Electronics Merit Badge

Class 1

Equipment Used

Volt/Ohm/Amp Meter or <u>Multimeter</u>
Usually referred to as a **DVM**.
With this we can measure current, voltage and resistance.

Oscilloscope
Usually referred to as <u>scope</u>.
With this we can 'see' voltages.
This is very useful when voltage is changing, as a meter is no good to us when this is happening.

Computer

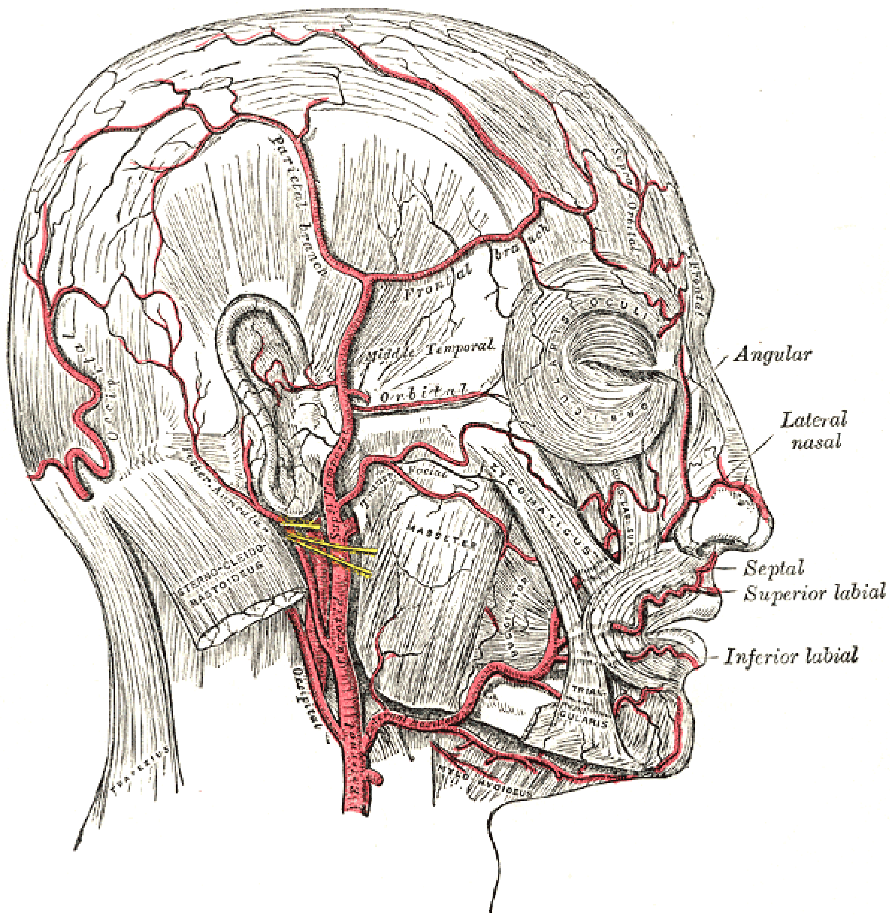
Computers are used heavily for research, for drawing schematics, for writing programs, for assisting in fixing broken circuits, etc…

Frequency Counter

Circuit Boards

Two of the most important tools of the trade

Your Brain



A brain assistant.

What does the term

Electronics

Mean?

Electronics

- We use electronics to change the form of electrical signals to do something useful.

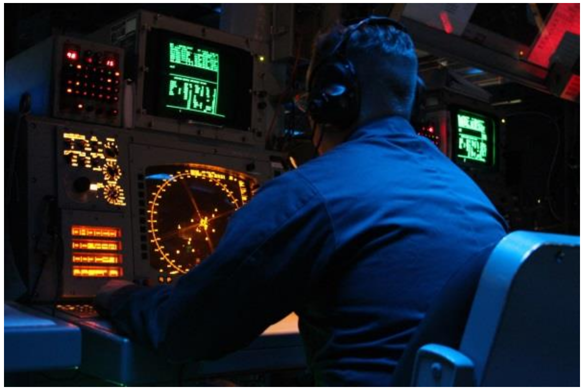
- The first use of electronics was for “wireless” radio broadcasts.

- Electronic circuits change the SHAPE, AMPLITUDE (SIZE), FREQUENCY, or PHASE of signals.

- Electronics are used for the control of devices and machines.

- Electronic circuits can convert energy from one type to another such as providing the electrical energy to drive a speaker which converts electrical energy to sound that you can hear.

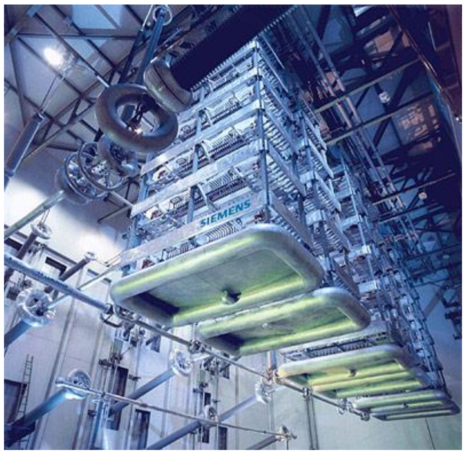
- Electronics are used to perform digital calculations (processors) and can store information (memory).



Radar and Air Traffic Control

Automotive

Satellites and Communications



Power

Radio

Smart Phones

Personal Computers

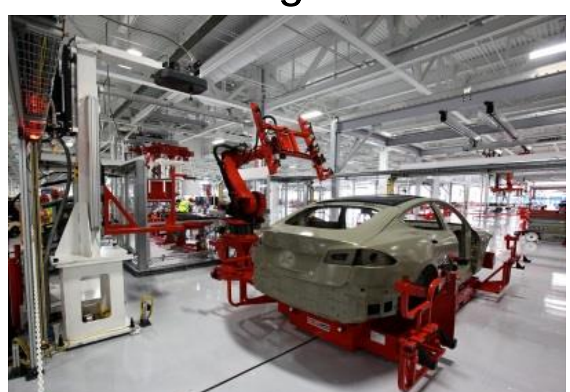
Navigation and Transportatio

Television

Games

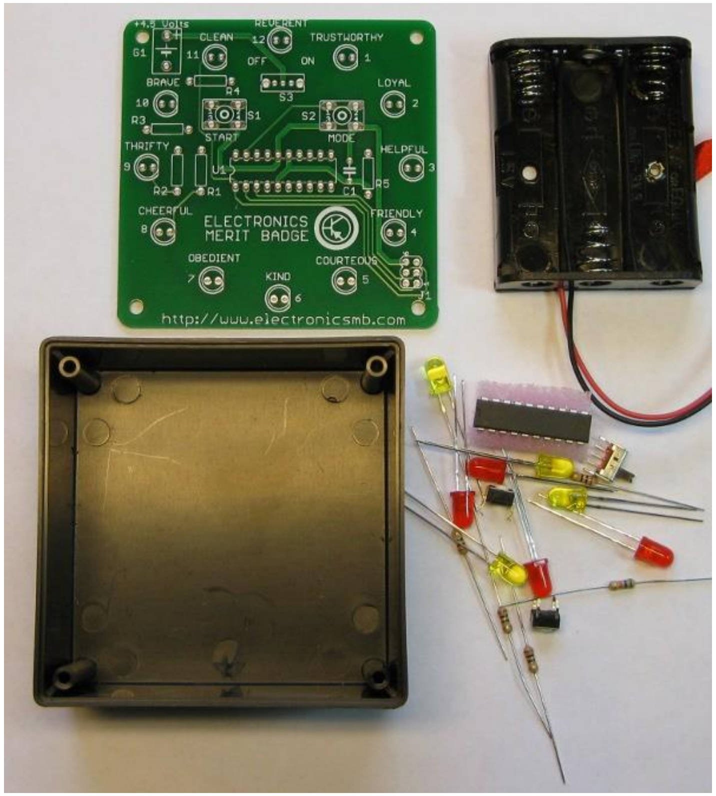
Medicine

Manufacturing and Robotics



Internet

Electronics Merit Badge Project

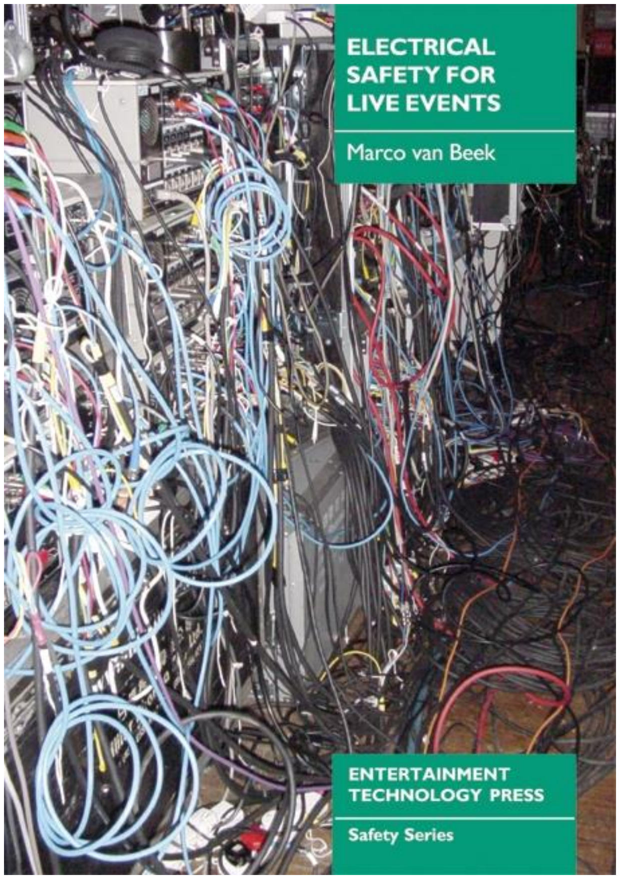


Before

After

This is the project you will build.

Safety with Electricity and Electronics



Describe the safety precautions you must exercise when using, building, altering, or repairing electronic devices.

emeritbadges.org

Electricity Safety

- High Voltage (120V AC or greater) – Safety mainly about not touching the wrong thing.

- Current kills – Only 16 volts can kill when enough electrons flow through the heart or head.
- Ventricular fibrillation – Electrons passing through the heart causes muscles to seize, causing death.
- If the shock doesn't kill you, you can still be badly burned from touching the wrong thing.

How to avoid shock.

- Turn power off before working on equipment.
- Don’t touch circuits that could have high voltage on them.
- Do not allow electrons to flow through the heart. I don’t think the snake knew about this detail.

