Opening Question:

What would your life be like without electricity?

Electrical Engineering Intro

Foundations of Engineering and Technology

Wheeler HS

PBS intro video

- https://www.youtube.com/watch?v=3nB1Ntku06w

Branches of EE

- Electronics
- Digital Design/Controls
- Computer
- Power
- Telecommunications

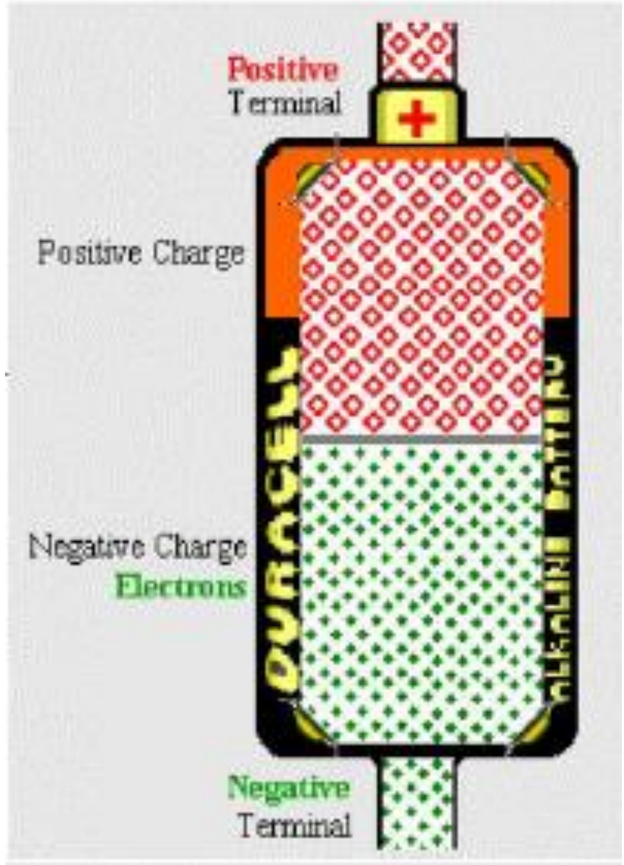
What is Electricity

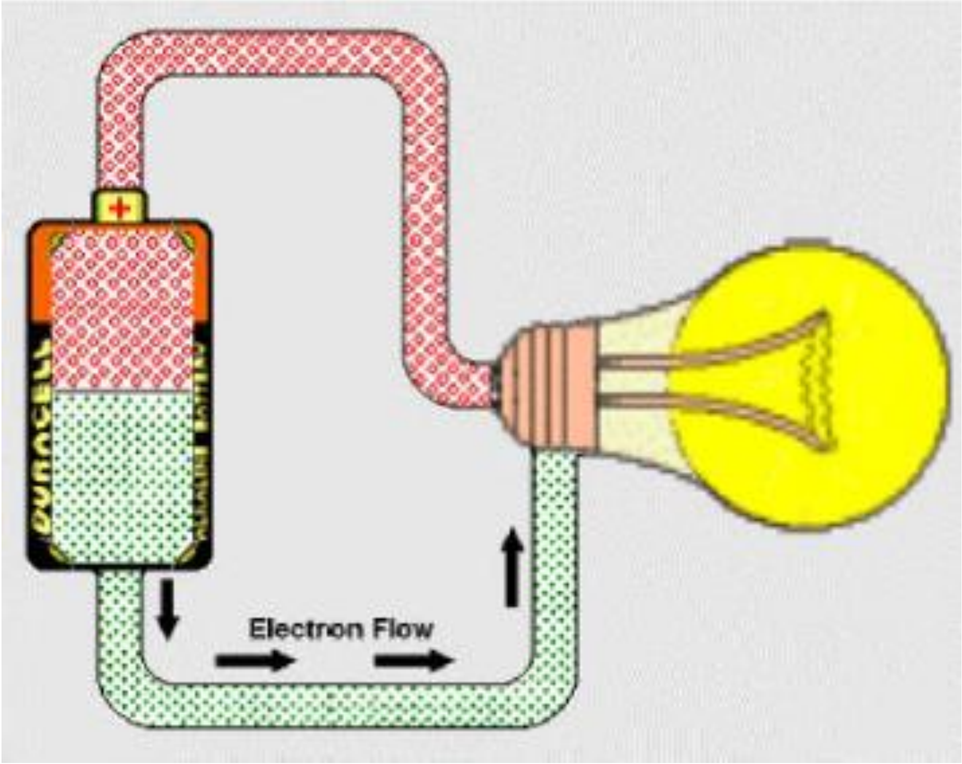
- Electricity: Flow of electrons
  - Atoms in every material are made up of electrons and protons
  - Electrons (- charge) are attracted to protons (+ charge)

