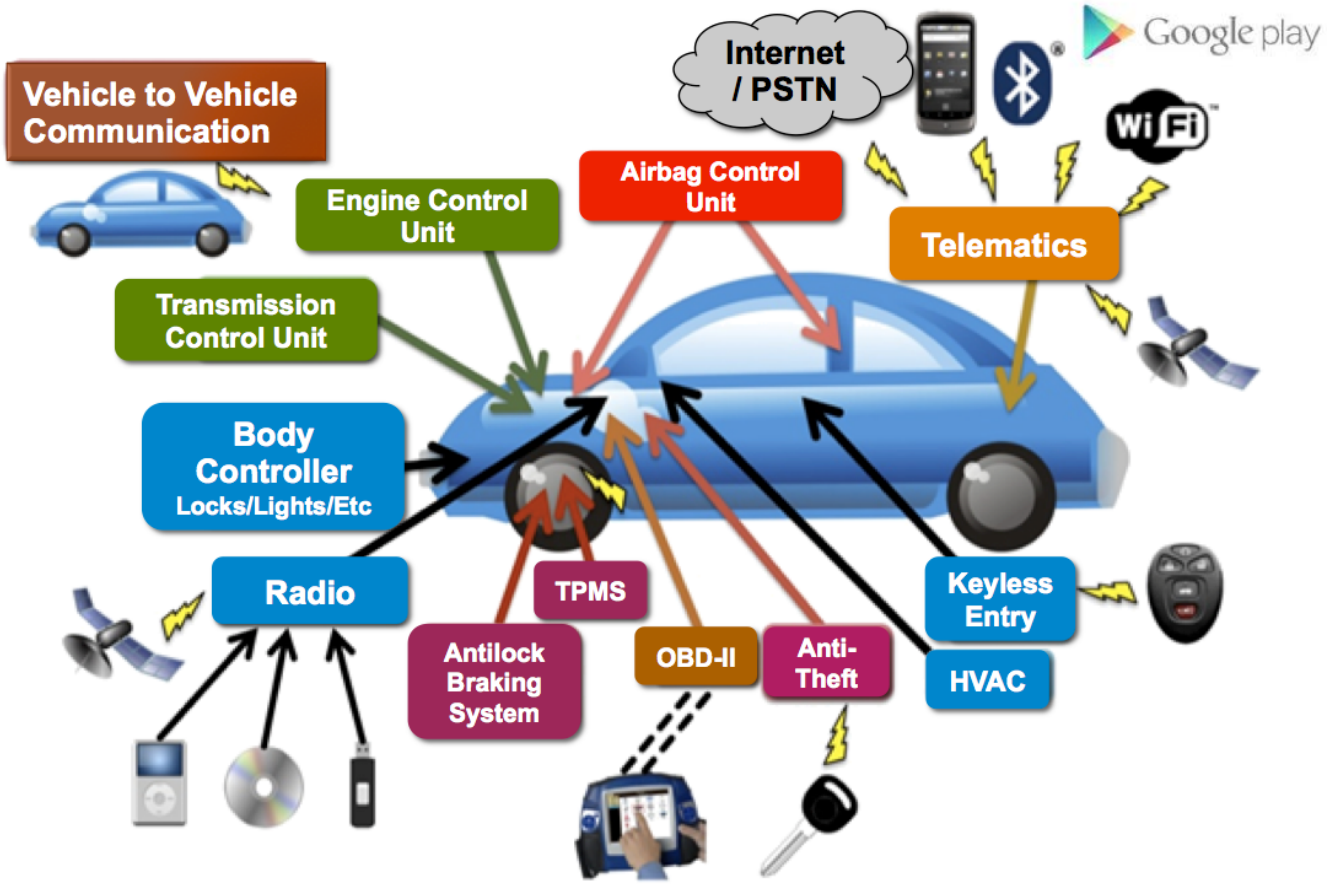
Basics of Circuitry

LECTURE -1

Rahman Rasulzada

To


Vehicle to Vehicle Communication
Internet / PSTN
Google play
Wi Fi
Engine Control Unit
Airbag Control Unit
Telematics
Transmission Control Unit
Body Controller
Locks/Lights/Etc
Radio
TPMS
Keyless Entry
Antilock Braking System
OBD-II
Anti-Theft
HVAC

It Has Never Been A Better Time For Making

- You have access to technology I never dreamed of
  - That is, you can do almost anything
- Most of it is cheap, cheap, cheap
  - So you can afford to play around
- There are so many areas where we need help
  - Energy, environment, health
  - And toys, too!