Electronics Safety

Requirement 1

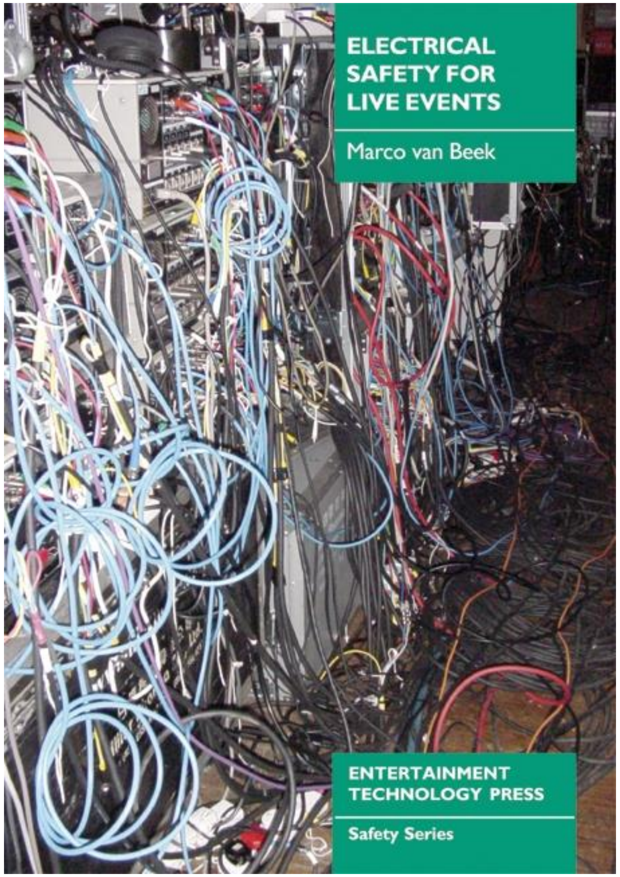
- Electronics devices generally use lower voltages (less than 48 volts). You are usually working with DC voltage instead of AC voltage.
- You are usually more concerned with sparks from connecting the wrong wires together, or burning yourself with a soldering iron, or some similar event.
- Even when working with lower voltages, you may still receive an electrical shock from equipment you are using.

Personal Safety

Requirement 1

- Be aware of what you are doing, and where you are placing equipment and yourself.
- Pay attention to hot soldering irons. Keep a good distance between you those next to you.
- Know when you are working with high current and/or high voltage circuits.
- THINK before you do something.
- <u>Wear safety glasses when soldering.</u>

Safety with Electricity and Electronics

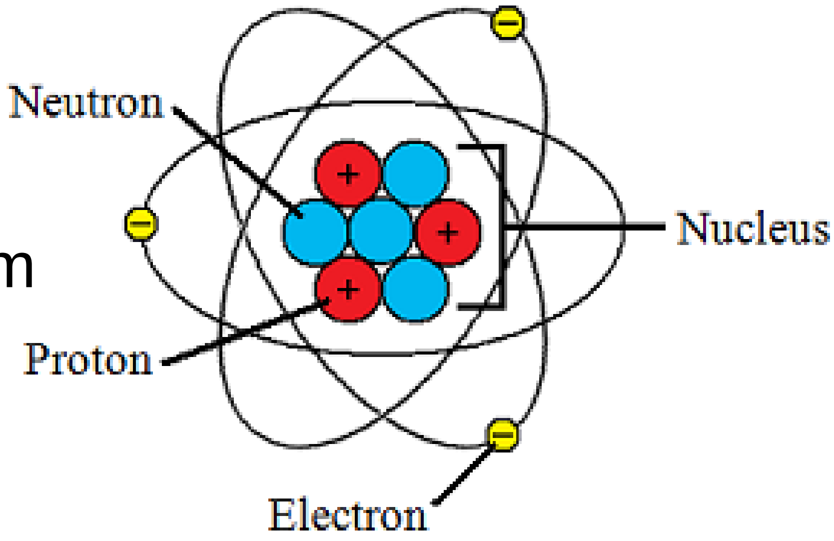


So what is ELECTRICITY?

What are the three main types of electricity?

What is Electricity?

- The atom is a basic component of matter.
- Composed of Protons, Neutrons and electrons. The number of each determines what element it is.
- Electrons have a **negative** charge while Protons have a **positive** charge.
- Sometimes electrons can be pulled free from an atom. They can be attracted to another atom that is lacking an electron.
- This flow of electrons is known as ***Electricity***.



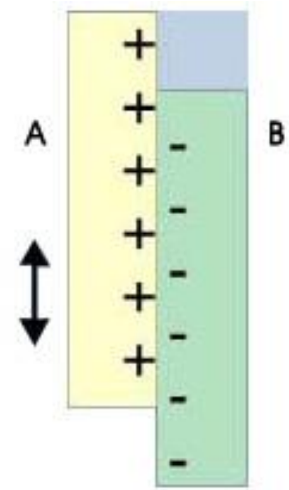
Types of Electricity

Static Electricity

Static electricity is usually created when materials are pulled apart or rubbed together, causing positive (+) charges to collect on one material and negative (−) charges on the other surface.. Sparks may result!

Examples of static electricity:

1. Lightning.
2. Combing hair.
3. Walking across carpet and getting shocked.
4. Pulling out scotch tape.



Generation Of Static Electric

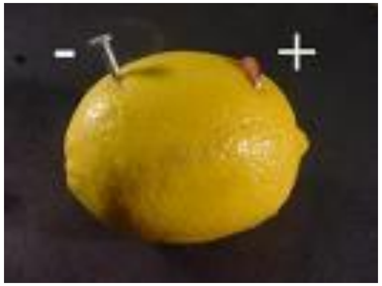
Types of Electricity

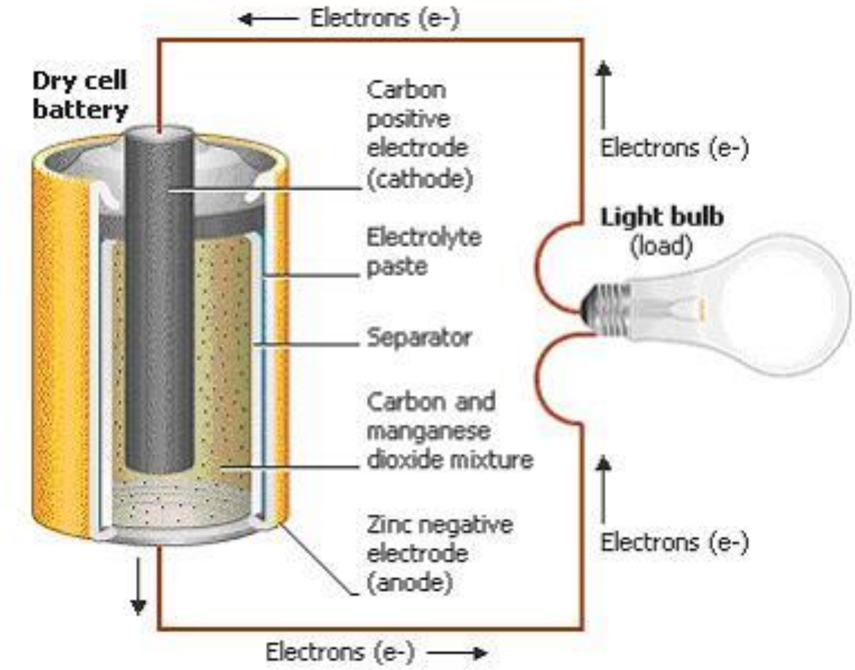
Direct Current (DC)

Type of electricity used in most electronics we have today. Current only flows in one direction (not both directions, like AC).

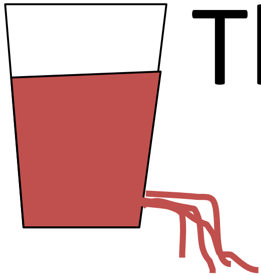
Examples of DC usage:

1. MP3 players
2. Radios
3. Electricity in cars.
4. Anywhere you use a battery for power.



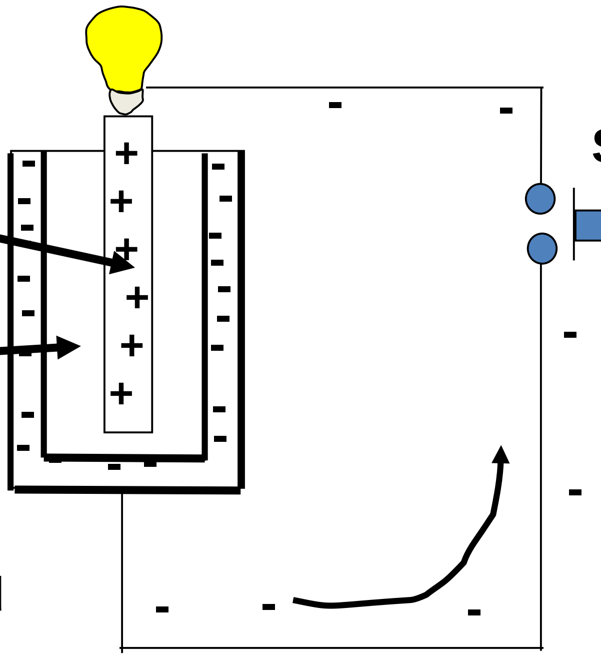


The Battery as a Direct Current source.



Glass of Water has Force called pressure

Flashlight



Carbon Rod

Gel Insulator

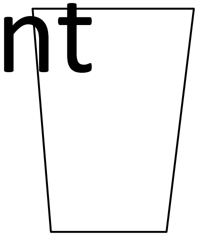
Zinc Casing

Switch

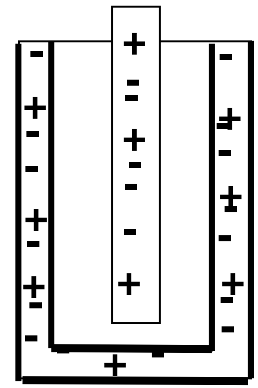
Battery works from a chemical reaction between the carbon rod and zinc case

