

LECTURE I

OPS Roadmap and Introduction to Circuits

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SECTION I

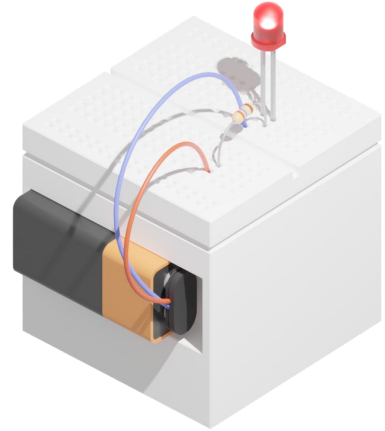
Project 1: LED there Be Light

Project 1 Overview

- Build an **LED circuit** with a switch and solder it to a perfboard.

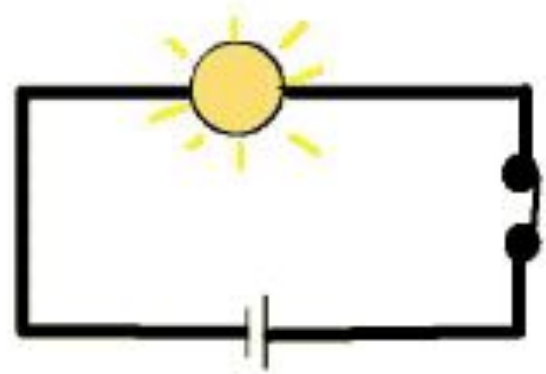
You will learn:

- Introduction to Circuits
- Ohm's Law (Voltage, Current, Resistance)
- Breadboarding
- Soldering



Introduction into Circuits

- A **circuit** is a **closed loop** path where electrons can flow
- An **open circuit** contains a **discontinuity** that disrupts the current flow
 - Ex) An open switch on a circuit prevents current from flowing
- A **closed circuit** has a **fully continuous** path for current to flow through



Circuit Components

- All circuits require the following three components:
 - A **voltage source** to provide electrical energy and generate current
 - Ex) DC generators, batteries, solar cells
 - A **conductive path** for current to flow
 - Ex) wire, copper, circuit board traces
 - A **load** to expend the electrical energy
 - Ex) light bulbs, sound speakers, motors, occasionally you

- For Project 1 (In your OPS Kit):
 - **Voltage source:** 9V battery



- **Conductive path:** Jumper Wires

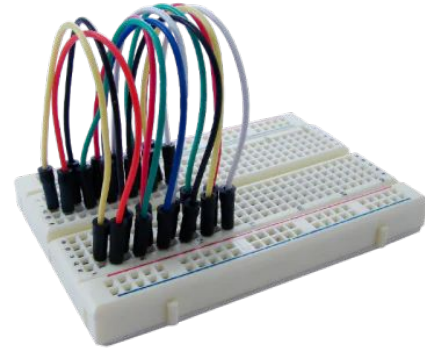


- **Load:** LEDs, motors, resistors



How Current Flows Through a Circuit

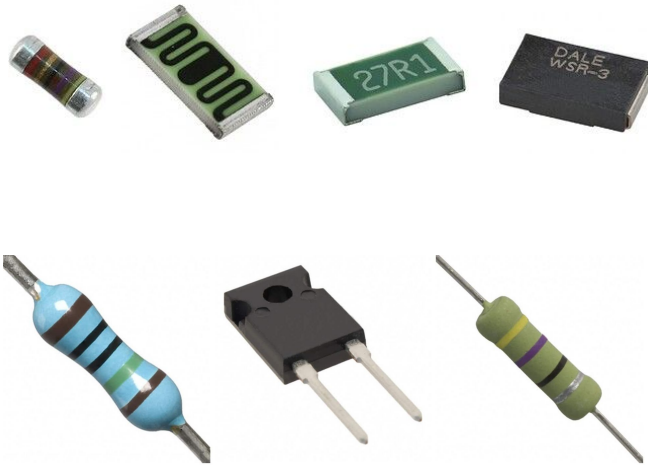
- Current cannot flow without a path for the electrons to move
- It is also difficult for current to flow through an insulator
- A **conductor** is a material in which electrons can move freely
 - If a **voltage** exists across a conductor, current will flow
- We connect circuits up through jumper wires, which are conductive paths



How do we limit/control current through a circuit?