- **Insulators:** Materials with immobile electrons
- **Conductors:** Materials with free-to-move electrons

More on Electricity

- A surplus of electrons is called a negative charge (-)
- A shortage of electrons is called a positive charge (+)





- Connecting a **conductor** from the positive to negative terminal on a battery causes electricity to flow

Why we’re learning it

- Major branch of Engineering
  - Broadest and with the most job opportunities [citation needed]
- Related to many different fields
  - Biomedical
  - Relations to computer and software engineering
  - Electricity in mechanics
    - Cars
    - Planes
  - Electricity in infrastructure
    - Buildings
    - City planning
  - Electricity in everything

What we’re doing

1. Basics of electricity
2. Analogue electronics (think wires and lightbulbs)
3. Digital electronics (think computers)
4. Coding with Arduino (&Raspberry Pi????)
5. Summative project
    - Project with Arduino or with electronics

Basics of Electricity

Foundations of Engineering and Technology

Wheeler HS

Basics of Electricity

- Key terms to know
  - **Voltage** (V): difference in electrical charge between two points (such as the + and - ends of a battery)
    - Unit: Voltage (V)
  - **Current** (I): rate of flow of electricity
    - Unit: Current (A)
  - **Resistance** (R): resistance to the flow of electricity
    - Unit: Ohms (Ω)

Analogies for Voltage, Current and Resistance

- Analogy #1: Electricity as a water pump
  - https://www.youtube.com/watch?v=O5Cpd4U-v80
  - Voltage ~ pressure of the pump
  - Current ~ the rate of water flow
  - Resistance ~ how much the hose resists the flow of water
- Analogy #2: Electricity as a ball rolling down a hill
  - Voltage ~ height of ball on a hill
  - Current ~ mass of the ball
  - Resistance ~ friction on hill

Voltage

- The voltage is the difference in charge between two points in space
  - EX: difference in charge between a battery's + and – terminal

Water Analogy

- A battery is analogous to a pump
- A **higher voltage** battery is analogous to a **higher pressure** pump