Charged Battery
<u>1.5 volts</u>

<u>Current Flow Electrons</u>



Empty Glass Has no Force



Discharged Battery
<u>No Voltage</u>

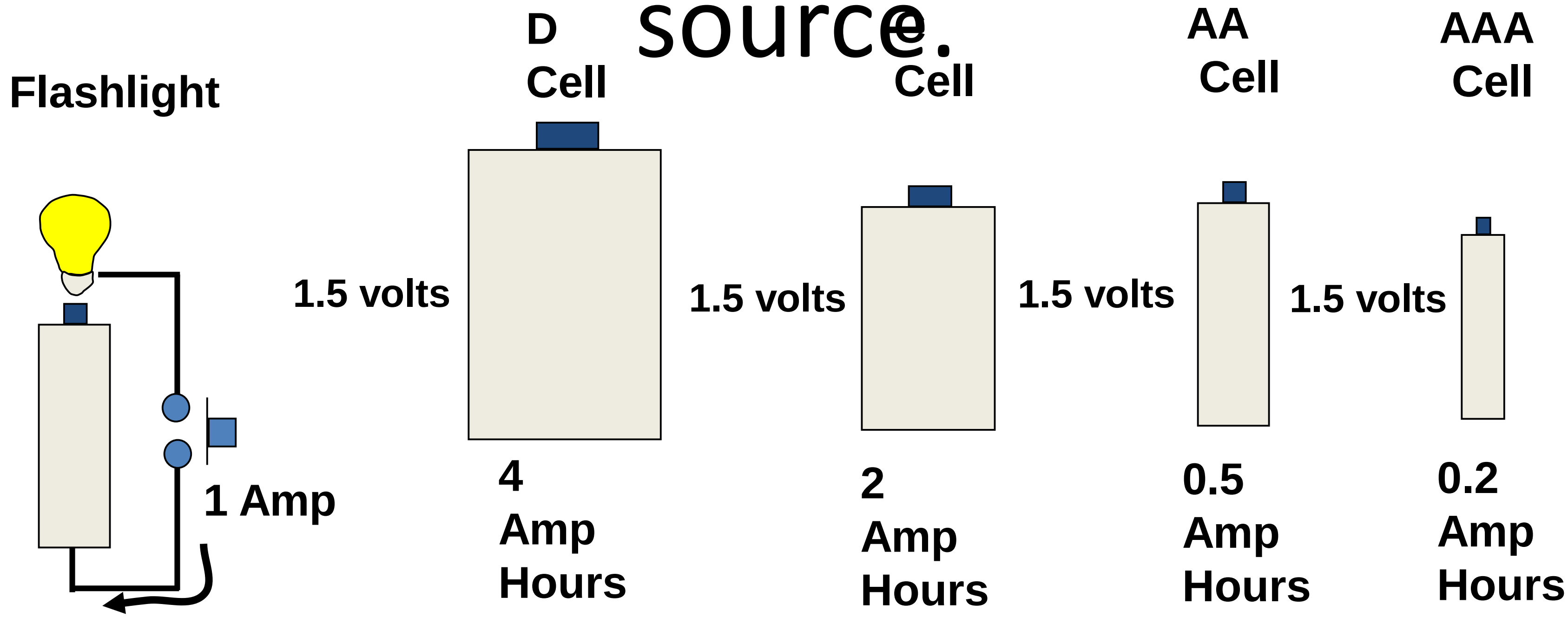
Voltage is the quantity of <u>electrical force</u> Measured in Volts
Current is the flow of <u>electrons</u> Measured in Amps
DC Stands for <u>Direct Current</u>
DC is current flowing in <u>one</u> direction

The Battery as a Direct Current source.

So what factors do you think affect how much electron flow a battery is able to deliver (*Current*)?

What might affect how much electrical pressure (*Voltage*) is generated by the battery?

The Battery as a Direct Current source.



With batteries, the type of materials used for the chemical reaction as well as the physical size determines the capacity of the battery to deliver a given amount of current for a length of time.

Direct Current

Cost of Batteries for the Same Output

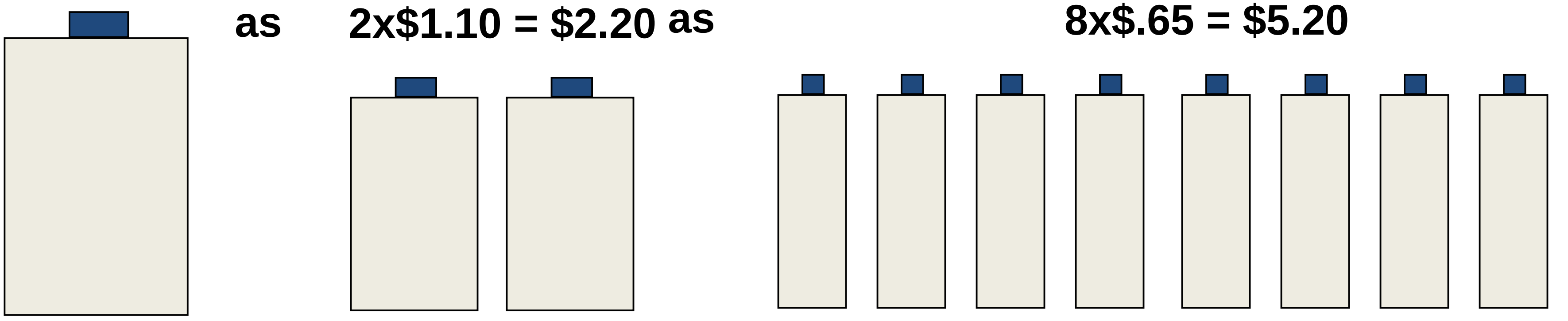
D Cell
$ 1.50

Same as

2 - C Cell
2x$1.10 = $2.20

Same as

8 – AA Cell
8x$.65 = $5.20

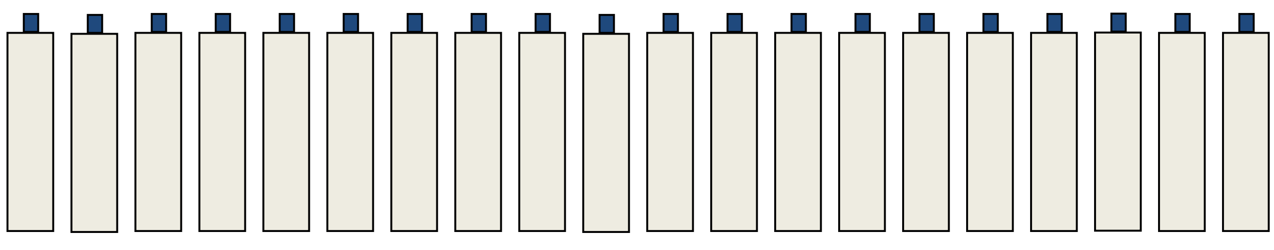


4 Amp Hours **=** **2 Amp Hours** **2 Amp Hours** **=**

.5 .5 .5 .5 .5 .5 .5 .5 Amp Hours

8 x .5 = 4 Amp Hours

Same as

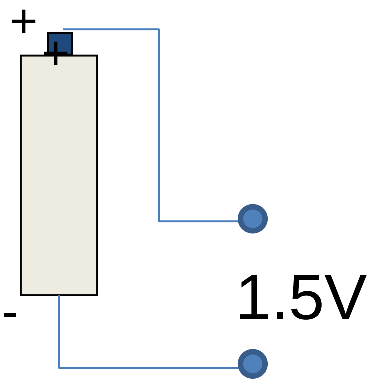


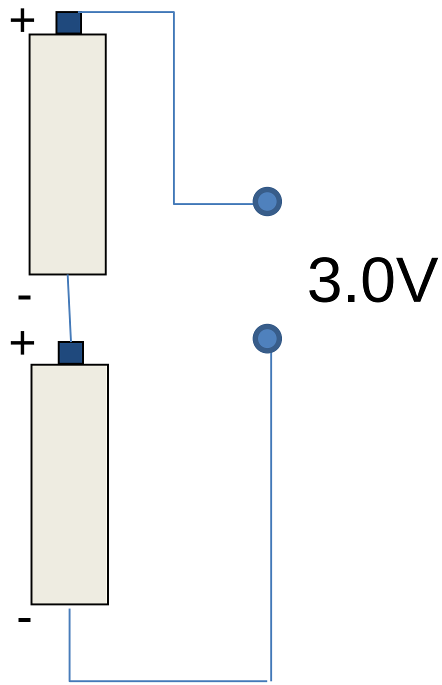
= **20 – AAA Cell**
20 x $.45 = $ 9.00

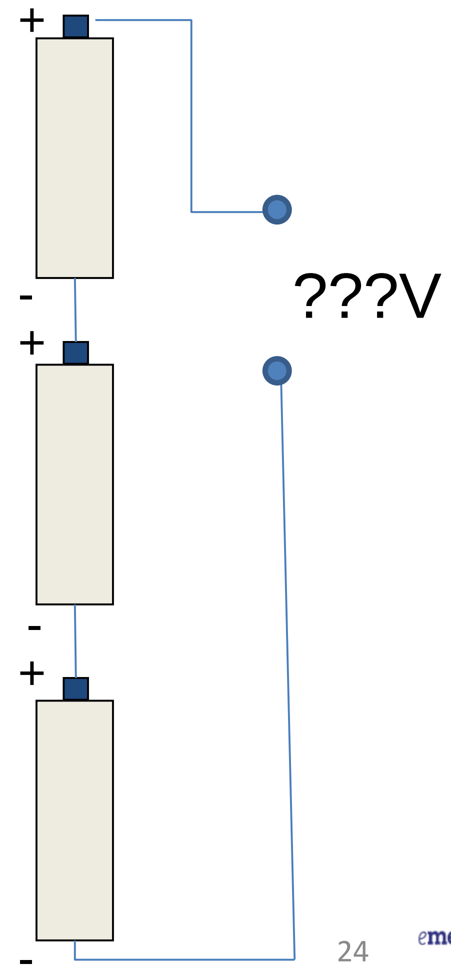
20.2X = 4 Amp Hours

The more Batteries
The more Waste

Batteries in series—voltage adds.



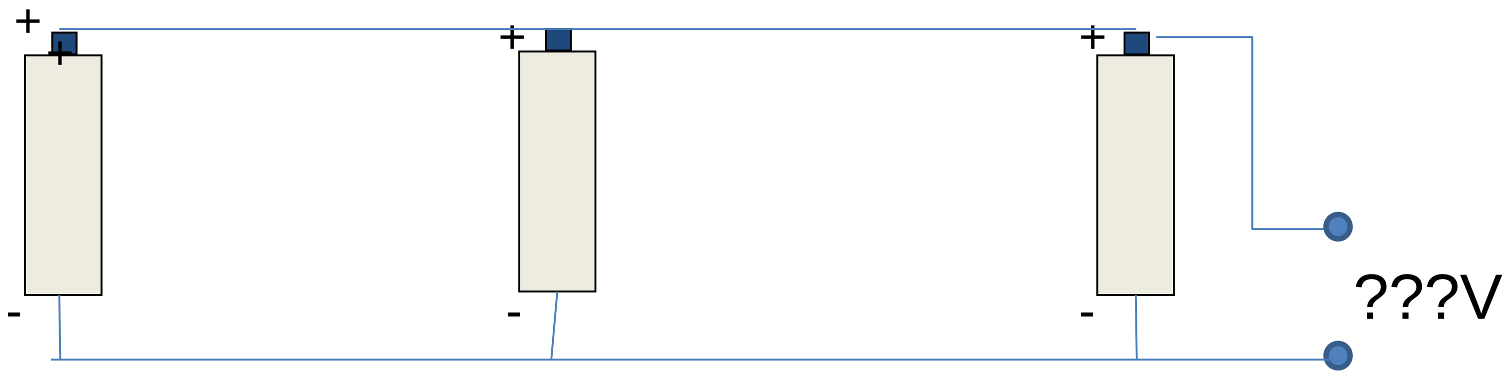




Voltages add together but electron flow is limited by biggest battery.