Class Projects

- 3D printer
- Solar USB charger
- Useless box
- LED plane
- Arduino Projects

All based on learning some EE, and Arduino programming

Course Resources

- Edmodo
  - Grading , Attendance , Submittting lab , projects , Homeworks etc, Lecture notes Announcement ,

- Course Website
  - www.wix.com/rasulzada/area/college
  - All course resources, handouts, homeworks

Grading

Percent (%)		
Active participation	At each lesson	5
Term Project	At the end of the semester	20
Lab Work / Homework/Quiz		20
Midterm exam		20
Final exam		35
Final		100

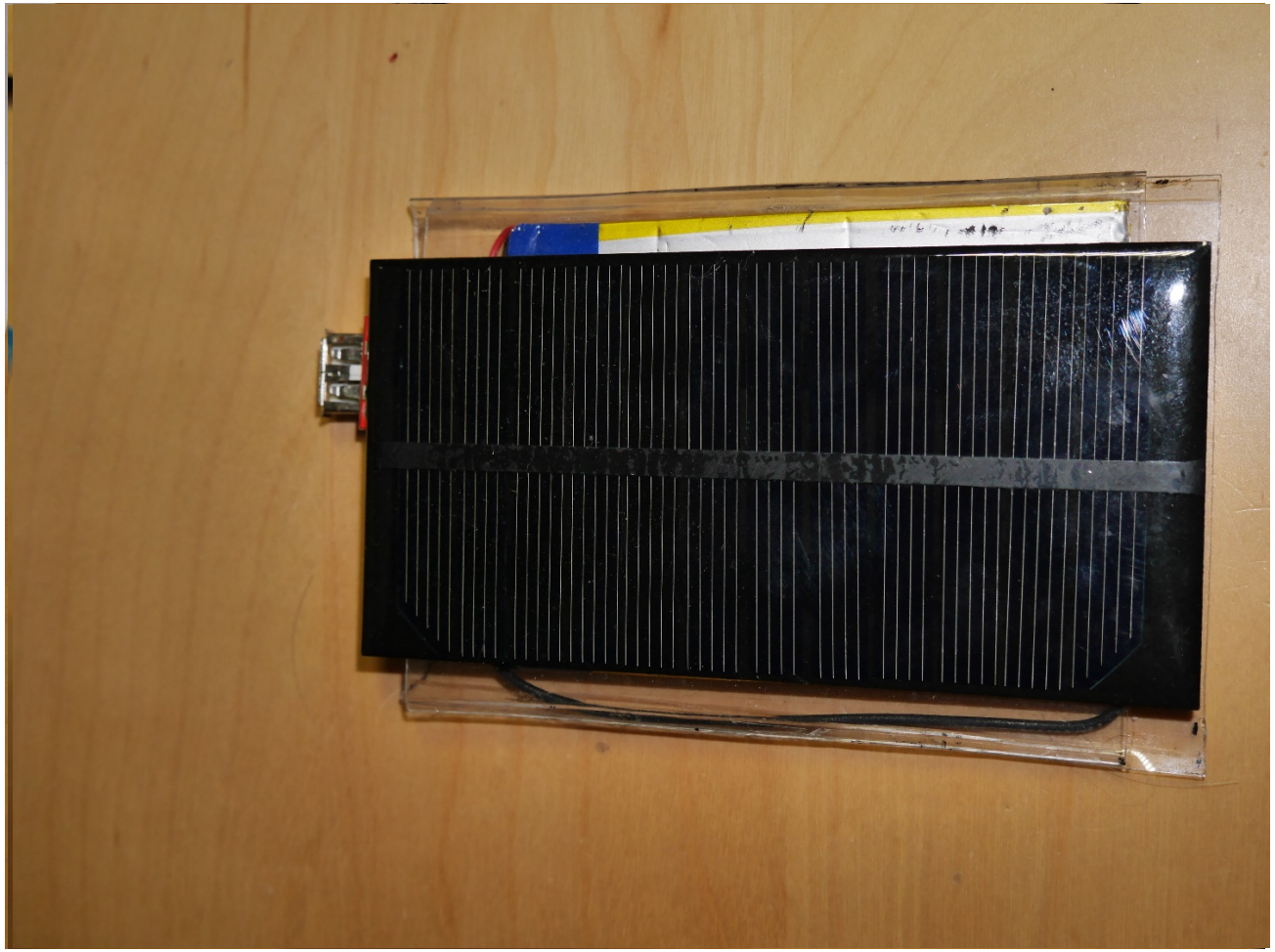
Part Kit / Lab Fee

- You will each get parts to build all the projects
- The parts cost the EE Dept. more than $100
  - Even though we tried to find the cheapest vendors …
- So the $100 lab fee for the class is to pay for the parts
  - They are in the boxes up front
- If you are sure you are going to take this class
  - Please pick up a box. We will need to check your name off

The Textbook

- We are putting together a reader for this class, and most of the material should be found there
- In addition we will have references to A. Agarwal and J. Lang, *Foundations of Analog and Digital Electronic Circuits*, Morgan and Kaufmann, 2005
- The textbook is generally more mathematically rigorous than the lectures, the homework, the labs, or the exams
