LECTURE I

OPS Project 1: Introduction to Circuits

SECTION I

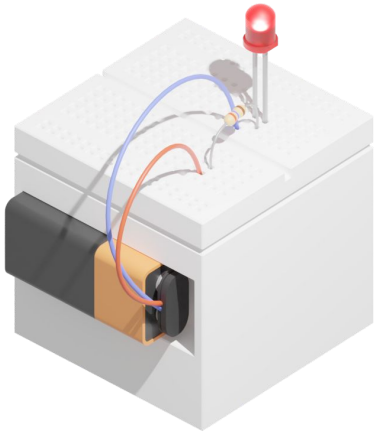
Project 1: LED there Be Light

Project 1 Overview

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

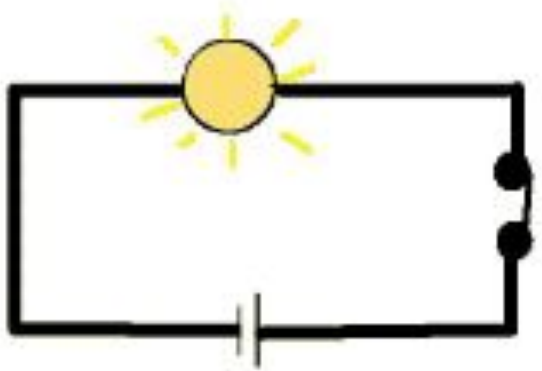
You will learn:

- 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

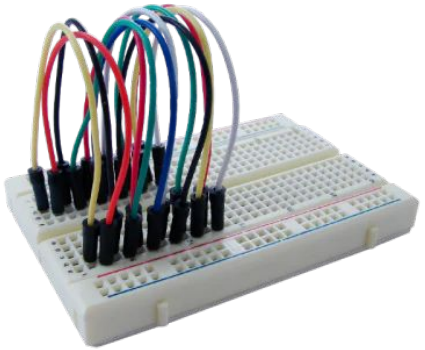
- For Project 1 (In your OPS Kit):
  - **Voltage source:** 9V battery

  - **Conductive path:** Jumper Wires

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

How Current Flows Through a Circuit

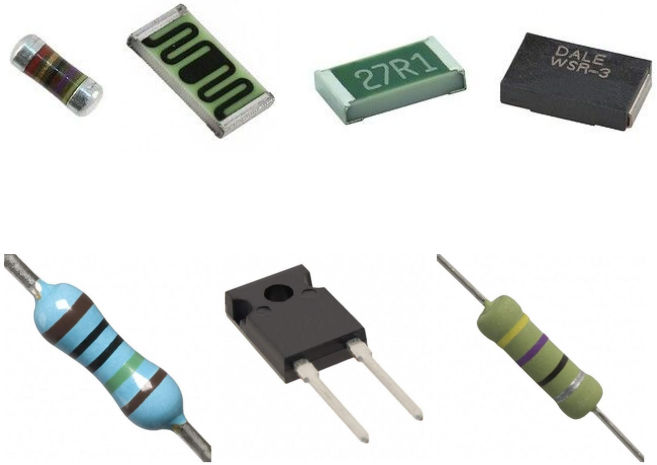
- Current cannot flow without a path for the electrons to move
- It is also difficult for current to flow through an insulator
- A **conductor** is a material in which electrons can move freely
    - If a **voltage** exists across a conductor, current will flow
- We connect circuits up through jumper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