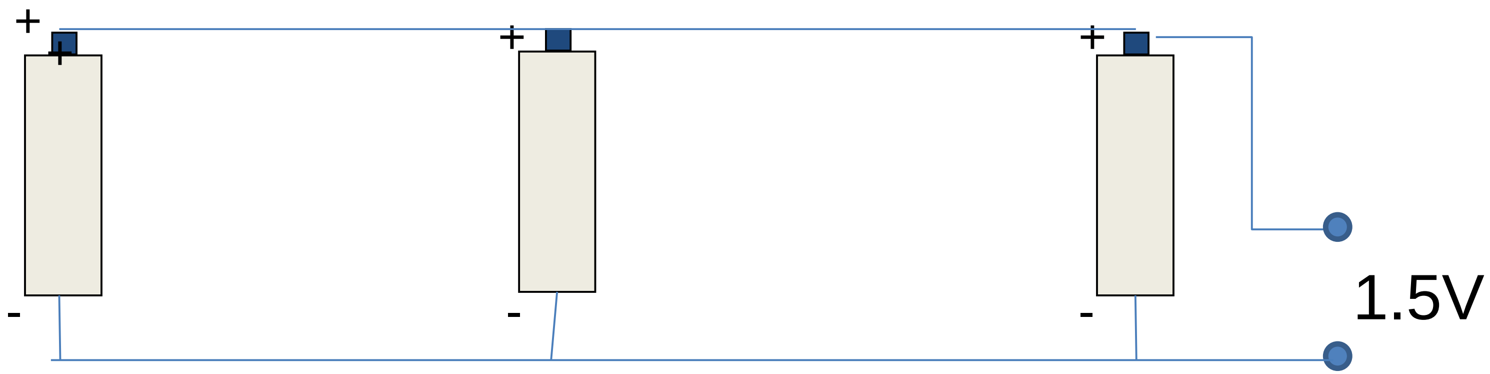
If SERIES Voltages ADD, what do you think happens if they are in parallel?

These batteries are connected in parallel.



What do you think the final output voltage of this combination of batteries will be?

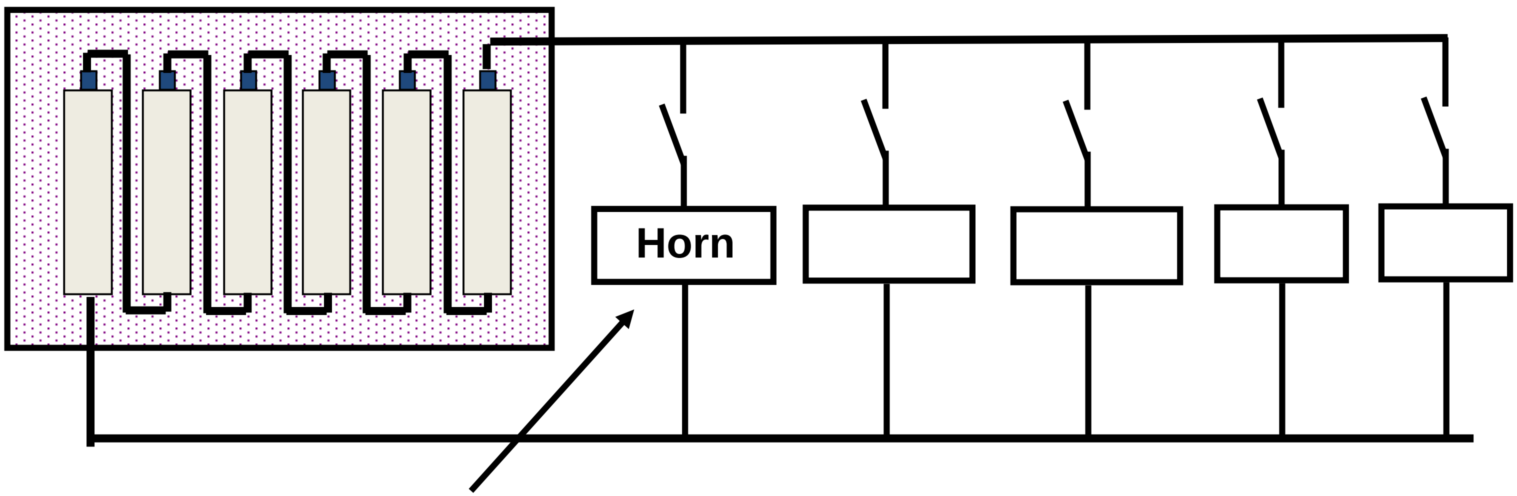
Batteries in parallel, voltage stays the same but current adds.



Since the voltage is roughly the same on all the batteries, it is roughly the average. Each battery can supply electrons so the total flow adds.

Direct Current
Car Battery System

Batteries can be joined together to either add to their voltage or add to their current. This is a diagram of a car battery. Are we adding to the battery voltage or current? Are these in series or parallel?

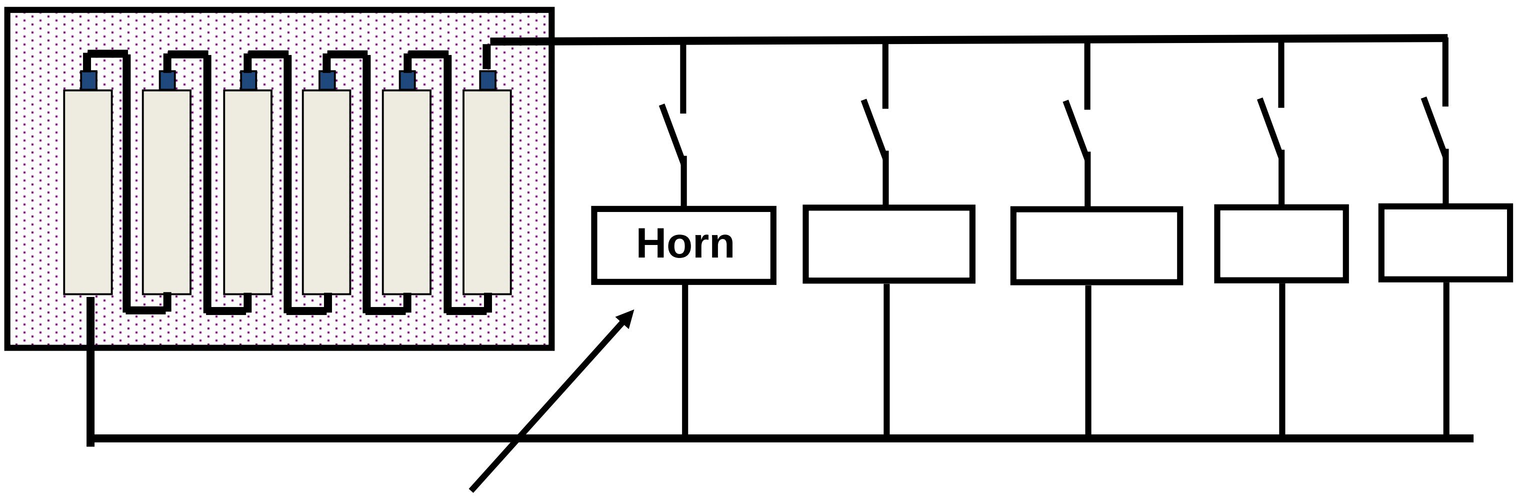


What are some of the electrical items in a car?
What voltage do most of these devices run on?

Direct Current
Car Battery System

Car Battery consist of six 2 Volt cells. How much total Voltage?

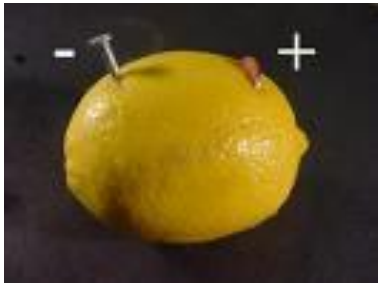
2v + 2v + 2v + 2v + 2v + 2v = __________Volts

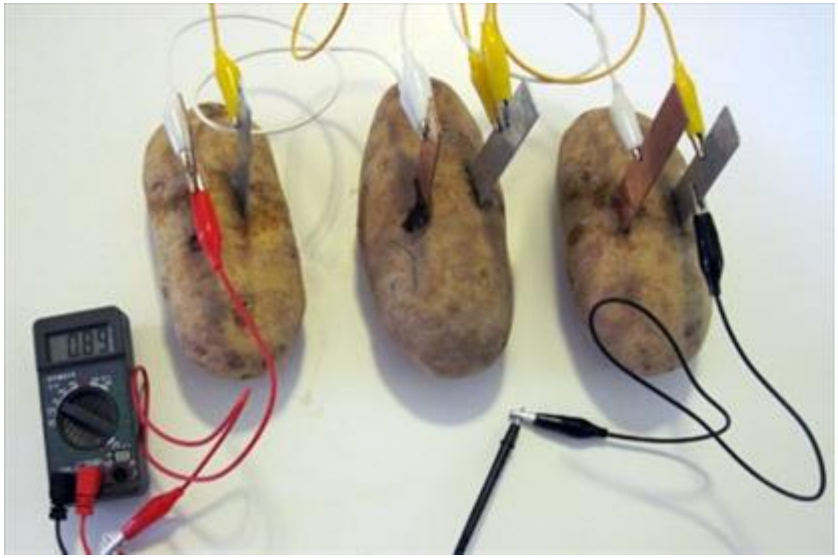


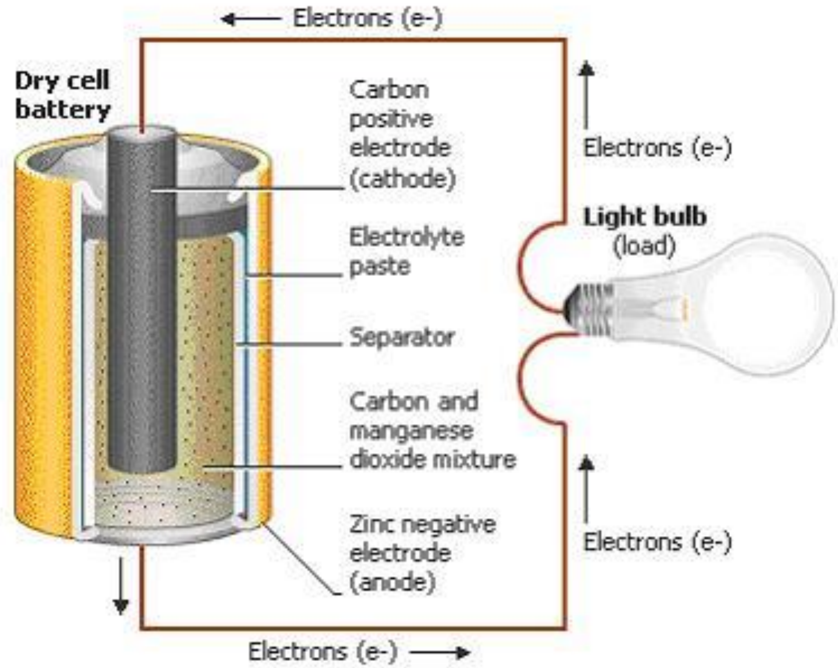
What are some of the electrical items in a car?
What voltage do most of these devices run on?