Hill Analogy

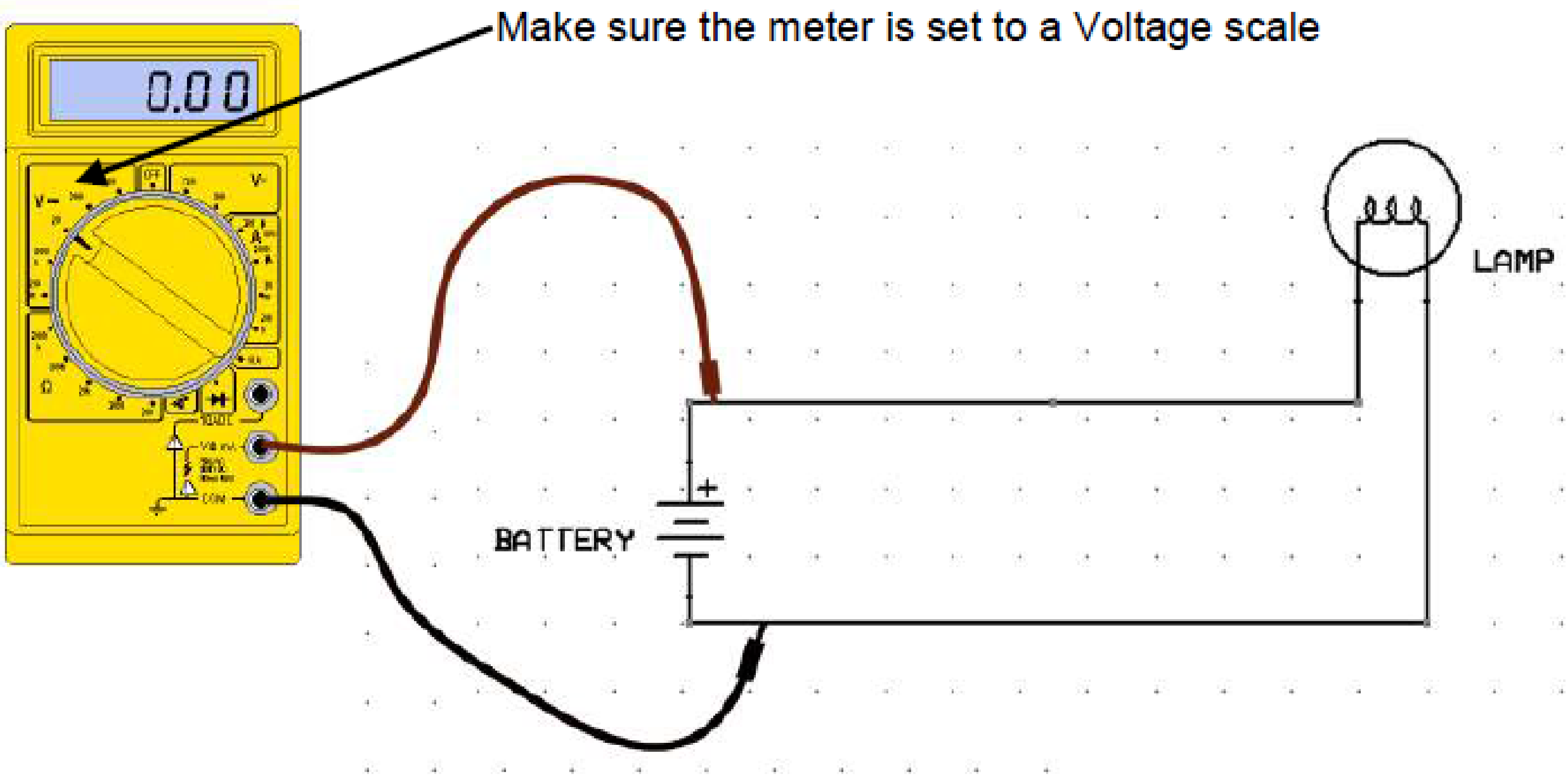
- A battery is analogous to the hill
- A **higher voltage** battery is analogous to a **taller** hill

Measuring Voltage

- Always measured between two points in a circuit
- Negative (black lead) connects to a reference point
  (often ground or battery -)
- Positive (red lead) connects to another point in the circuit

What To Do

1. Turn dial to this symbol: $\overline{V}$
2. Make sure black wire is in "COM" and Red in "V"
3. Test away!



Current

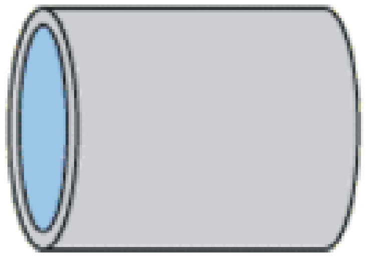
- The rate at which charge flows

Water Analogy

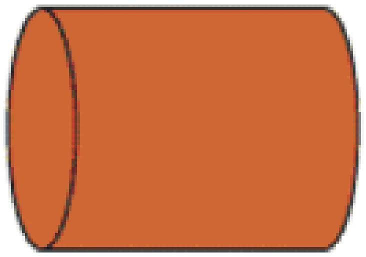
- Current is like the rate of water flow