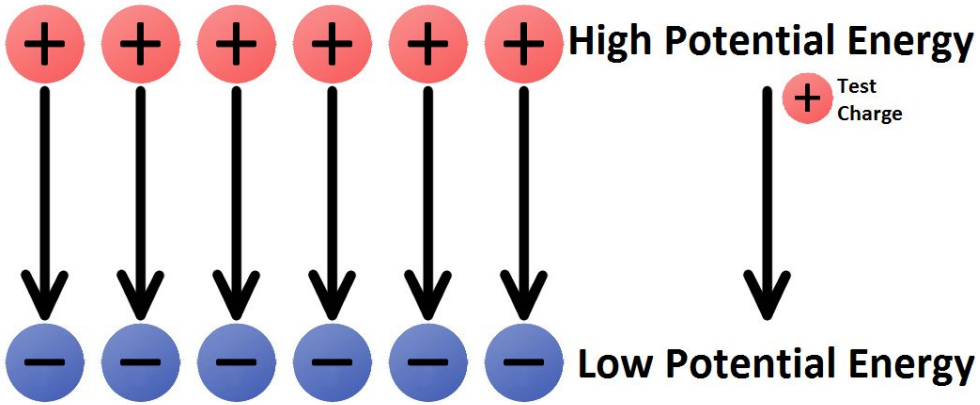
Ohm’s Law

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 (-)**

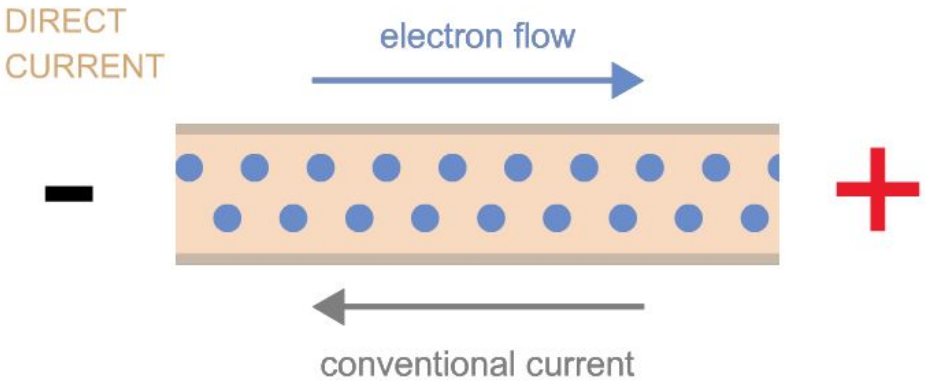
Voltage

- **Measuring voltage requires a reference point** 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

called “**Ground**”/”**GND**”