Types of Electricity

The Lemon vs. the Potato as a battery



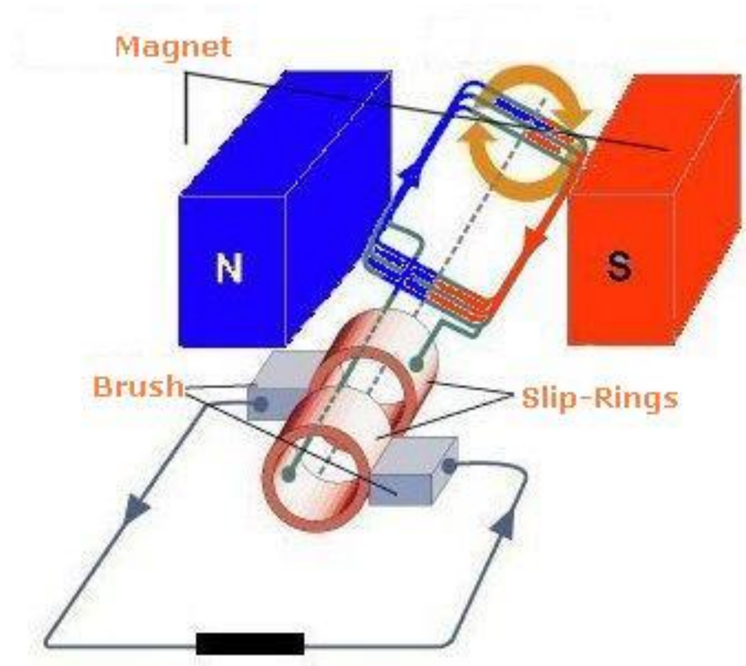




Types of Electricity

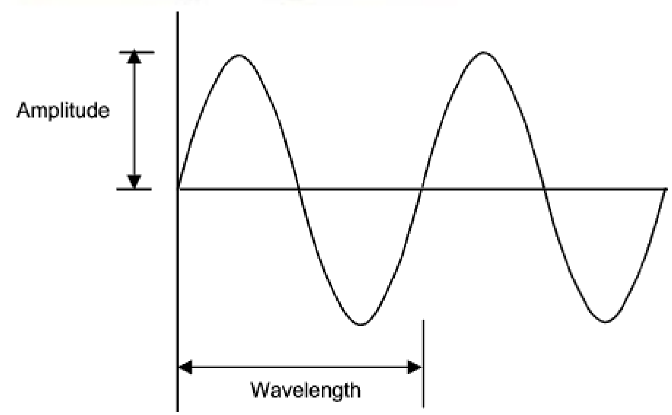
Alternating Current (AC)

The common form of electricity from power plant to home/office. Its direction is reversed 60 times per second in the U.S.; 50 times in Europe.



Examples of AC usage:

1. Kitchens: Stoves, ovens, mixer, etc.
2. Computers (the plug)
3. Lights in house
4. Home air conditioners.



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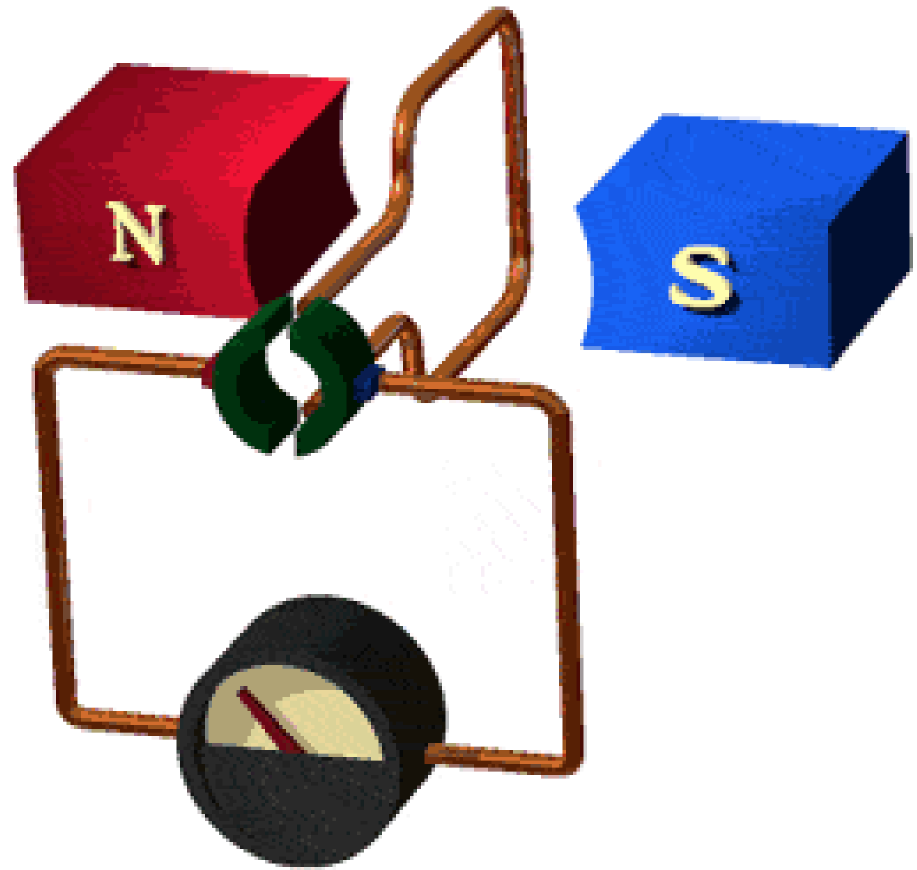

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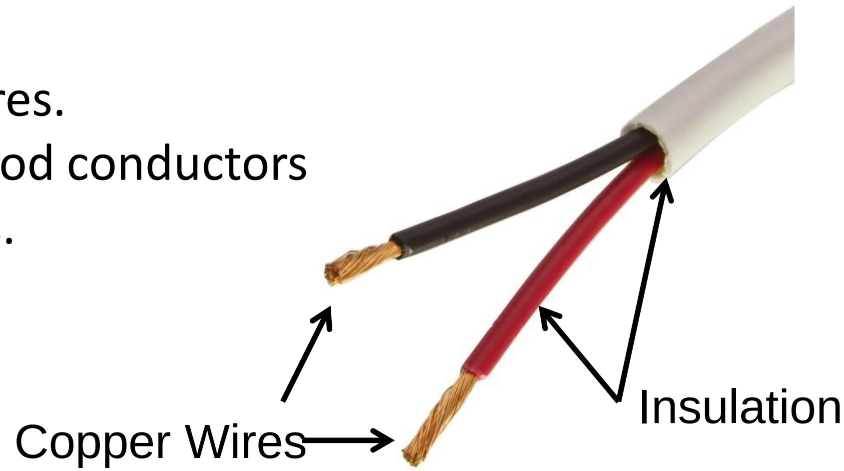
Conductors and Insulators

Conductors

- Act as a path for electrons to flow.
- Most metals are conductors.
- Metal is used for electrical cables and wires.
- Gold, silver, copper and aluminum are good conductors because they have a lot of free electrons.

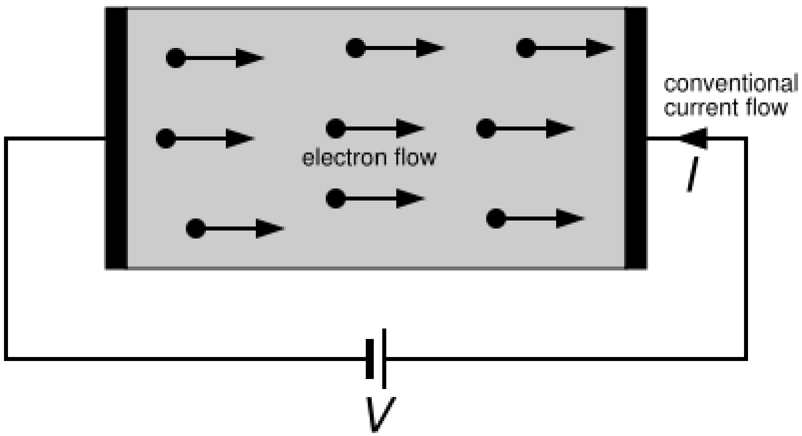


Insulators

- Prevent the flow of electrons.
- Plastics, glass, and ceramics are good insulators because they don't have many free electrons.
- Insulators are used as the jacket on wires and cables to protect people from electrical shock and prevent 'short circuits'.

Basics of Electronics

- Current: Defined as "flow of electrons".

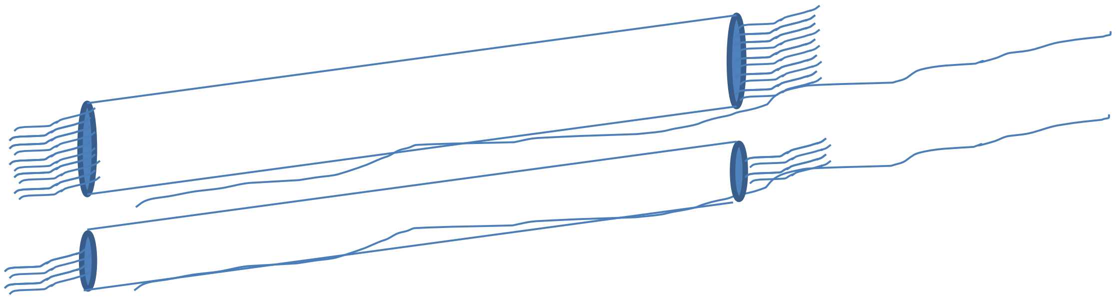


- Current: Unit of current is AMP.
- Current: Current is represented by the letter **I or A**.

Current

- Current: Defined as "flow of electrons".
- Current: Unit of current is AMP.
- Current: Representation for current is **I** or **A**.
- Common units for current are:
  - Amps
  - Milliamps (ma): 1 ma = .001 amp
  - Microamps (ua) : 1 ua = .000001 amp, or .001 ma
  - Nanoamps (na) : 1 na = .000000001 amp or .000001 ma, or .001 ua.

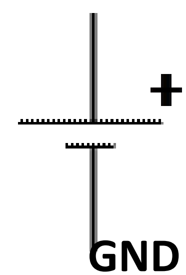
Current Flow – Water Analogy



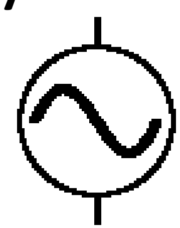
1. Water flows in the hose, entering at the top and exiting the bottom.
2. The water is the “current” ; the flow of electrons.
3. The more water flowing in the pipe, the more electrons are flowing in the wire.
4. Different pipe diameters illustrates different resistance to water flow, which correlates to different resistor values.

Voltage

- The electrical force that causes electrons (current) to flow.
- Voltage can also be thought of as the electrical pressure that pushes electrons in a wire.
- Unit for this pressure is the VOLT.
- Voltage is represented with either an **E** or **V**.
- The schematic symbol for DC voltage is generally shown as a battery

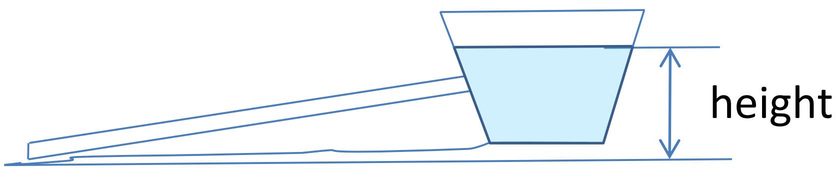


AC voltage shown as



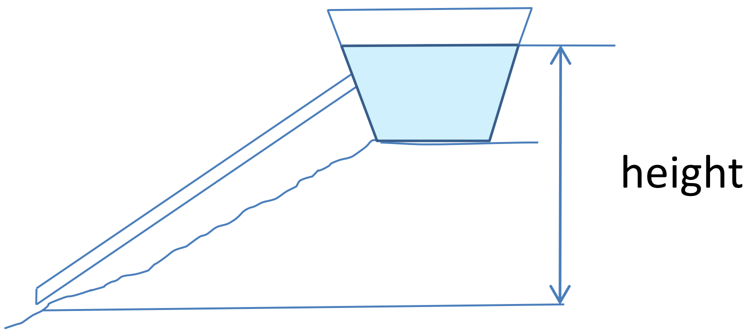
Voltage – Water Analogy

Small height = low voltage



1. Gravity provides the force for water (current) to flow.
2. This illustrates a small voltage, so electron flow is small.