- Coding in general and Arduino coding in particular are not covered in the textbook, but will be covered in the labs

Let’s Start With Something Simple



Lecture 1

Building a Solar Charger: Charge, Current, and Voltage

Roadmap

In this lecture we start talking about the fundamental things we need to understand if we want to “make” a solar charger. We start with charge, which is the thing that makes the system electrical. Electrical signals are about the movement of charge. The movement of charge is called current (i), and voltage (V) is the potential energy that causes charge to move.

What Does It Do?

- Takes energy from sun light
- Stores it
- Provides that energy later
  - To charge your cellphone
  - Create reading light, flashlight

How does it do that?

How Our Solar Charger Works

- Converts some energy from sunlight into an electrical signal
- That **electrical signal** connects to a rechargeable battery
  - So energy flow from solar cell to battery
- Another electrical signal connects the battery to the USB port
  - So energy can flow to the USB, and charge your phone
- So to understand how this and other stuff is made
  - Need to understand electrical signals

Electrical Charge

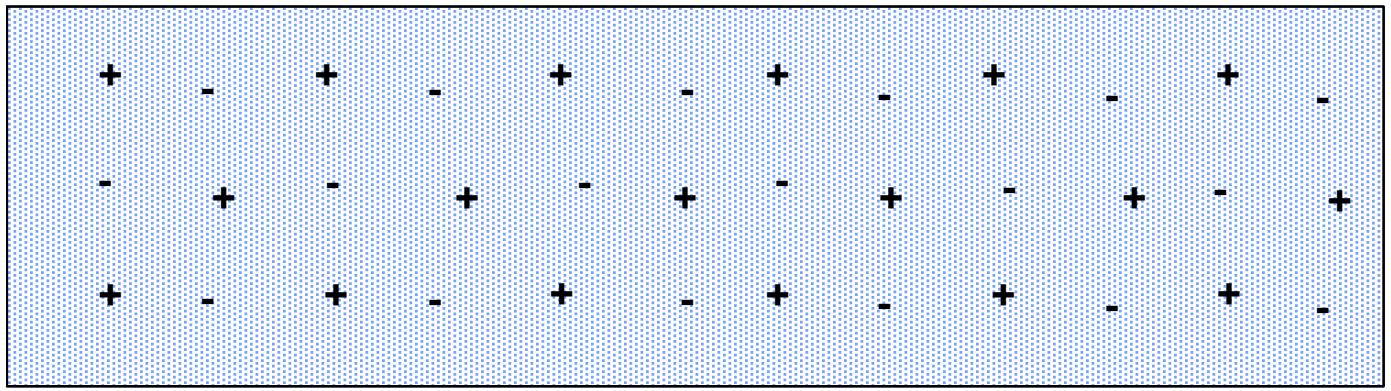
- In electrical systems **charge** is the stuff that does the work
  - In some ways, charge is what makes the system electrical