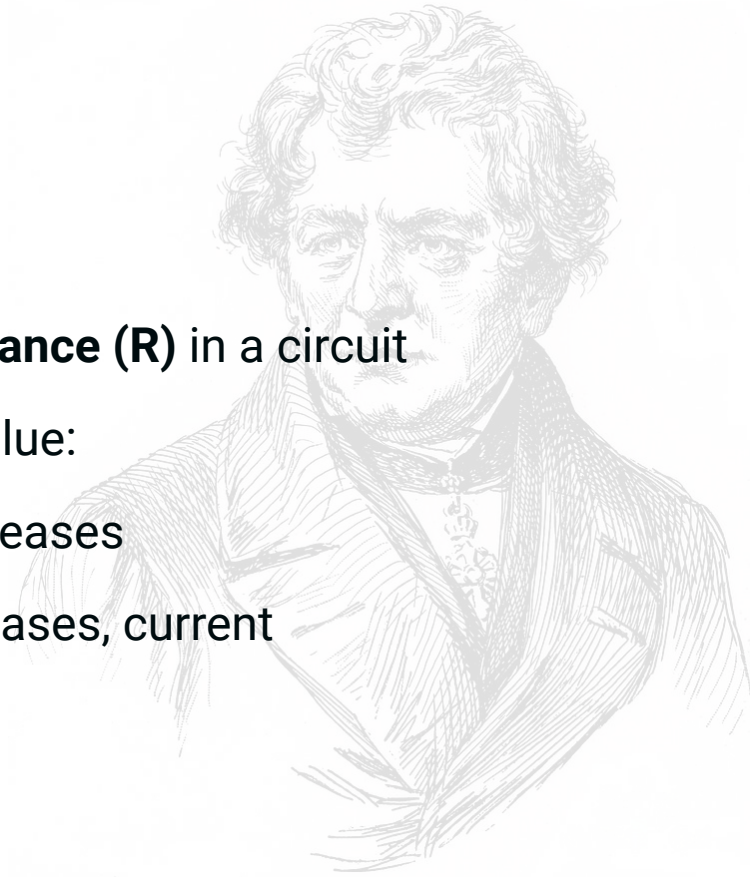
Current

- **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

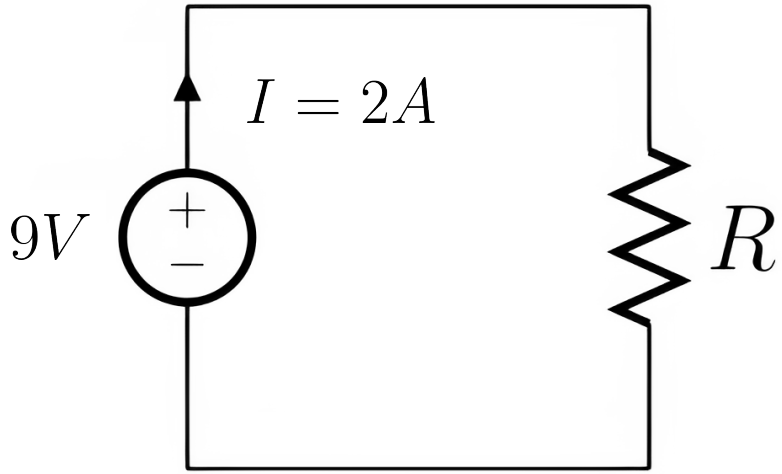
$$V = IR$$

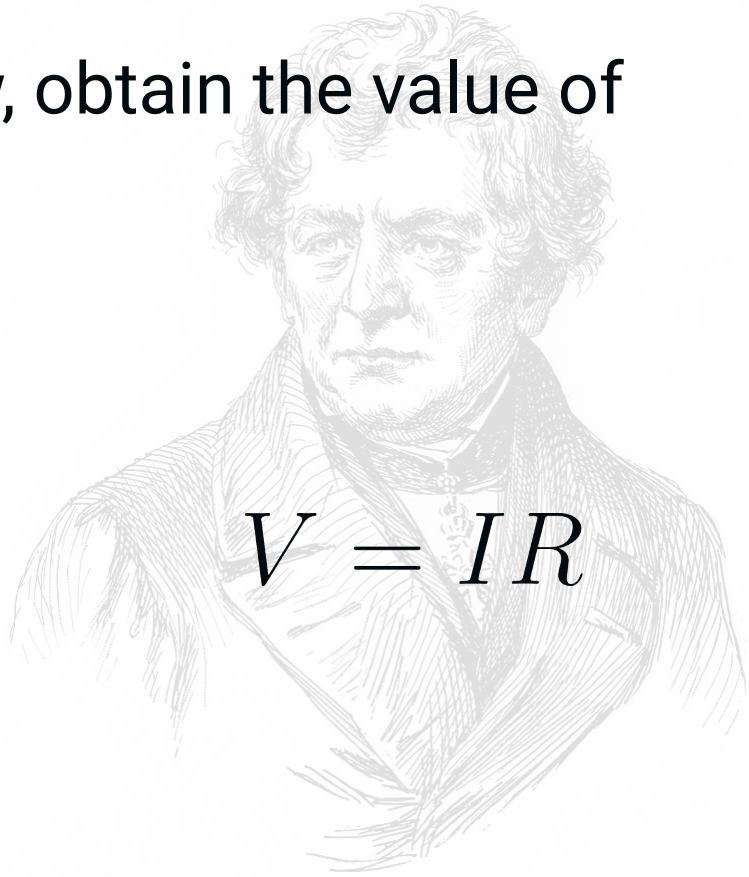


- Relates the **voltage (V)**, **current (I)**, and **resistance (R)** in a circuit
- Suppose we hold the voltage at a constant value:
  - As the resistance increases, current decreases
  - In the opposite case, as resistance decreases, current increases