Big height = high voltage



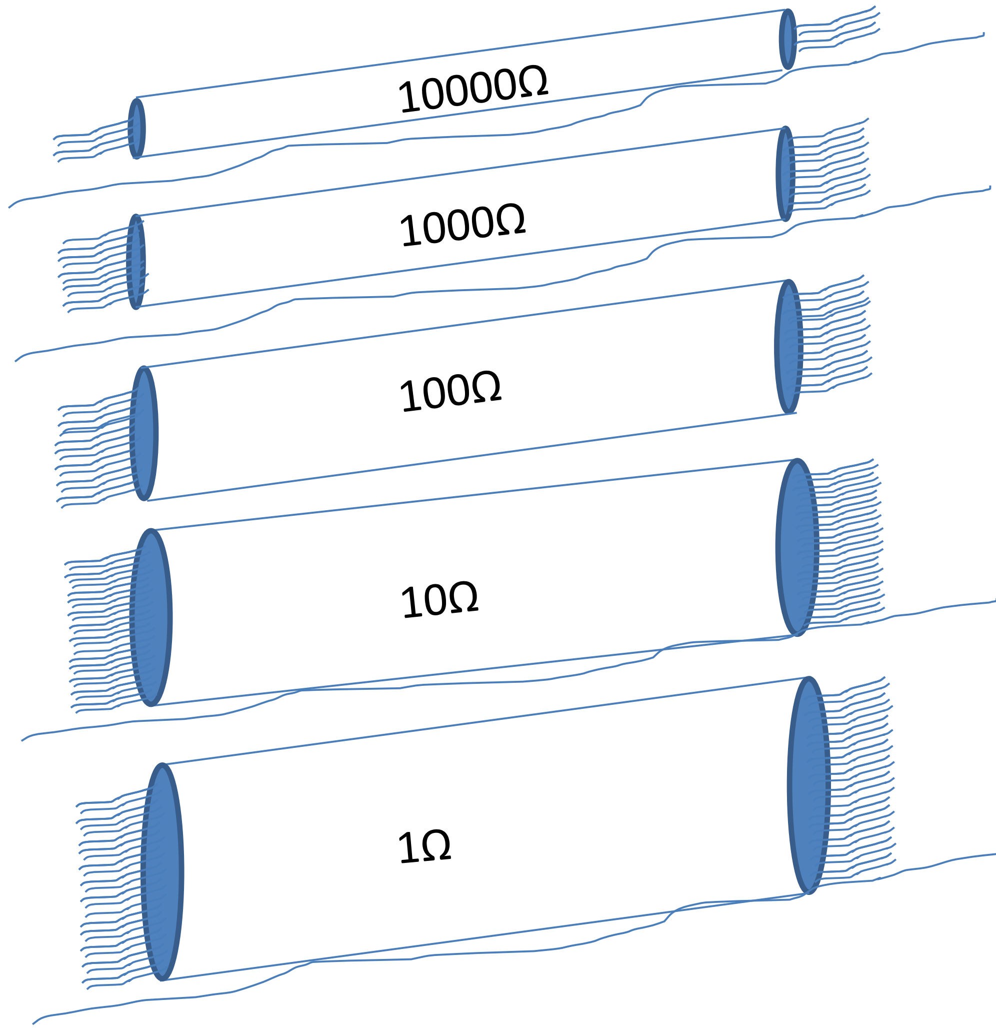
1. Gravity provides the force for water (current) to flow.
2. This illustrates a larger voltage, so electron flow is larger.

Resistance

- Resistance is the electrical property of a substance to **resist** the flow of electrons (current).
- The unit for resistance is OHM (Ω).
- Resistance is represented by the letter **R**.
- The schematic symbol is 
- The larger the value of resistance, the more opposition to current flow.
- Opposite of Resistance is **Conductance**.

Resistance – Water Analogy

- Different pipe diameters represents different resistor values.
- The smaller the diameter of the pipe, the larger the resistance.



Power – Water Analogy

In electronics, power is equal to current X voltage.
The units for power is WATTS.
The symbol for power is W.

In our water analogy, power is equal to water flow X pressure.

You can see from the picture that more water flow will mean more force, and more pressure will mean more force.

More force means more work gets done. **Power = Work**

Show how to solve a simple problem involving current, voltage and resistance using Ohms Law.

What is Ohms Law?

Why is it important?

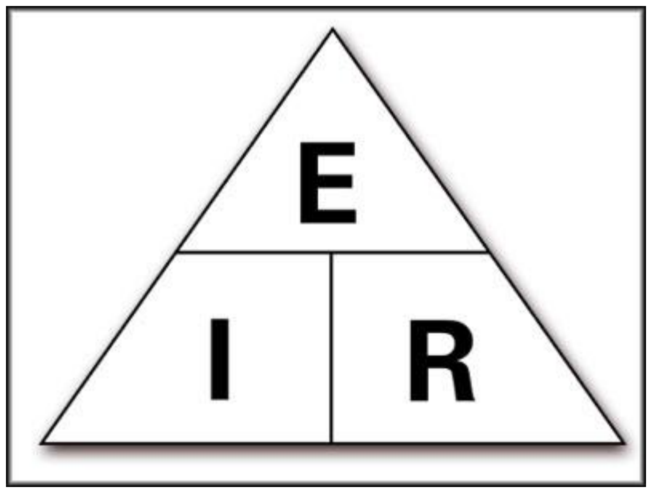
Ohm's Law

- One of the most important laws in electronics/electricity.
- V = I x R : Voltage = Current x Resistance
- Volts is measure in VOLTS, current is measured in AMPS, and resistance is measured in OHMS.
- 1 AMP, going through 1 OHM of resistance, equals a voltage drop of 1 VOLT.
- 1 V = 1 A x 1 Ω.

DC Electronics, Ohm's Law

Requirement 5A

- E= I x R : Volts = Current x Resistance



- Alternate forms

I=E/R R=E/I

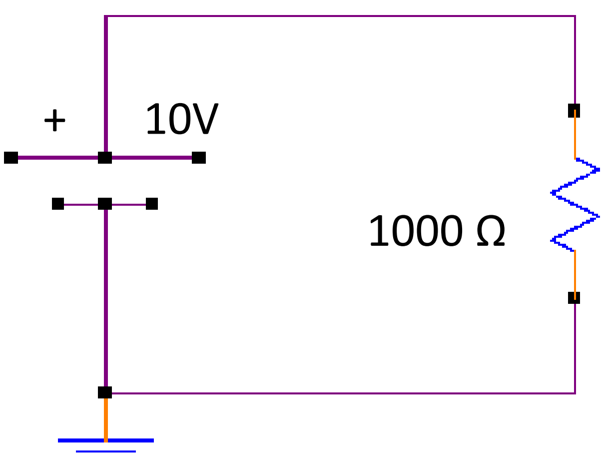
More Ohm's Law

Different forms of Ohm's Law:

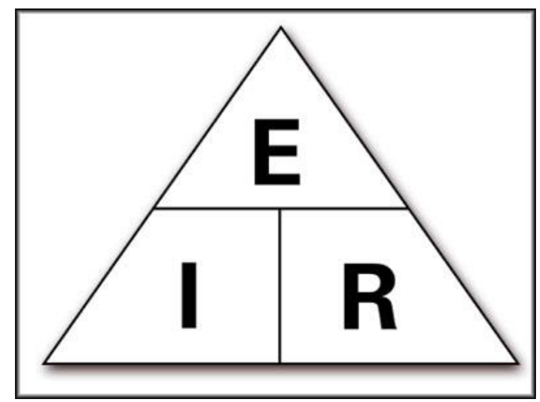
V = I x R : Voltage = Current X Resistance

I = V / R : Current = Voltage / Resistance

R = V / I : Resistance = Voltage / Current



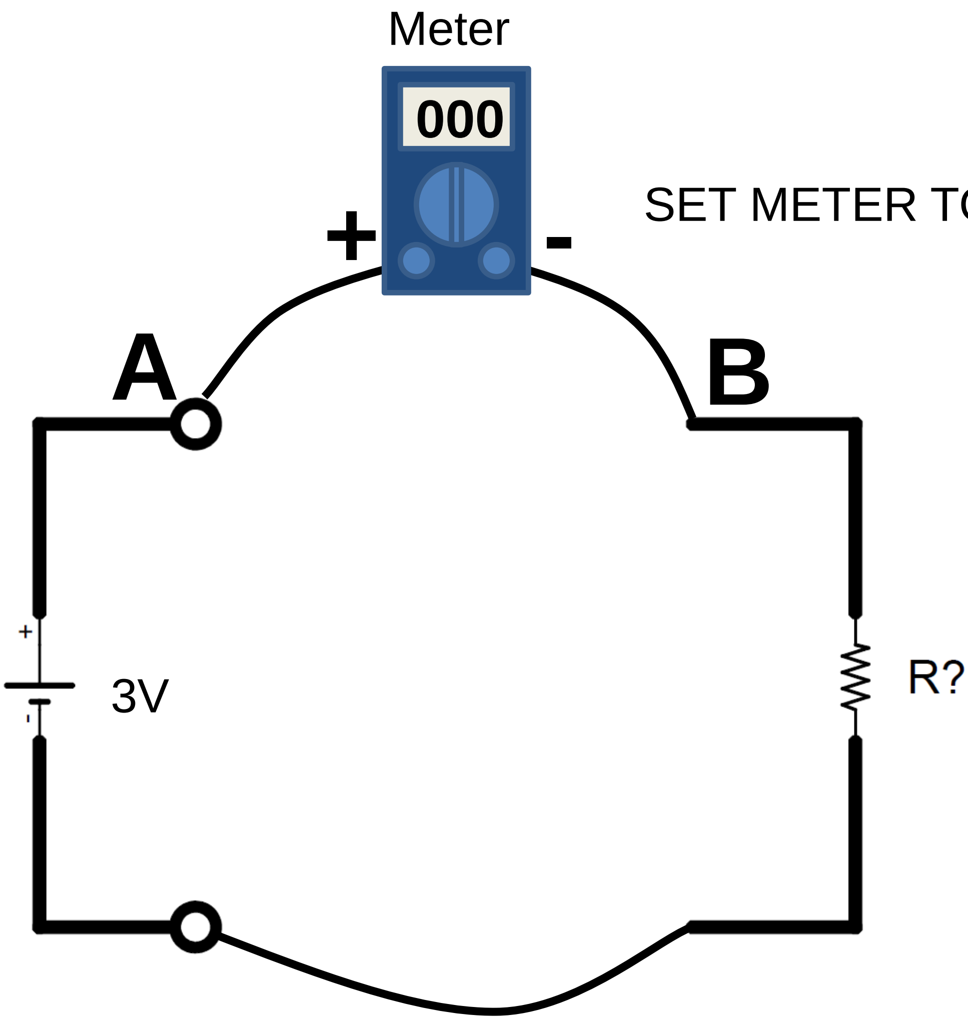
Volts = 10.
Resistance = 1000Ω
Compute current.
I = V / R
I = 10 / 1000 = .01A
.01A = 10ma
Question: what would the current be if the voltage was 1 V? How about 1000 V?