- Charge is measured in **Coulombs**
  - 1 coulomb is a *lot* of charge
  - Each electron has a charge of -1.6×10^{-19} Coulombs

- Charge can flow (move) in material that **conducts**
  - Often called wires

Inside a Wire

- A wire is charge neutral
  - Has both + and – charges
  - In a wire, one of the charges can move



Current

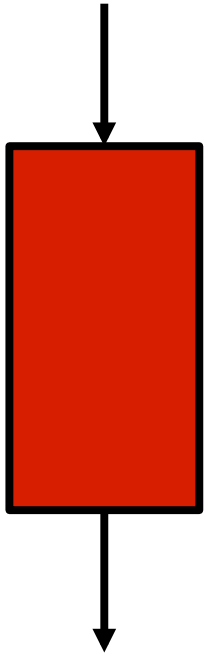
- Moving charge is called **current**
  - Current is the flow of charge per second
    - Past some measure point

- Its unit is the **Ampere**, usually called **amps** and abbreviated A
  - 1 A = 1 Coulomb/sec = 1 Cs^{-1}

- When people write equations for current
  - Current is represented by **'i'** in most equations (huh?)
    - First referred to as "l'intensité du courant électrique"

An Electrical Device

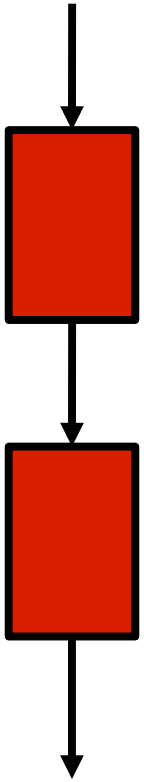
- An object that charge can move through
  - That is current can flow through it



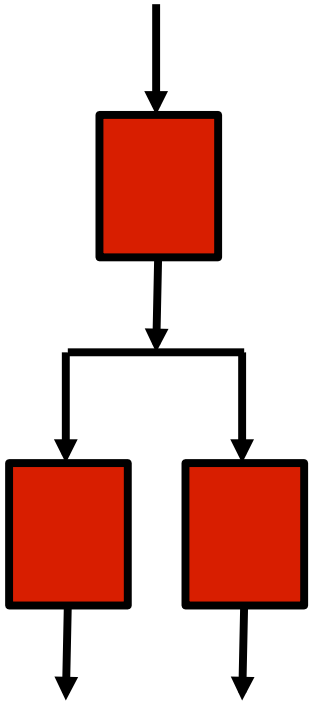
1st Rule: All Electrical Devices Have Two or More **Leads**

- All electrical devices are **charge neutral**
  - That means the charge stored in the device is zero
  - The charge that leaves one terminal, must re-enter another
    - Thus, they must have more than one lead
- The net current into any device is **always zero**
- This fact holds for wires, too!
  - Current that flows into on end of a wire must flow out the other
  - Often called KCL (Kirchhoff's Current Law)

Connection in Series



Constraints on Currents (KCL)



If You Think of Charge as a Liquid

- Current is then the flow of the liquid

- Current constraints are then about fluid conservation
  - The fluid in any object is constant

- But we know that a fluid doesn't move unless it is pushed
  - What pushes charge to make it move?