We use resistors:

- A **resistor** is a component that reduces the flow of current
- **Resistance**, measured in **ohms (Ω)**, is the ability to *resist* current



Why do we need Resistors?

- We need resistors to reduce/control the flow of current because components are usually designed with a specific current in mind
- If that current range is exceeded, then it could damage the component



SECTION II

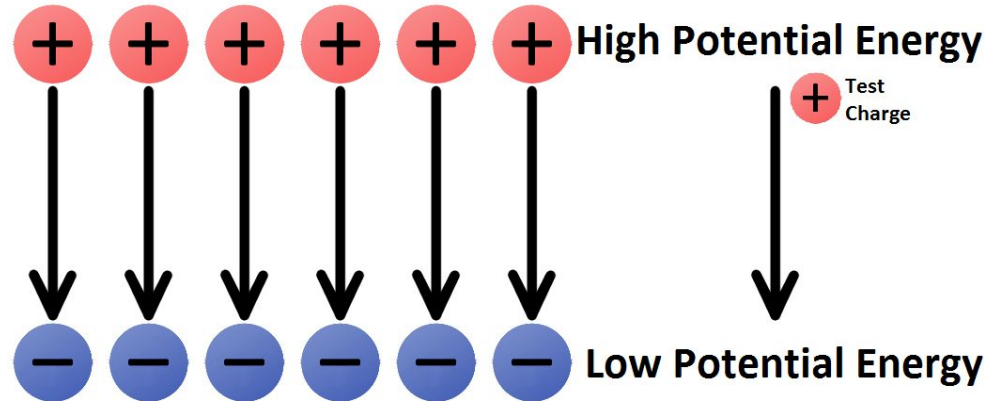
Ohm's Law

Energy

- **Energy** is the ability to do work
 - In physics class, you learned about potential and kinetic energy
 - **Potential energy** represents the energy stored in an object that has the *potential* to become another form of energy (usually kinetic)
 - **Kinetic energy** is the energy associated with an object's motion
 - Mechanical motion
 - Electron flow
 - We focus on **electrical energy** - the energy associated with charged particles

ELECTRIC POTENTIAL

- **Electric potential energy** is the amount of work needed to move a charged particle between two points
 - Measured in **Joules (J)**
- Charged particles move from points of higher electric potential to points of lower electric potential
 - ... this means that electron flow - **current** - is **generated when there is a difference in electric potential** between two points



Voltage

- **Voltage** is the **electric potential difference**
 - Current can flow where **voltage** exists
 - Measured in **Volts, V**
- **Batteries** are a voltage source
 - Conventional current will flow from the **positive (+)** terminal to the **negative (-)** terminal when connected
 - The **positive (+)** terminal has a *higher* potential than the **negative (-)**



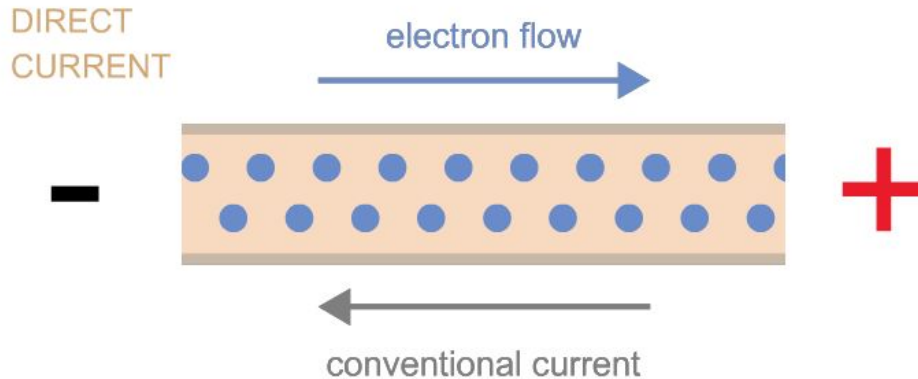
Voltage

- **Measuring voltage requires a reference point** ← called “Ground”/”GND”
because it is the difference in volts between two points
- Using the **negative (-)** terminal of the battery as a reference point...
 - The **positive (+)** terminal has a **voltage** of **+9V**
 - The **negative (-)** terminal has a **voltage** of **+0V**
 - **Why zero?** There is no potential difference at the same location as the reference point