Applying Ohm's Law

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

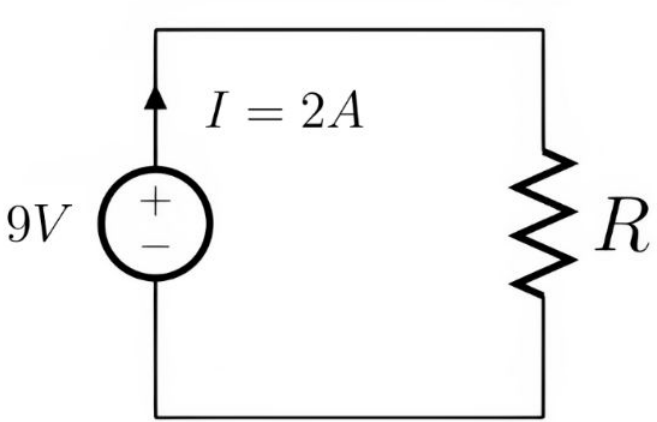




$$V = IR$$

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

$$V = IR$$



1.8

2.3

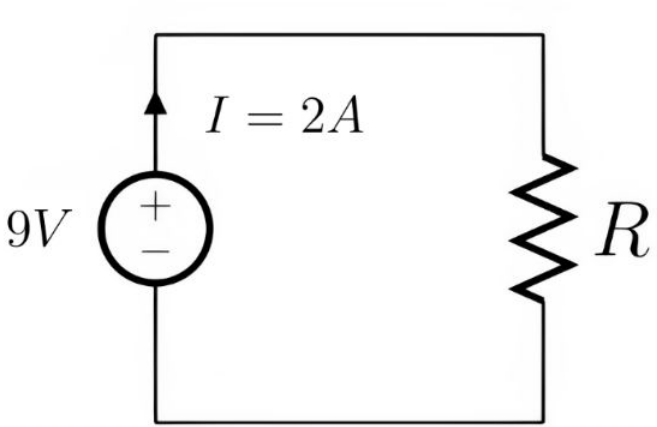
4.5

5.2

None of the above

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

$$V = IR$$



1.8

2.3

4.5

5.2

None of the above

SECTION III

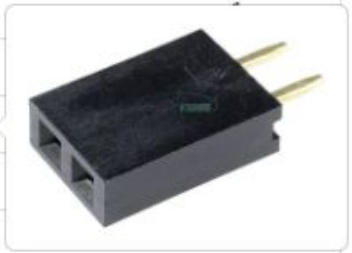
Project 1 Notes

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	
9V Snap Connector	
Header, 2.54mm, Female, 1x2	
LED, 2V	
Slide Switch	
Resistor, ?Ω	1
Perfboard	1

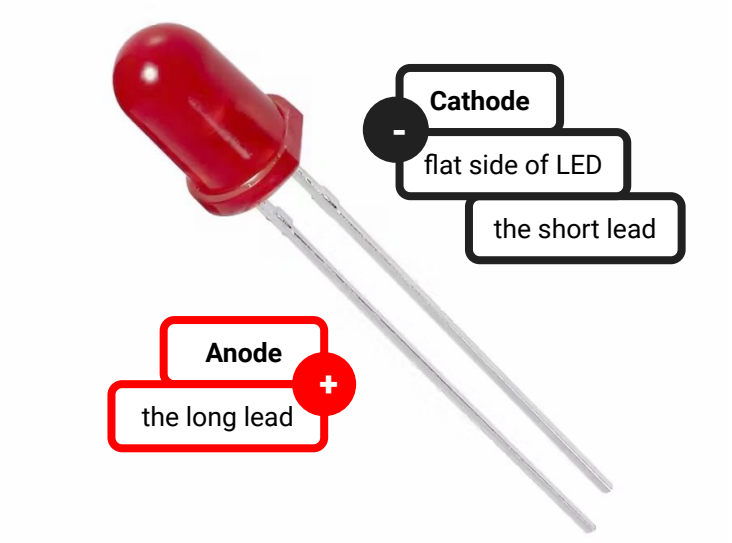


Polarized Components

- 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

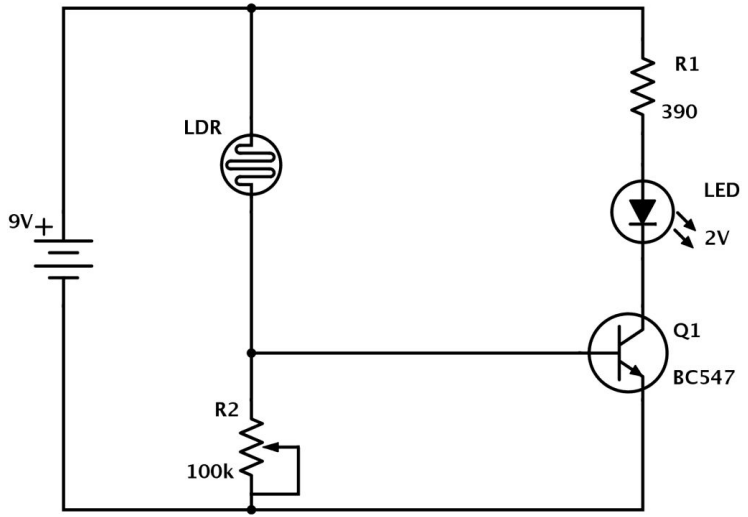
LEDs

- 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?