A Voltage Source

More About Charge

- In Physics, **charge** is a fundamental property of particles
  - Particles can have + charge (protons), - charge (electrons) or have no charge (most stuff)

- Like magnets, like charges repel, and opposites attract
  - Think of balloons and static electricity (that is charge)

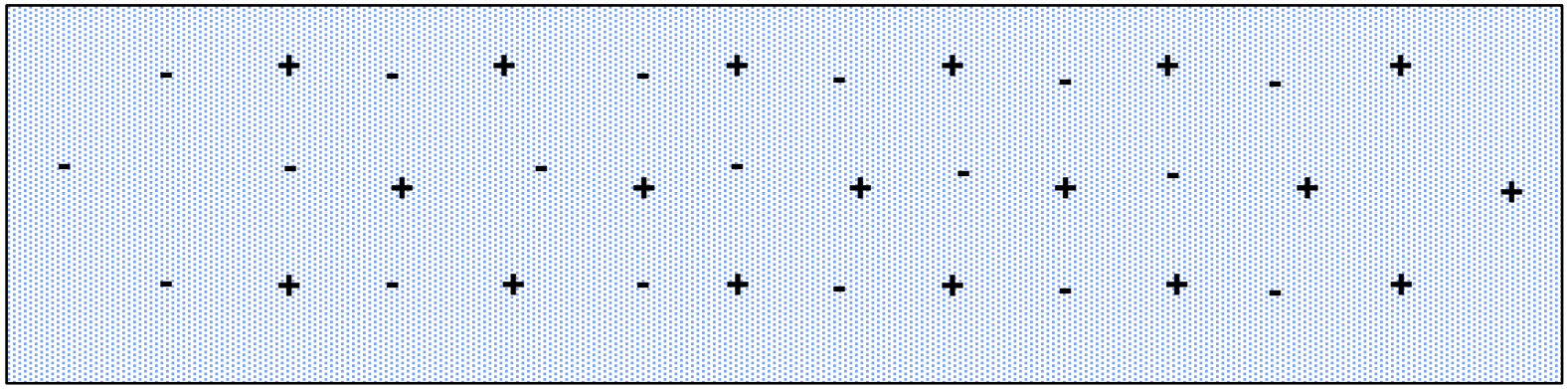
What Happens If You Separate Charge?

- Imagine inside of a device you have an electron pump*
  - The pump takes electrons and moves them to one side
  - It leaves the a positive charge on the other side of the device
    - So the device is still charge neutral as it must be

*an example of an electron pump: a battery

Separating Charge

- The device is still charge neutral



Remember That Like Charges Repel?

- They don't like to be with their brothers
  - Repel means that there is a force pushing on the charge as you try to move the electrons together
  - It takes energy (force * distance) to move the charge
  - It is just like pumping water up a hill