Current

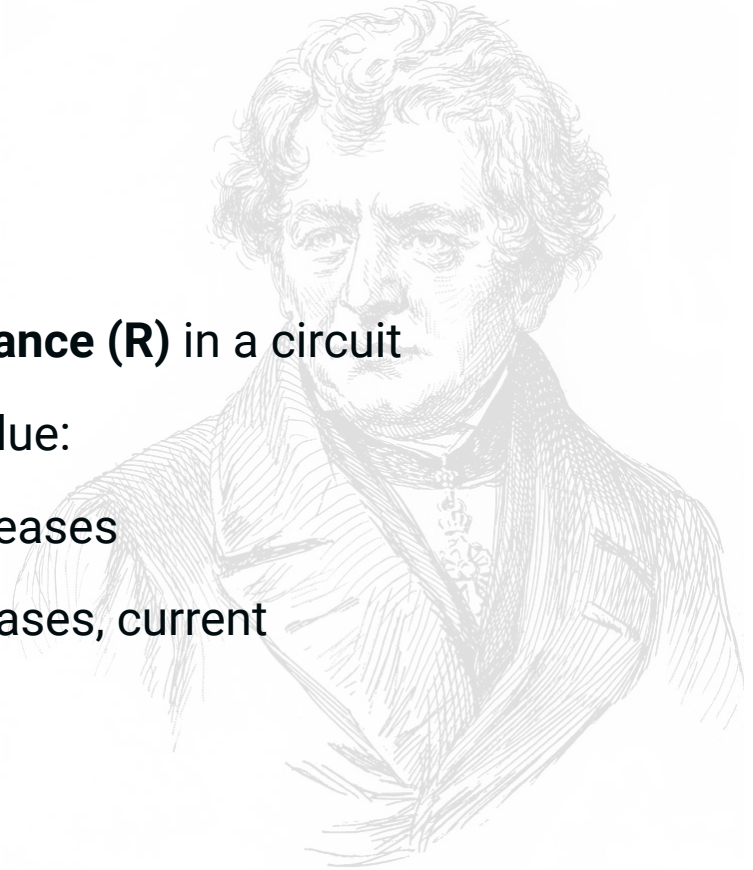
- **Current** is the flow of electrons
 - Current has a magnitude **Amperes (A)** and direction
 - **Conventional current** flows in the direction *opposite* to the electron flow



Ohm's Law

$$V = IR$$

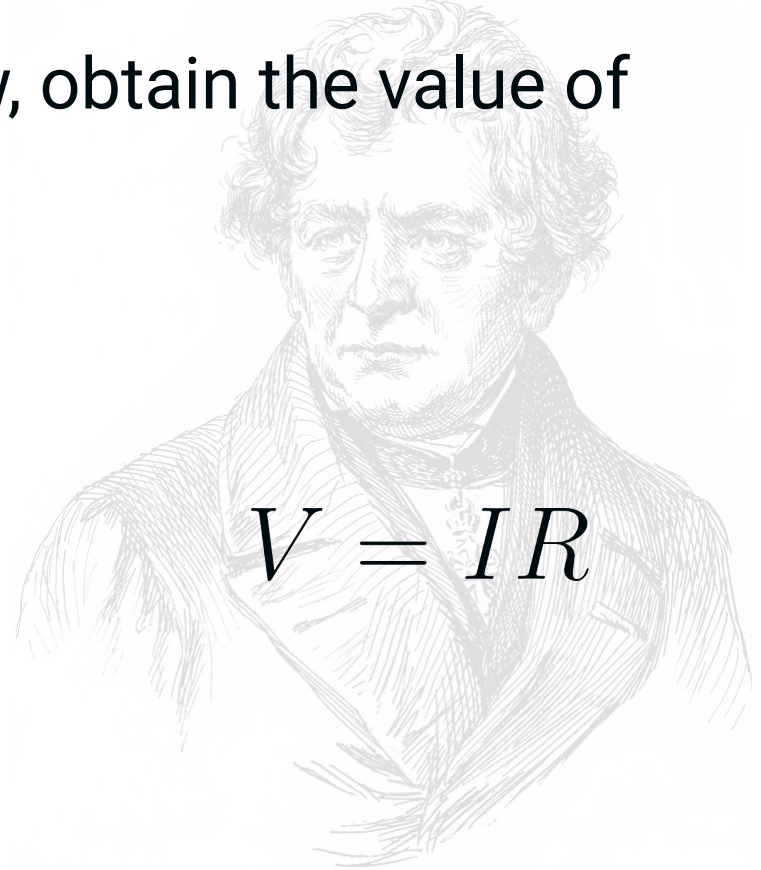
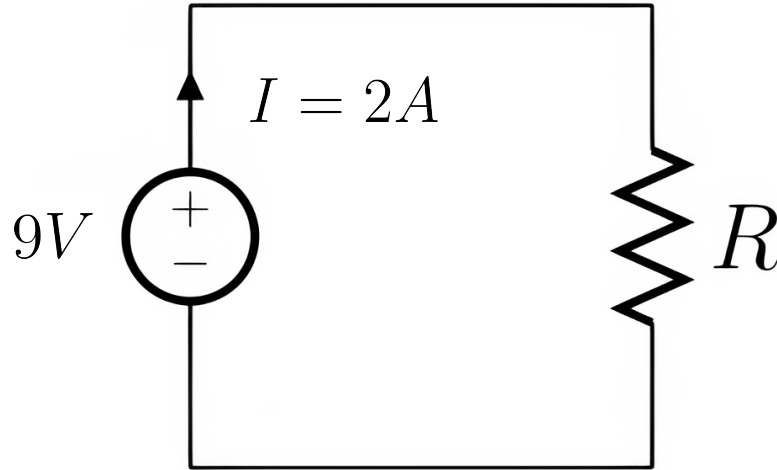
- Relates the **voltage (V)**, **current (I)**, and **resistance (R)** in a circuit
- Suppose we hold the voltage at a constant value:
 - As the resistance increases, current decreases
 - In the opposite case, as resistance decreases, current increases