Ohm’s Law Exercise

- Using a meter, we will measure some components.
- Then, using ohm’s law, we will calculate the value of resistance in a circuit. To do this, we will use the meter to measure current and voltage in the circuit.

Ohms Law – Step 1

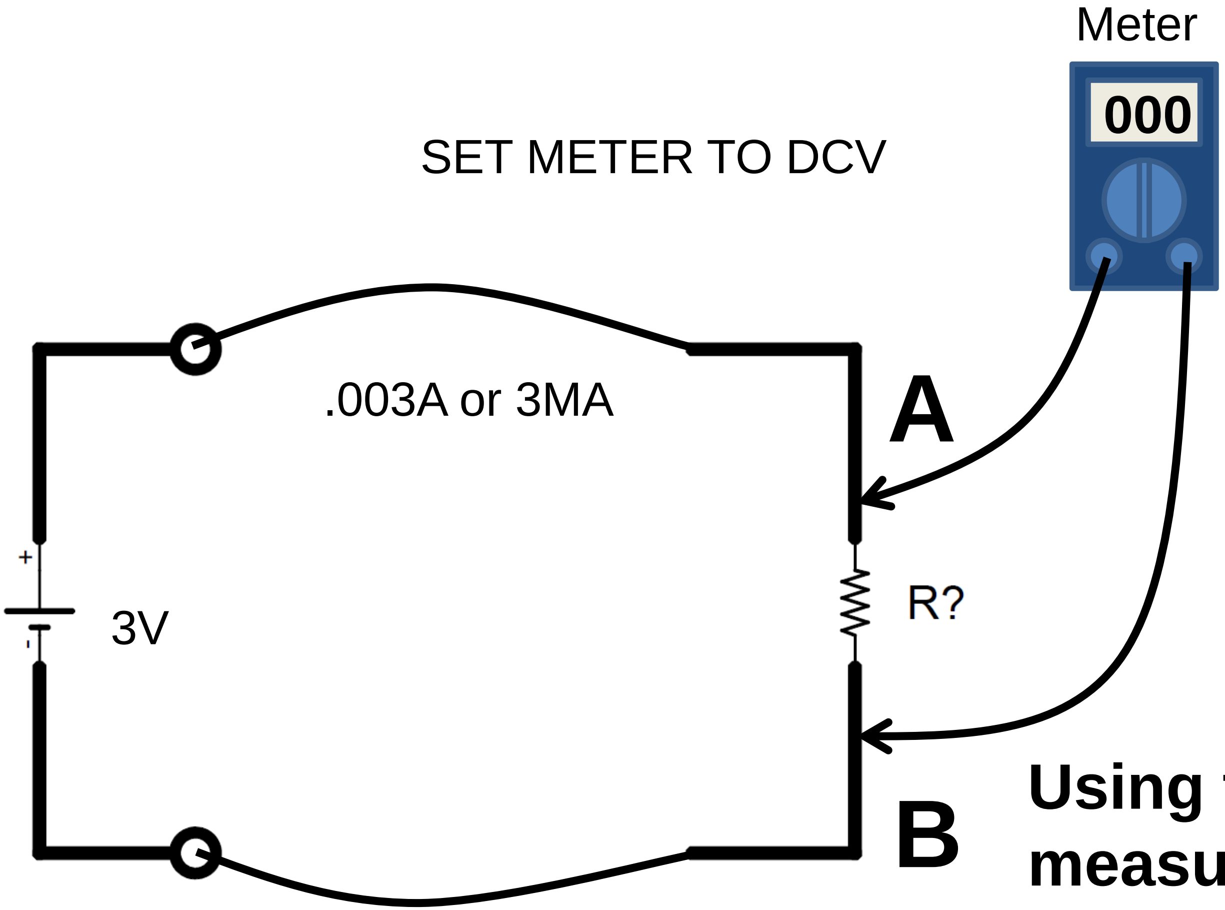


SET METER TO DCA

Using the meter, measure current.

I = __________ amps

Ohms Law – Step 2



Using the meter, measure voltage.

V = ___________ volts

Ohms Law – Step 3

Calculate resistance from your 2 measurements.

Ohms Law : V = I x R.

Therefore, $R = V / I$ <- Use this equation.

Note: you will be measuring current on the Ma range, so a value of 3ma needs to be written as .003A when using this equation.

Ohms Law – Step 3

Calculate resistance from your 2 measurements.

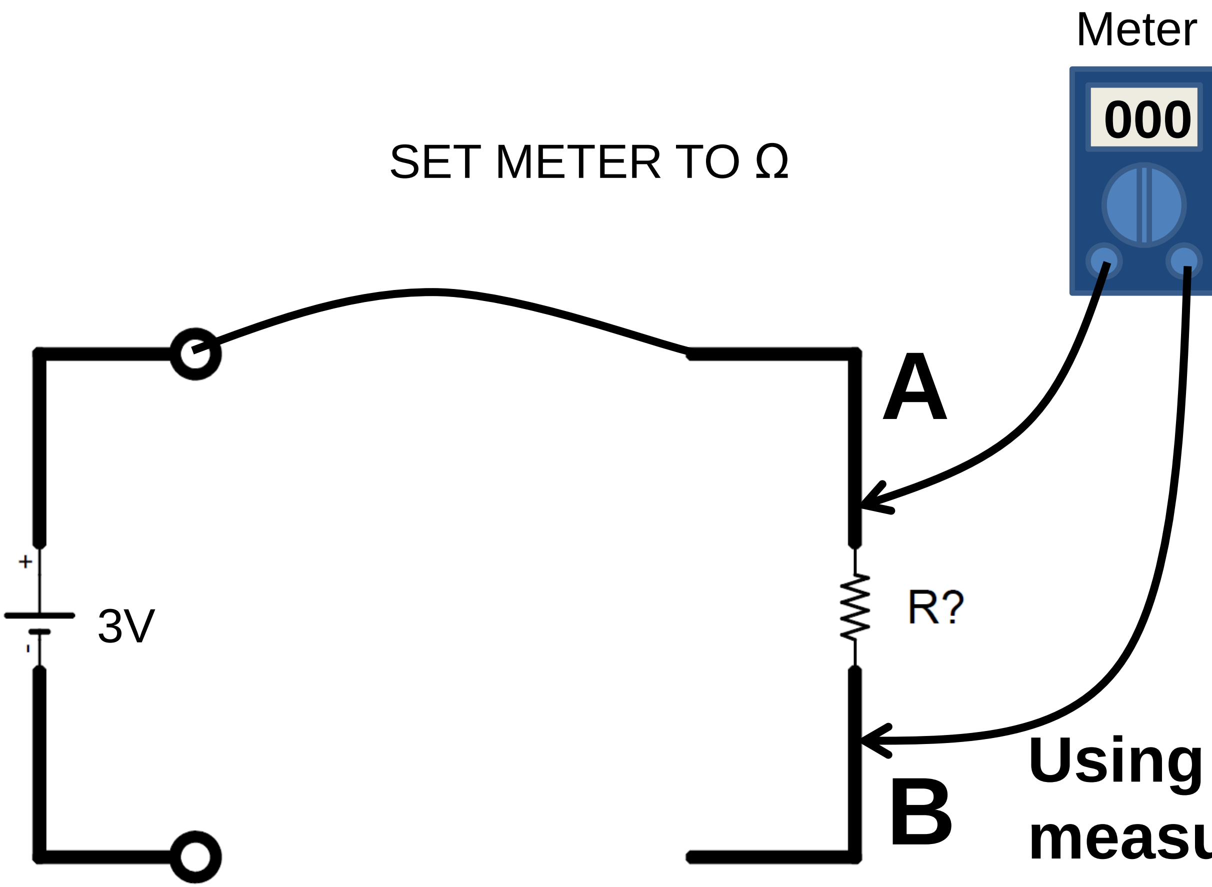
Ohms Law : V = I x R.

Therefore, R = V / I <- Use this equation.

R= 3/.003

R=1000 Ohms

Ohms Law – Step 4



Using the meter, measure the actual Resistance.

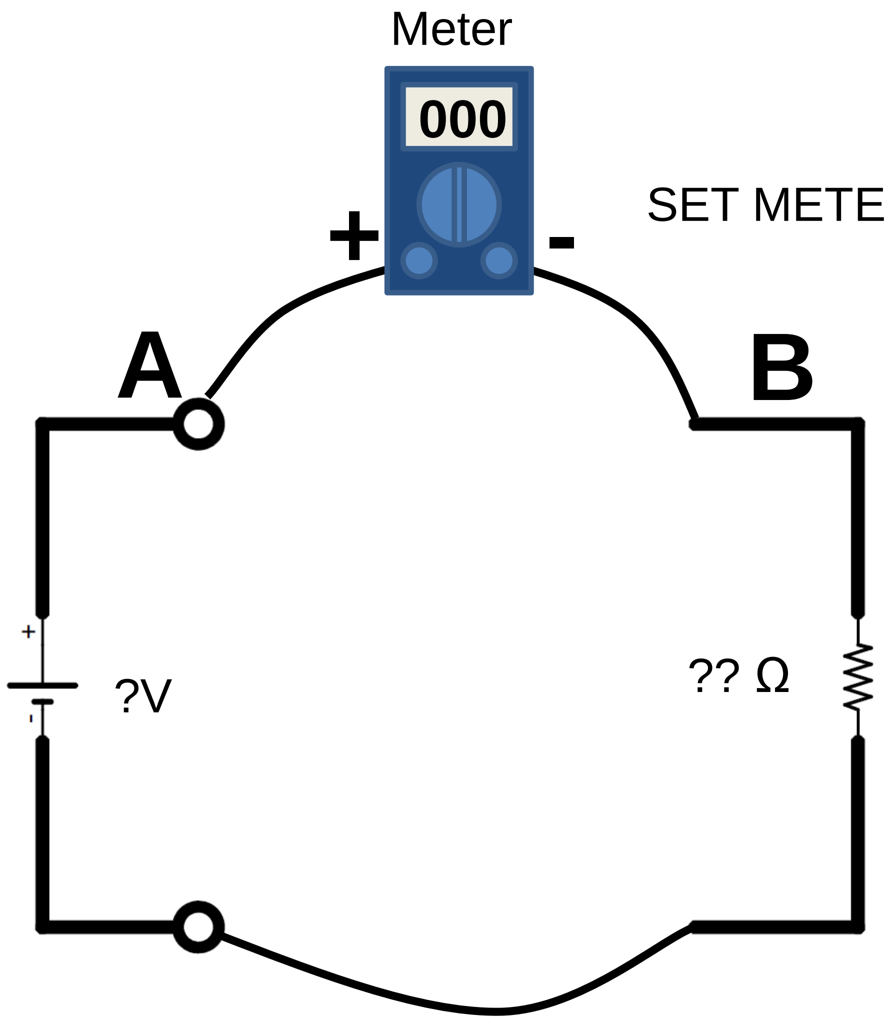
R = ___________ ohms

How does this compare with your calculated value?