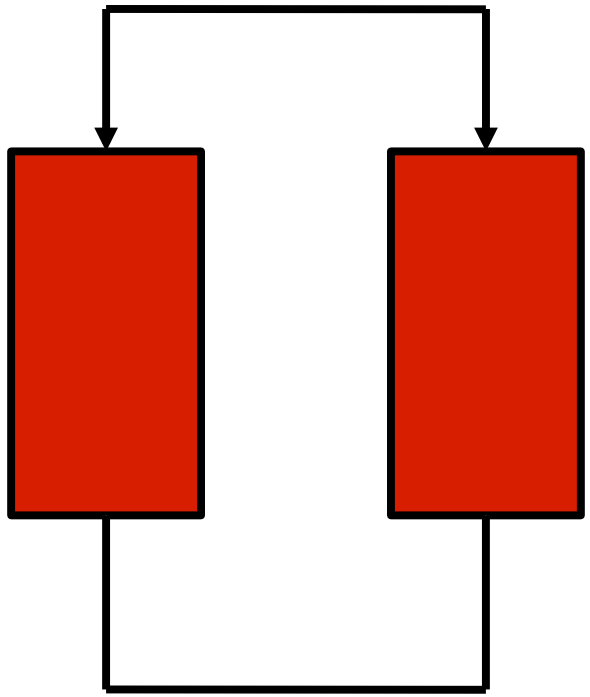
- I have a little demo here…

Measuring the Potential Energy

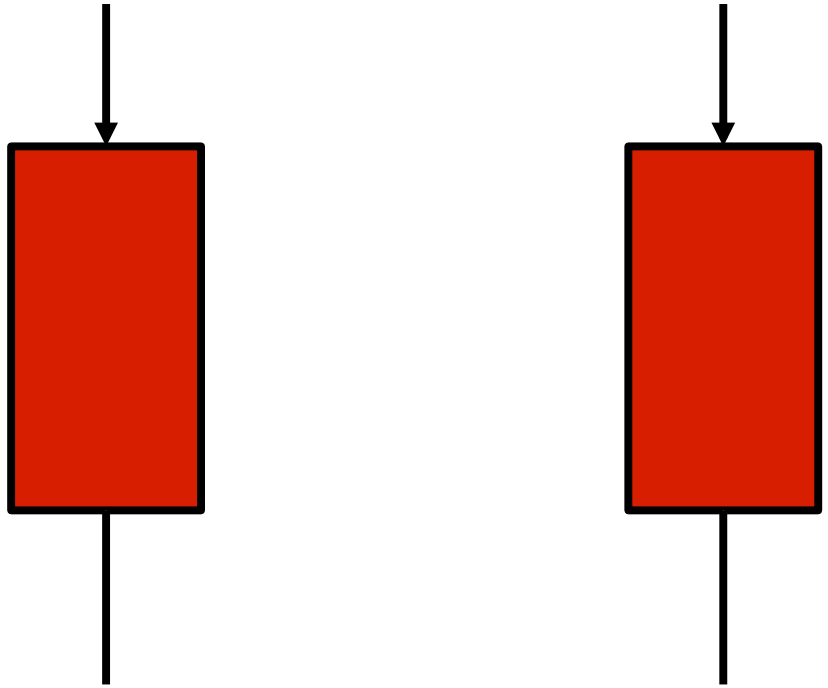
- **Voltage** is a measure of this potential energy per unit charge
  - It is measured in **Volts**
    - Which has units of Joules per Coulomb.

- The charge on the higher energy side of the device will move through an external path (a wire) to neutralize the negative charge on the other side of the device.
  - This causes the charge to flow in the circuit, as well as through the device.