Applying Ohm's Law

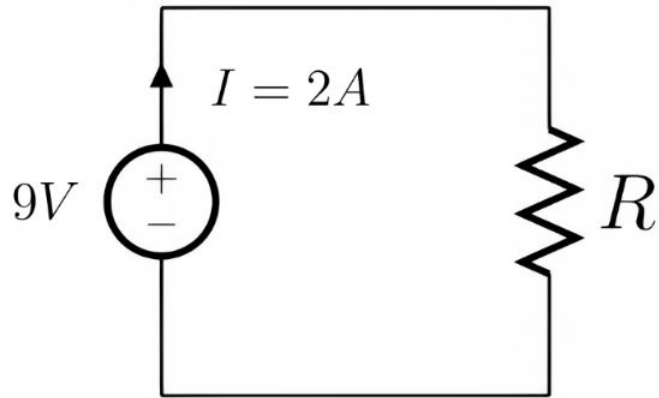
I/A

Given the circuit schematic below, obtain the value of resistor (**R**).



Given the circuit schematic below, obtain the value of resistor (R).

$$V = IR$$



1.8

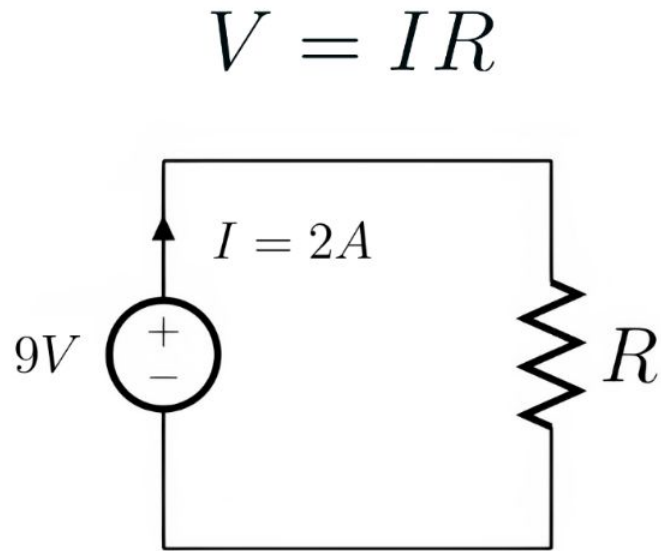
2.3

4.5

5.2

None of the above

Given the circuit schematic below, obtain the value of resistor (R).