Hill Analogy

- A battery is analogous to the mass of the falling rock



Flow of Water



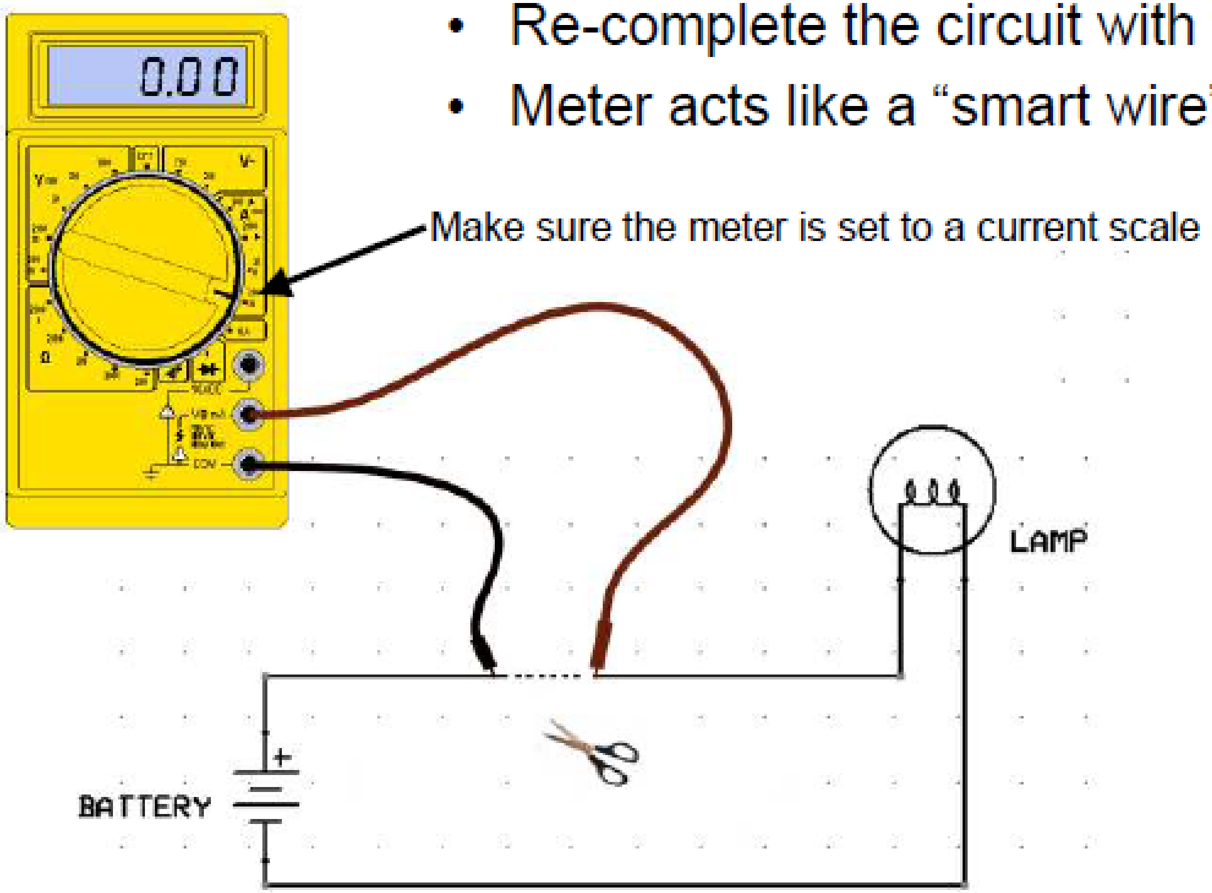
Flow of Charge

Measuring Current

- Current is measured **through a section** of a circuit
- Meter must be connected in series
- Open a section of the circuit
- Re-complete the circuit with the meter
- Meter acts like a “smart wire”

What To Do

1. Turn dial to this symbol: $\overline{A}$
2. Make sure black wire is in “COM” and Red in “A”
3. Connect the meter into the circuit
4. Test away!