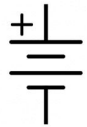
Schematics

- 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

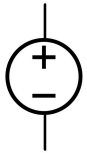


Schematic Symbols

Battery

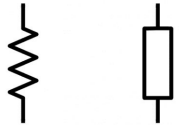


Voltage Source



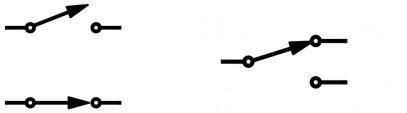
Ground

Resistor

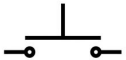


Potentiometer

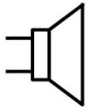
Switches



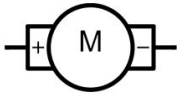
Pushbutton



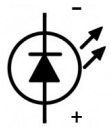
Speaker



DC Motor

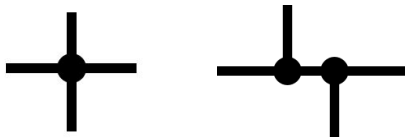


LED

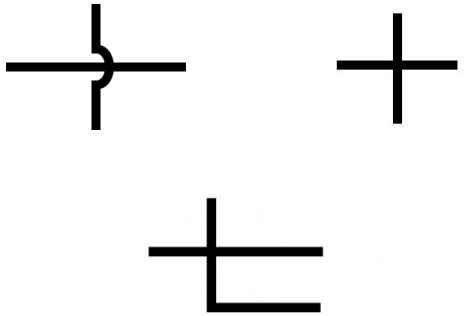


Schematic Connections

Connected Wires

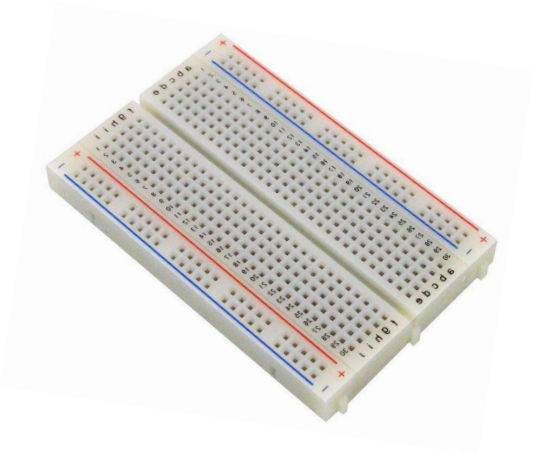


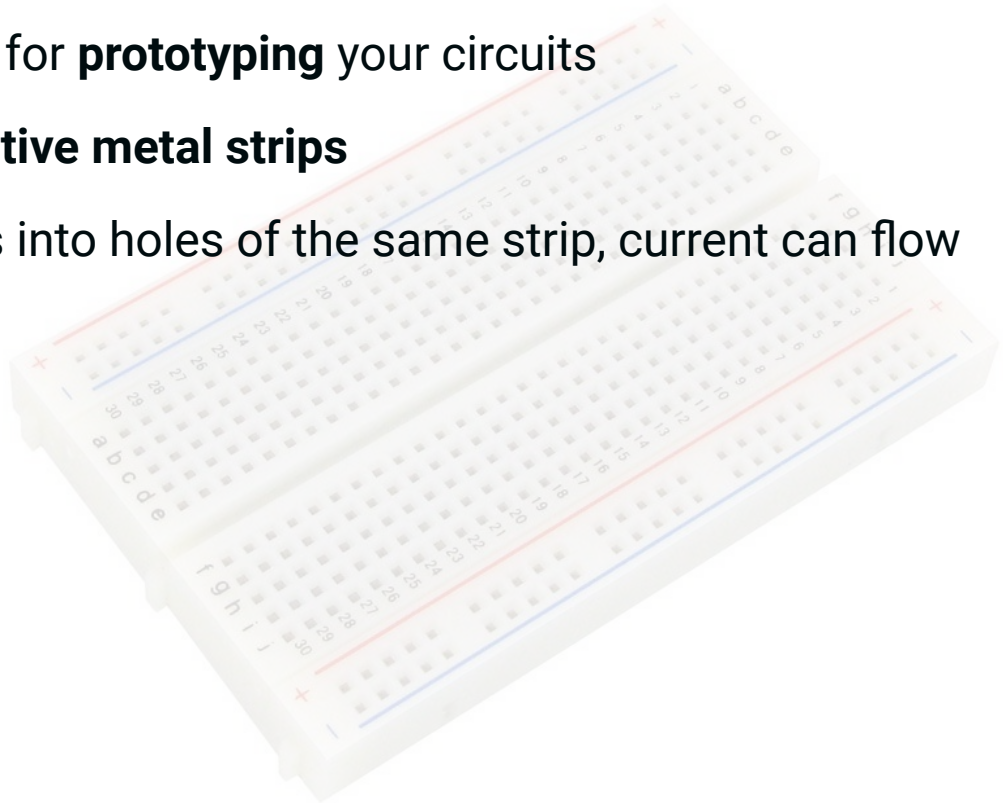
Unconnected Wires



Breadboards

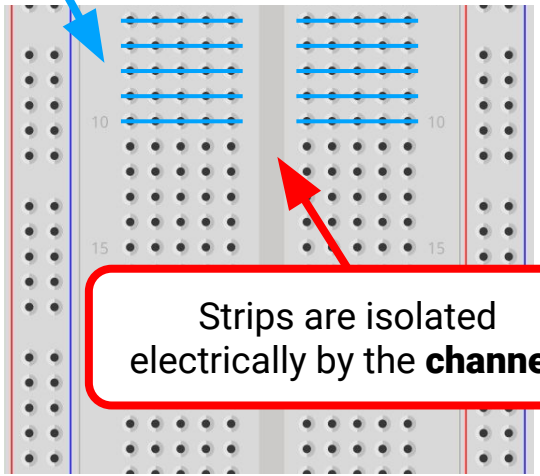
- A **breadboard** is a reusable board for **prototyping** your circuits
- Inside the breadboard are **conductive metal strips**
    - When you insert components into holes of the same strip, current can flow between those components





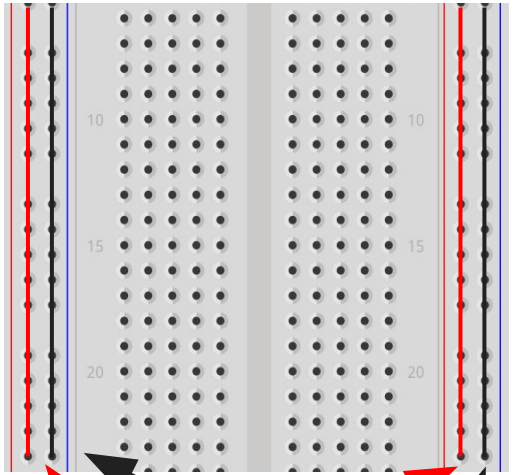