1.8

2.3

4.5

5.2

None of the above

SECTION III

Project 1 Notes

Project 1 Components

- Battery, 9V
- Breadboard
- Header, 2.54mm, Female, 1x2
- Jumper Wires
- LED, 3.2V
- Perfboard
- Resistor
- Slide Switch
- Snap Connector, 9V

Parts

Part Name	Qty
Jumper Wire	?
Breadboard	1
Battery, 9V	1
9V Snap Connector	1
Header, 2.54mm, Female, 1x2	1
LED, 2V	1
Slide Switch	1
Resistor, $?\Omega$	1
Perfboard	1

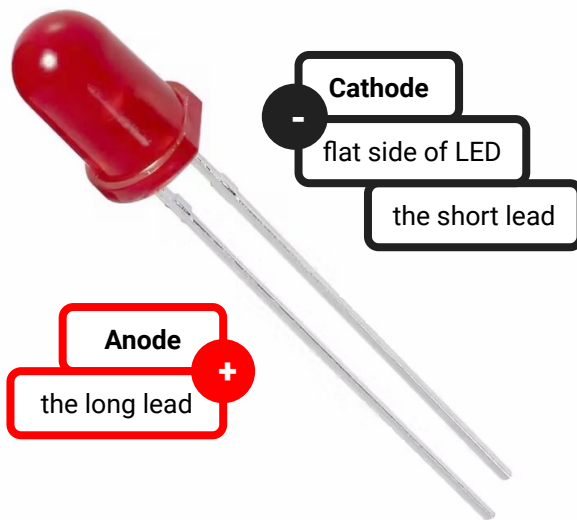


Polarized Components

- Why is this important? Some components in Project 1 are polarized
- A **polarized component** is one which can only be **connected** to the circuit **in one direction**
 - Ex) Batteries, LEDs, Electrolytic Capacitors
 - These components have a **positive (anode)** and **negative (cathode)** terminal
 - Remember that current flows from **positive** to **negative**
 - Terminals may be **distinguished by lead length, labels, or notches** on the component
 - Sketches of circuits will also indicate the components' polarities

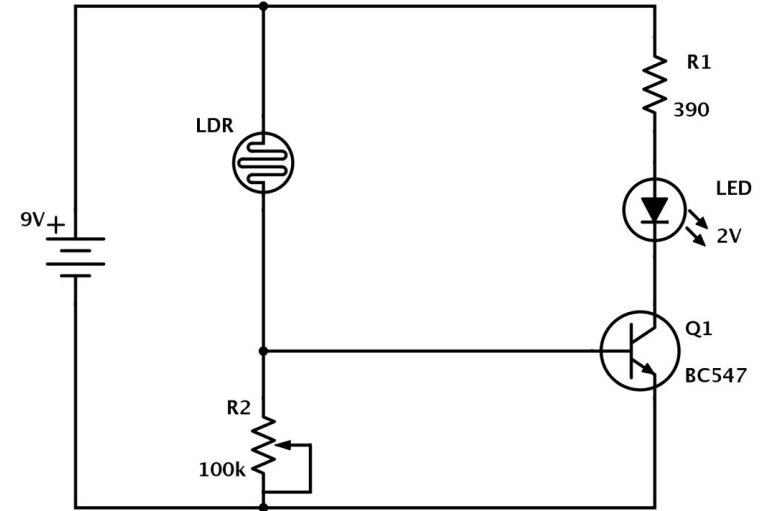
LEDs

- The **Light Emitting Diode (LED)** is a component that emits light (big surprise)
 - As a **diode**, the LED is **polarized** and has a constant **forward voltage** between its anode and cathode terminals (in normal operating conditions)
 - Refer to the LED's **datasheet** to find its **operating conditions**
 - Recommended operating current
 - Forward Voltage
 - These values are also provided on the project website
 - Any questions?



Schematics

- A **schematic** diagram defines the **connections between components** in a circuit
- Schematics also **summarize the components' values**
- Each component has a **unique symbol** associated with it