Resistance

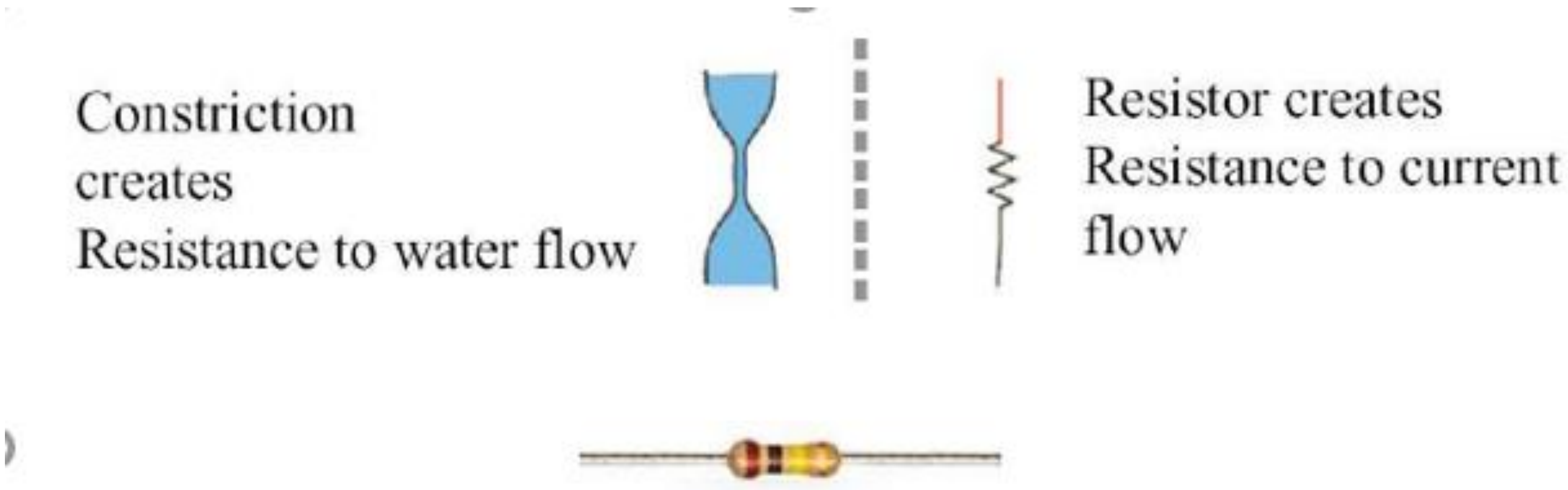
Def: Material's tendency to resist the flow of charge