Connection in Parallel



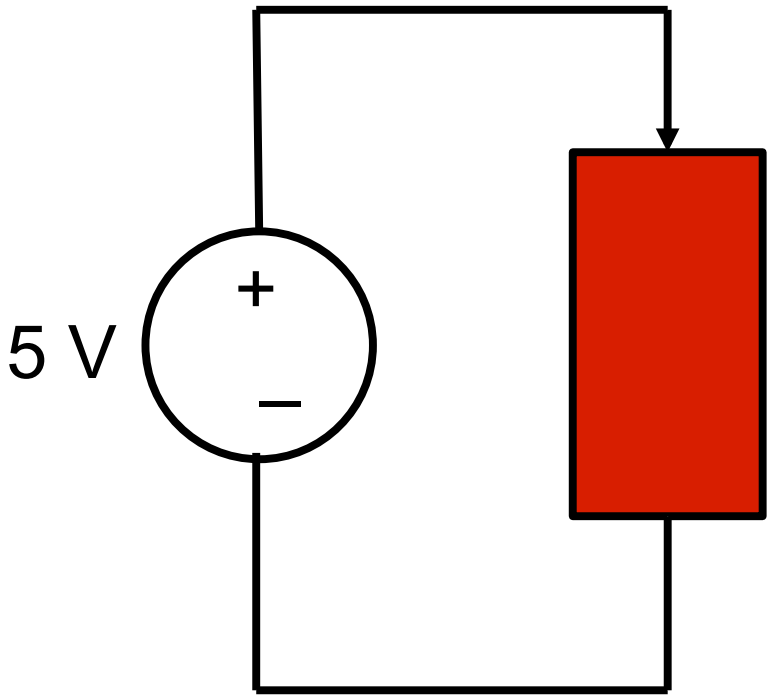
Representing a Simple **Circuit**



lead

node

Representing a Simple Circuit



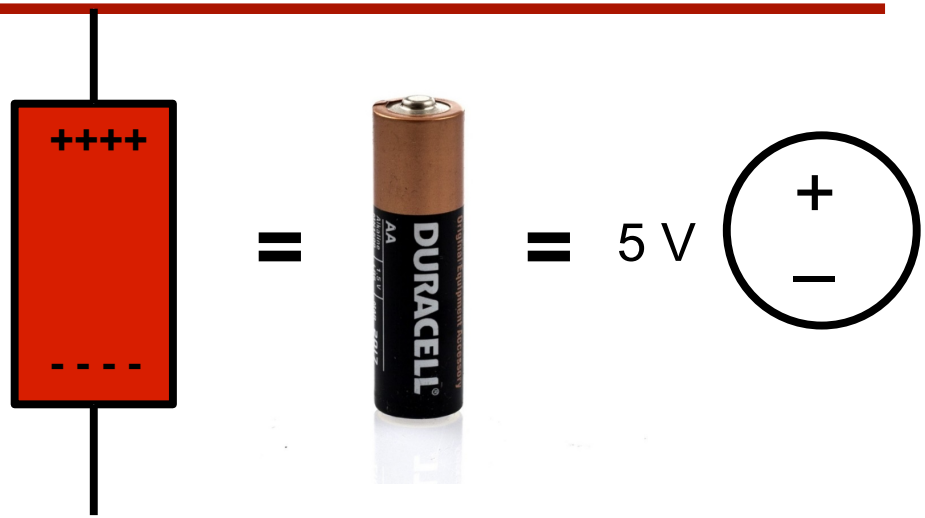
What is a Battery?

- It is a chemical pump for electrons!
  - There is a pair of chemical reactions that pump electrons from anode to cathode
    - Actually, a battery absorbs electrons at the anode and creates electrons at cathode (with ions moving through the middle), but it has exactly the same effect
  - The battery voltage is the potential energy given to electrons as a result of this pump.

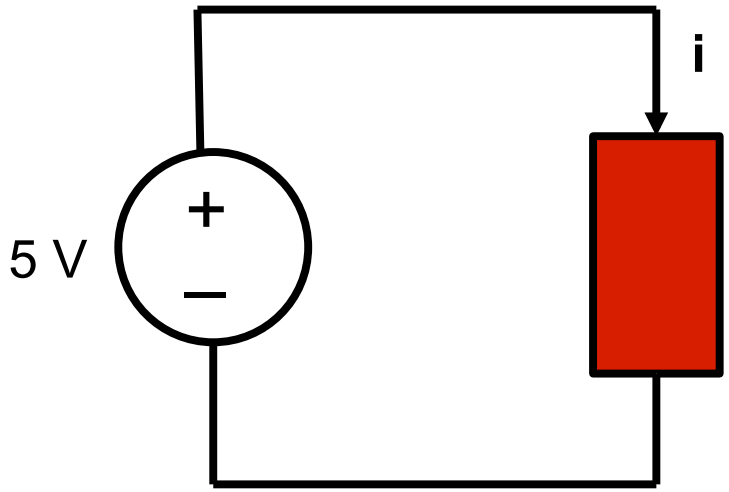
- The voltage of the battery depends on chemicals
  - Generally either 1.5 V, or multiples
  - Or around 3.5 V (lithium)

Voltage

Charge can be separated in an electrical device if we provide the energy to “pull” the charges apart. Batteries use chemical reactions to separate the charges.