Breadboards

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



Strips are isolated electrically by the **channel**

Vertical strips are connected down the entire board

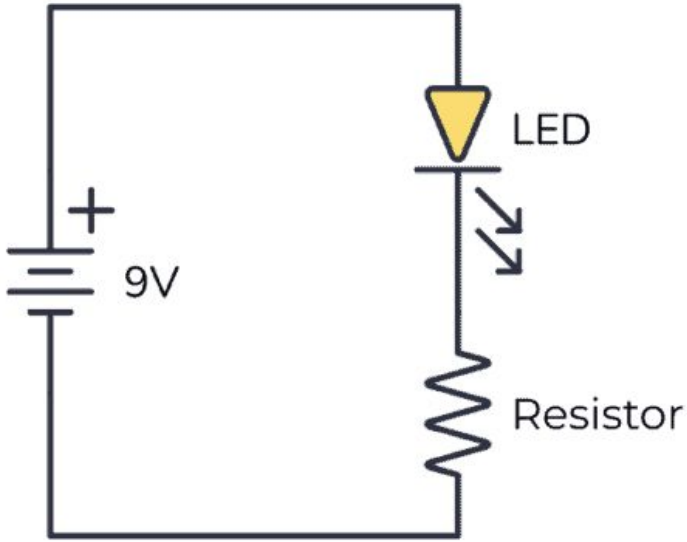


Power Rails +

Ground Rails -

Breadboard Exercise

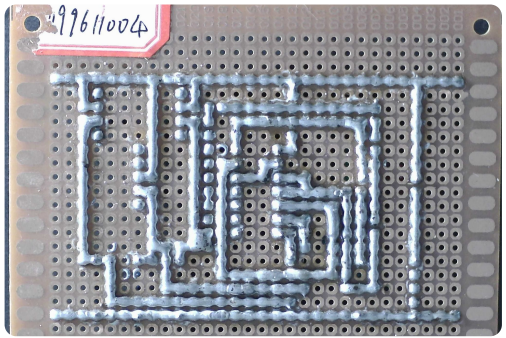
- Let’s set up a simple circuit on a breadboard with a 9V battery, LED, jumper wires, and a 390Ω resistor
- We have three components in this circuit - don’t forget to place their terminals on **different** breadboard strips!
- Don’t forget that the **longer** lead on the LED is **positive**, and the **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

FAIR USE DISCLAIMER

Copyright Disclaimer under section 107 of the Copyright Act 1976, allowance is made for “fair use” for purposes such as criticism, comment, news reporting, teaching, scholarship, education and research.

Fair use is a use permitted by copyright statute that might otherwise be infringing.

Non-profit, educational or personal use tips the balance in favor of fair use.