Water Analogy

- Restriction of water flow by tube

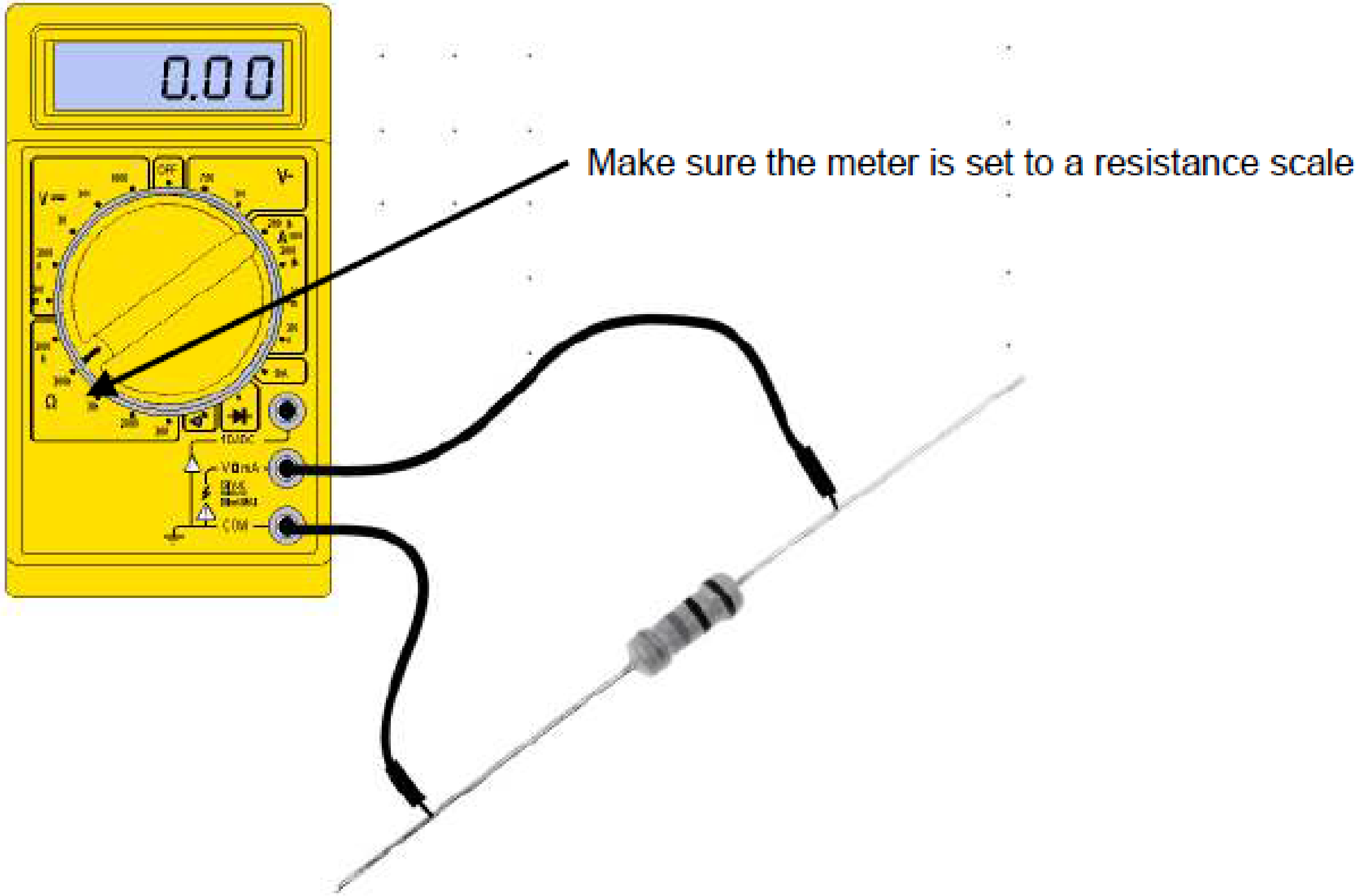
Hill Analogy

- Friction on hill/in air
- Angle of the ramp



Measuring Resistance

- Measured with resistor (or other device) out of circuit
- Connect one lead to each lead of the component



What To Do

1. Turn dial to this symbol: Ω
2. Make sure black wire is in “COM” and Red in “Ω”
3. Test away!

Voltage, Current and Resistance: How are they related

- There's a formula!
  - Ohm's Law: $V = I \times R$

$$I = \frac{V}{R}$$

$$R = \frac{V}{I}$$

Know your units!

- Prefixes matter!
  - Resistance is often measured in the 1000's of ohm's or more.
  - Current is often measured in 1/1000's or less.