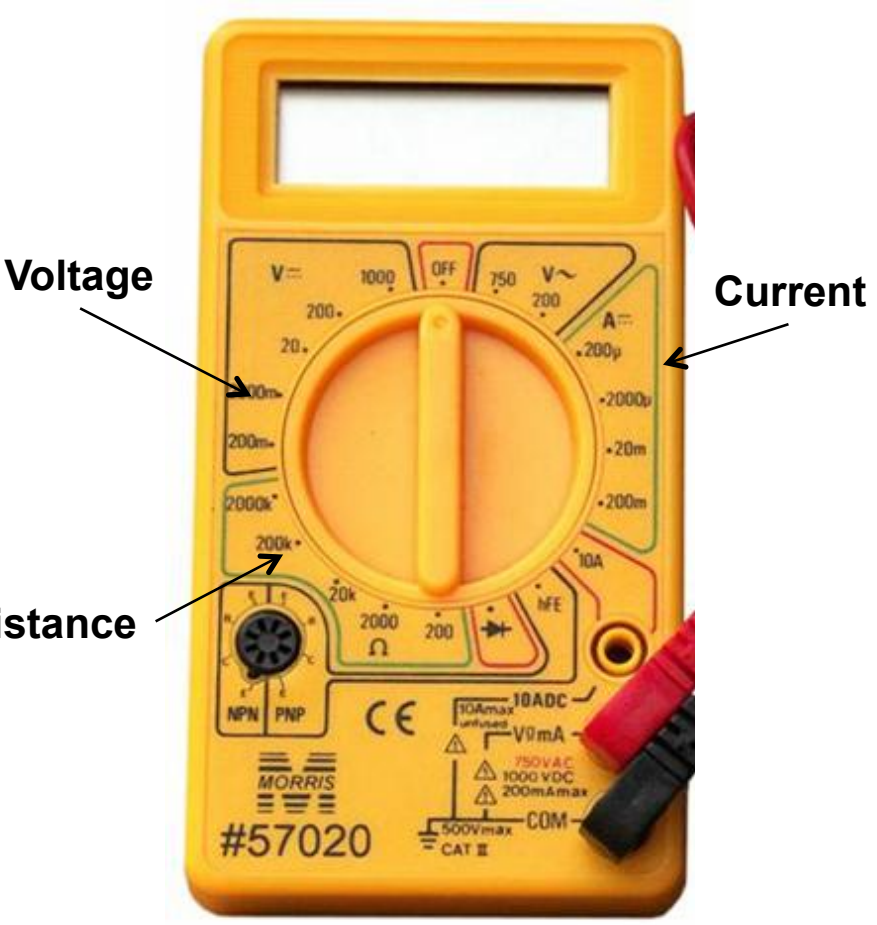
If an electrical device is connected to a battery or voltage source, current measured in amperes (amps) will flow through the device.



IN CLASS ACTIVITY

Digital Multi-Meter (**DMM**)

- Is going to be your friend
- It measures voltage and current
  - Measures voltage from red wire to the black wire
  - Measures current flowing from the red wire to the black wire
- It steals very little current when measuring the voltage
- It has a small voltage when measuring current (< 100 mV = 0.1 V)



Standard Prefixes for SI Units

10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ (or u)
10^{-3}	milli	m
10^{+3}	kilo	k
10^{+6}	Mega	M
10^{+9}	Giga	G

Measure the Voltage of an AA battery

- Take out your DMM
  - Turn the main dial to 2000 mV = 2 V
  - Put the red lead on the + end
  - Put the black lead on the - end
- Is the result 1.5 V, as advertised?
- What happens if you put the red lead on the – end?
- Measure the voltage of two batteries in series
  - Hint: need to move to the 20 V scale

Learning Objectives

- Understand that **charge** is what makes components electrical
  - Moving charge is called **current**, and often represented by "**i**"
    - Measured in **Amps** = Coulombs/sec
- Understand that all components and wires are **charge neutral**
  - This means that the net charge flowing into an object is 0
  - KCL – The sum of the currents into an device or wire = 0
- The energy that causes the charge to move is called **Voltage**
  - Measured in **Volts** = Joules/Coulomb
  - Voltage is a potential energy difference
    - Measured between two nodes
- Be able to use your **DMM** to measure voltage and current