Schematic Symbols

Battery



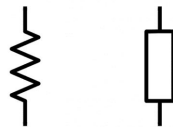
Voltage Source



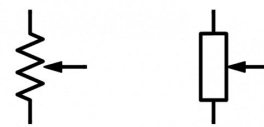
Ground



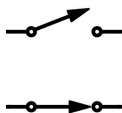
Resistor



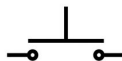
Potentiometer



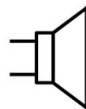
Switches



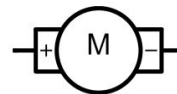
Pushbutton



Speaker



DC Motor

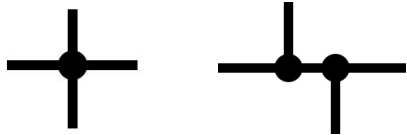


LED

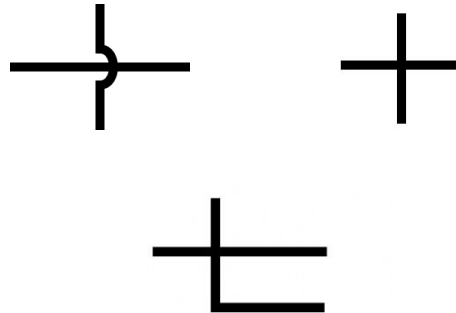


Schematic Connections

Connected Wires

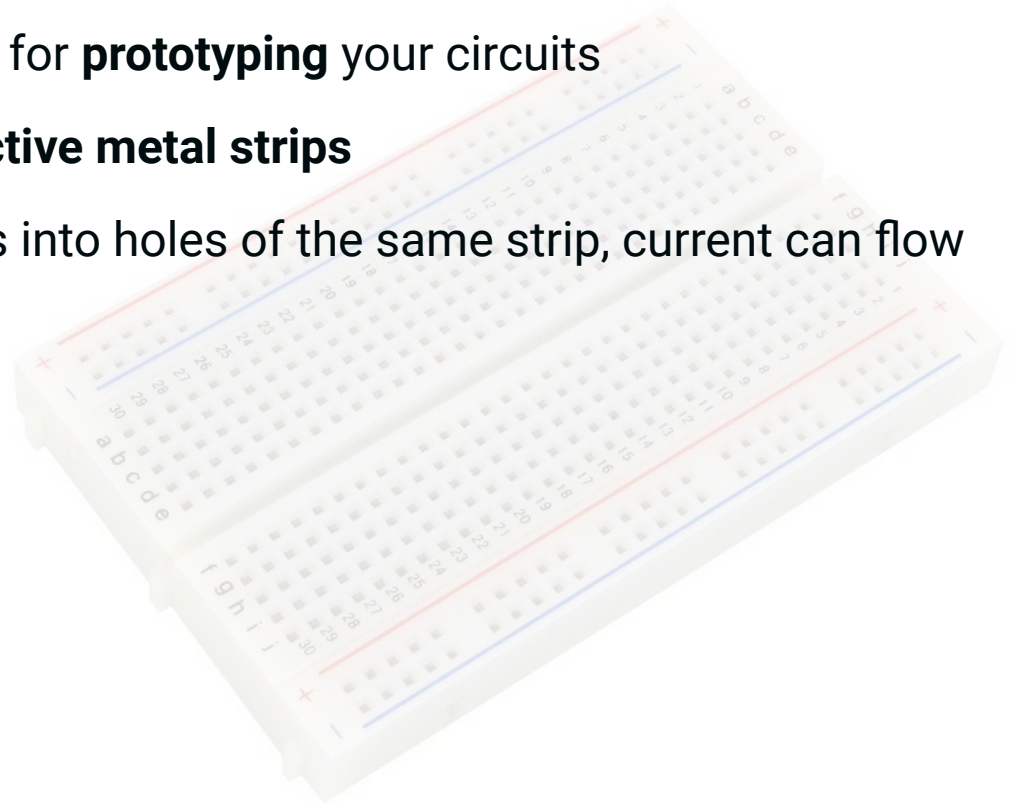
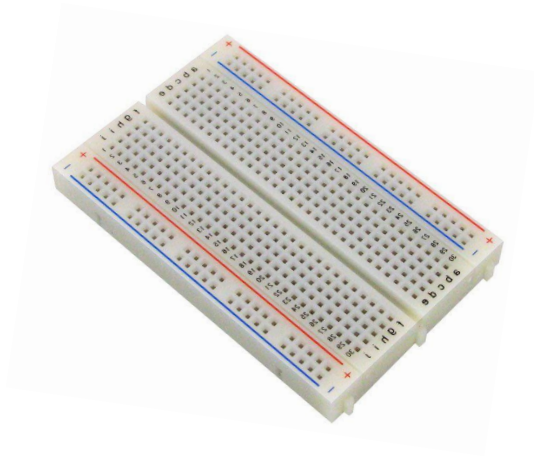