Important prefixes to know:

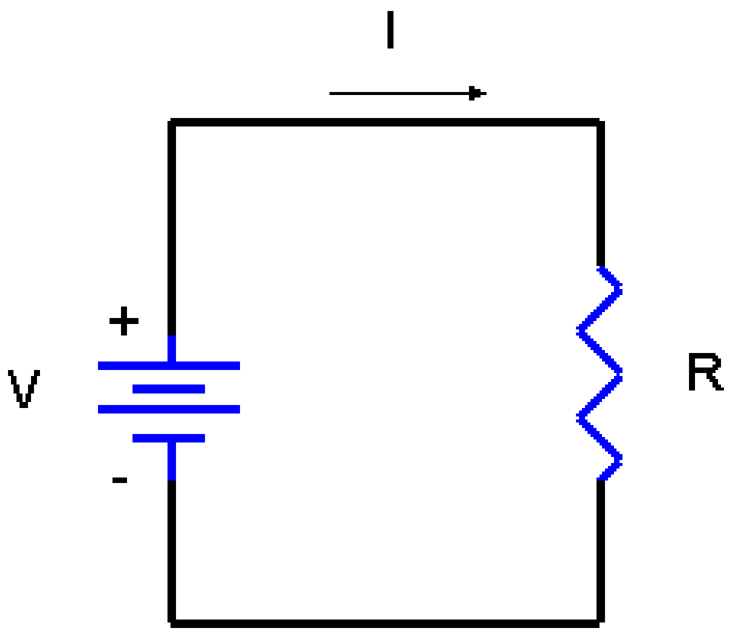
- 1 kΩ = 1000 Ω
- 1 MΩ = 1000 kΩ = 1,000,000 Ω

- 1 mA = .001 A
- 1 µA = .001 mA = .000001 A

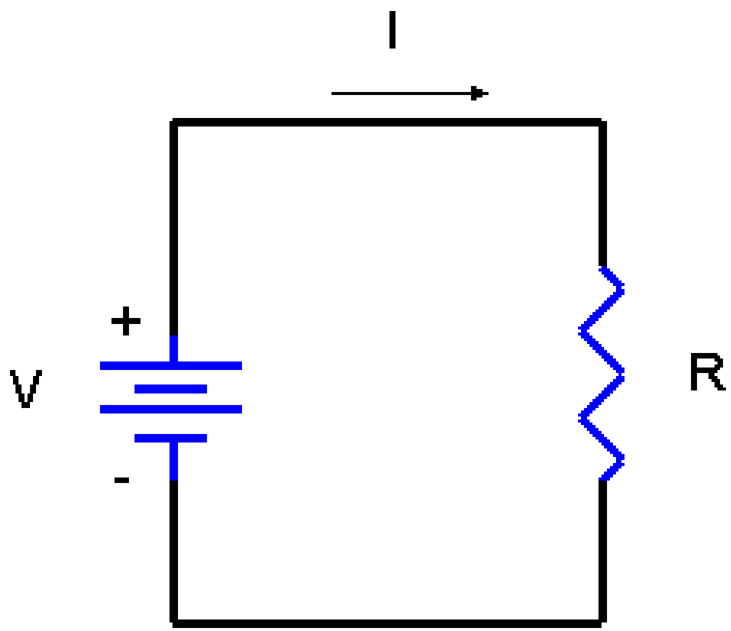
SI Unit Prefixes

Name	Symbol	
giga-	G	10^{9}
mega-	M	10^{6}
kilo-	k	10^{3}
deci-	d	10^{-1}
centi-	c	10^{-2}
milli-	m	10^{-3}
micro-	µ	10^{-6}
nano-	n	10^{-9}
pico-	p	10^{-12}

Simple Examples



Using a 12 V battery, you measure a resistance of 2 kΩ on a circuit. What is the current?



You measure 20 mA and 4kΩ, what voltage is the battery?

To Do

- Complete worksheet on Ohm’s Law

Closing: So which is more dangerous: Voltage or Current?