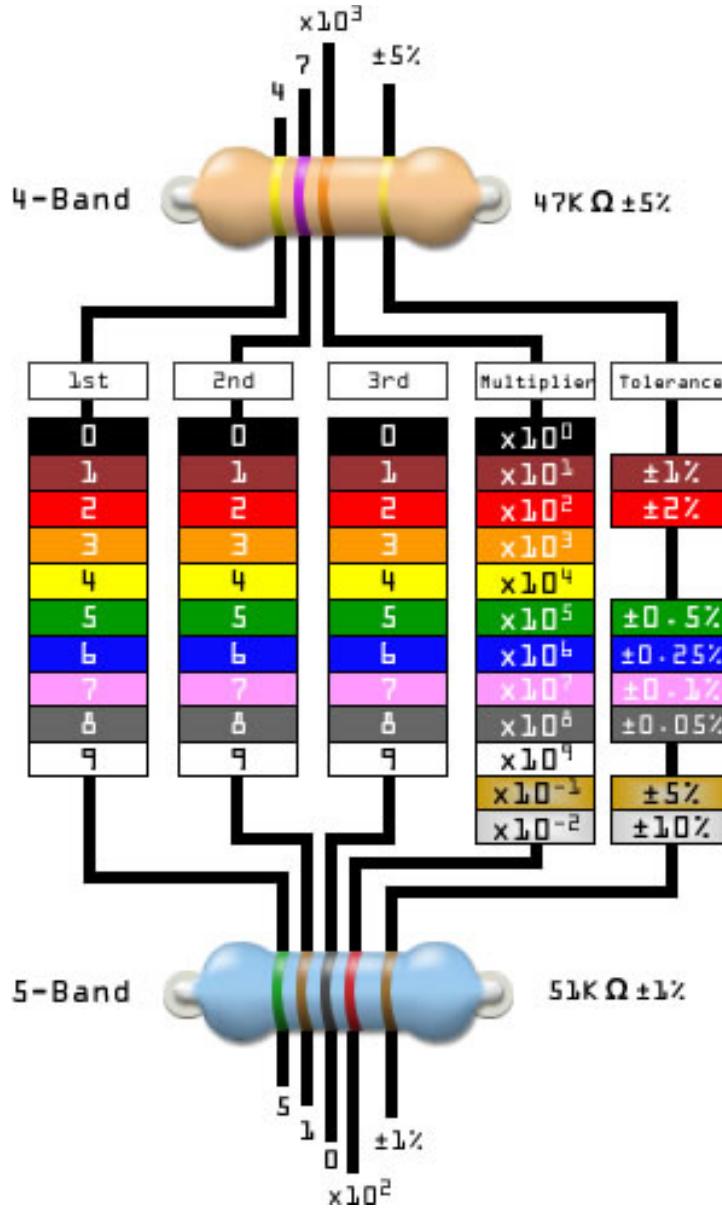
Less resistance->Higher current



Smaller pipe-> Less water will flow
Smaller wire-> Less current can flow
(Higher resistance)
Higher resistance -> Smaller current

Background Material

Resistor color code chart



Activity: Determine resistor value

- 1) Take a resistor
- 2) Match it to the color code chart on the left
- 3) Find the resistor value

Please skip this activity in the workshop due to lack of time

Source: myresistor.com

Following Documents Are Required

- Classroom Presentation: Ohm's Law Workshop.ppt
- Activity Guide: OL.Activity.xls
 - 1.0 A
 - 1.0 B
- Toolkit