Unconnected Wires



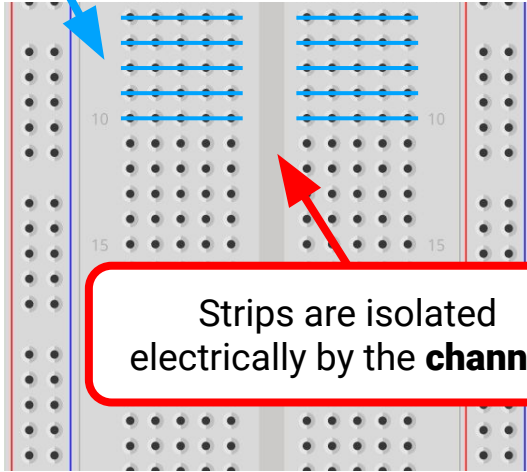
Breadboards

- A **breadboard** is a reusable board for **prototyping** your circuits
- Inside the breadboard are **conductive metal strips**
 - When you insert components into holes of the same strip, current can flow between those components



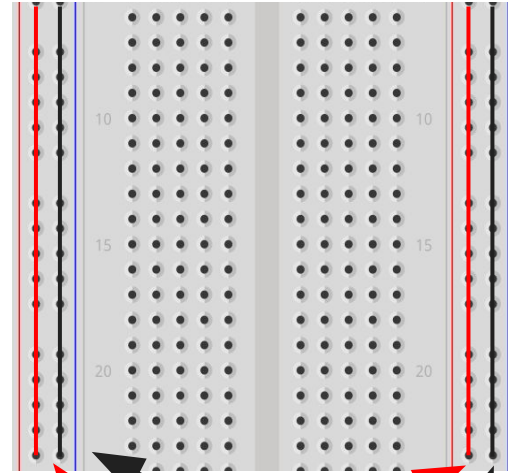
Breadboards

Horizontal holes are electrically connected in a **strip**



Strips are isolated electrically by the **channel**

Vertical strips are connected down the entire board



Power Rails

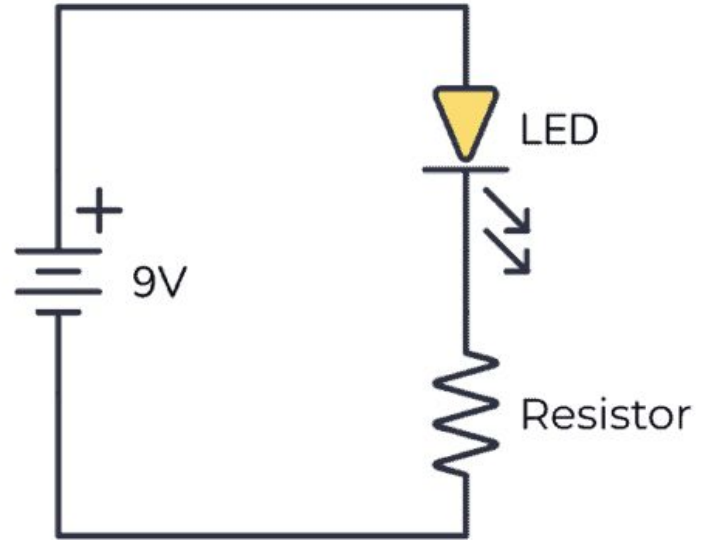
Ground Rails

+

-

Breadboard Exercise

- Let's set up a simple circuit on a breadboard with a 9V Battery, LED, and a 390Ω resistor
- We have three components in this circuit - don't forget to place their terminals on **different** breadboard strips!
- Don't forget that the **longer** lead on the LED is **positive**, and the **shorter** lead is **negative**
 - Remember that current flows from positive to negative - don't flip the placement of your LED!
- Find instructions on how to use a breadboard on the project page!

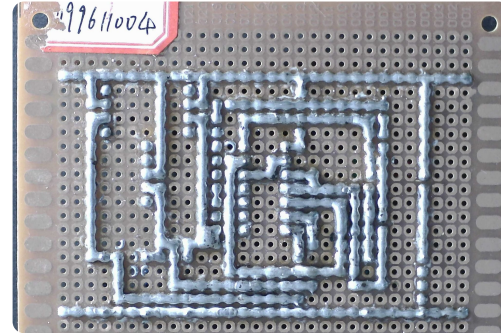


Soldering

- Final circuit designs are often soldered onto **printed circuit boards (PCBs)** or **perfboards**
- **Soldering** is a process that joins circuit components together with a filler metal called **solder**



Printed Circuit Board



Perfboard

Sign-Up for the Workshop

- Thank you for attending the first lecture!
- For any questions, reach out on Discord or to any instructor!
- To learn how to solder, RSVP for a soldering workshop here:



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