Ohm's Law Exercise

- Using a meter, we will measure some Components.
- Then, using ohm's law, we will calculate the circuits voltage. To do this, we will use the meter to measure current and resistance in the circuit.

Ohms Law – Step 1

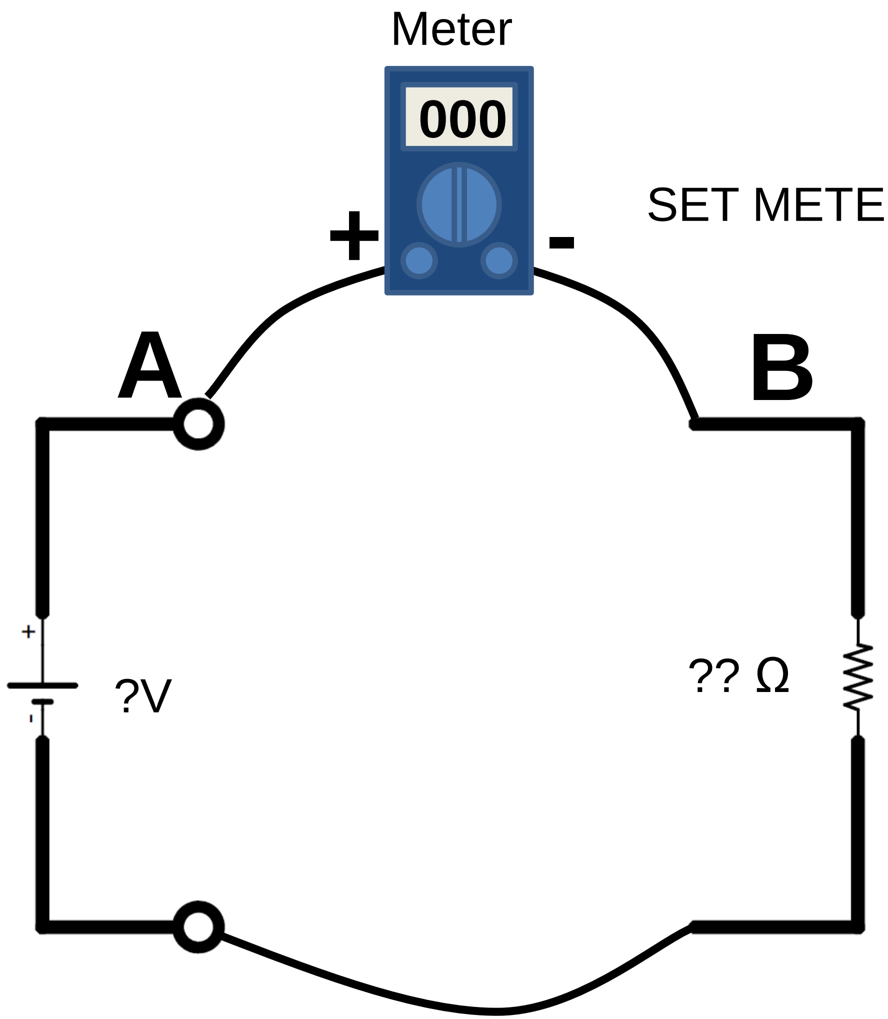


SET METER TO DCA

Using the meter, measure current.

I = __________ amps

Ohms Law – Step 1

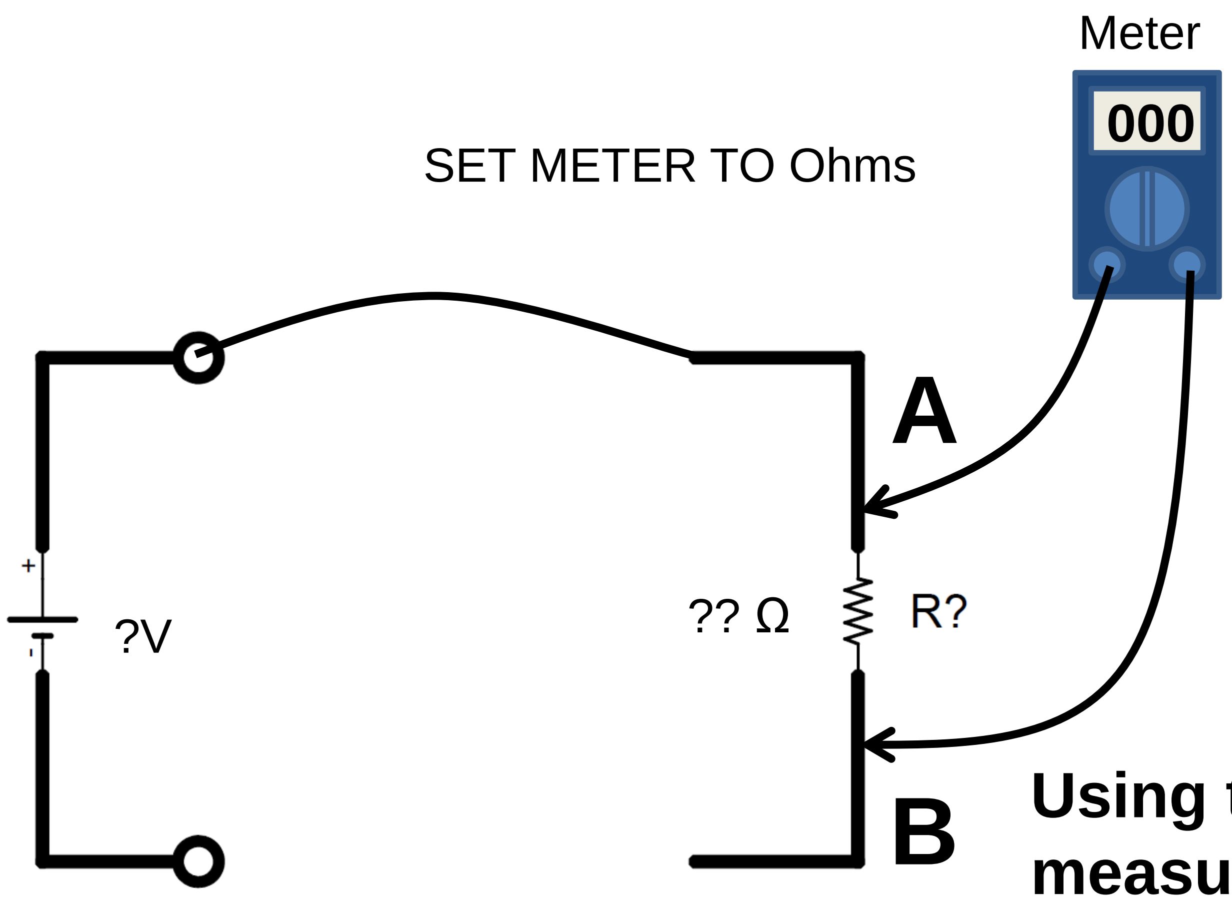


SET METER TO DCA

Using the meter, measure current.

I = ___0.012__ amps

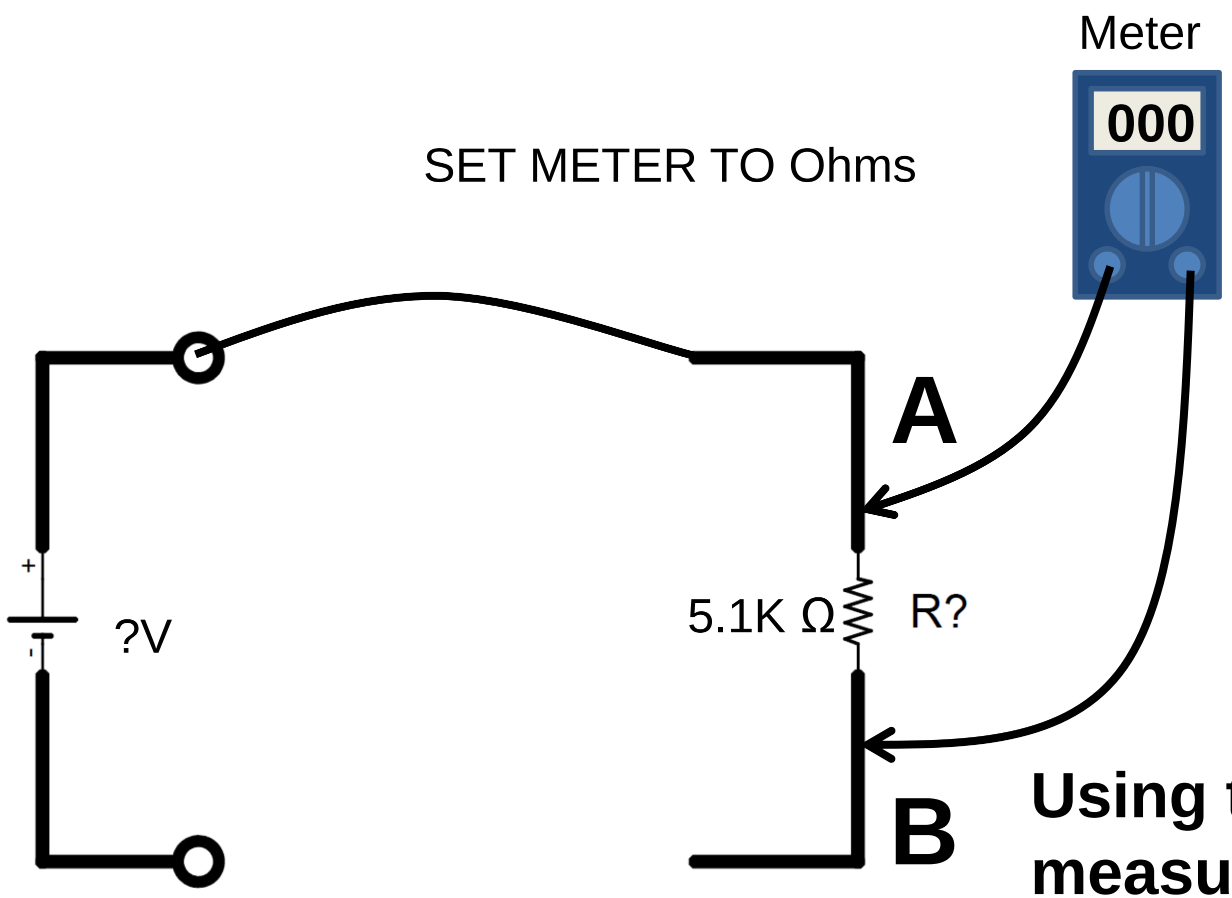
Ohms Law – Step 2



Using the meter, measure Resistance.

R = ___________ Ohms

Ohms Law – Step 2



Using the meter, measure Resistance.

R = __5.1K___ Ohms

Ohms Law – Step 3

Calculate resistance from your 2 measurements.

Ohms Law : $V = I \times R$. <- Use this equation.

Note: you will be measuring current on the Ma range, so a value of 3ma needs to be written as .003A when using this equation.

We will explain what a Ma is in a little bit.

Ohms Law – Step 3

Calculate resistance from your 2 measurements.

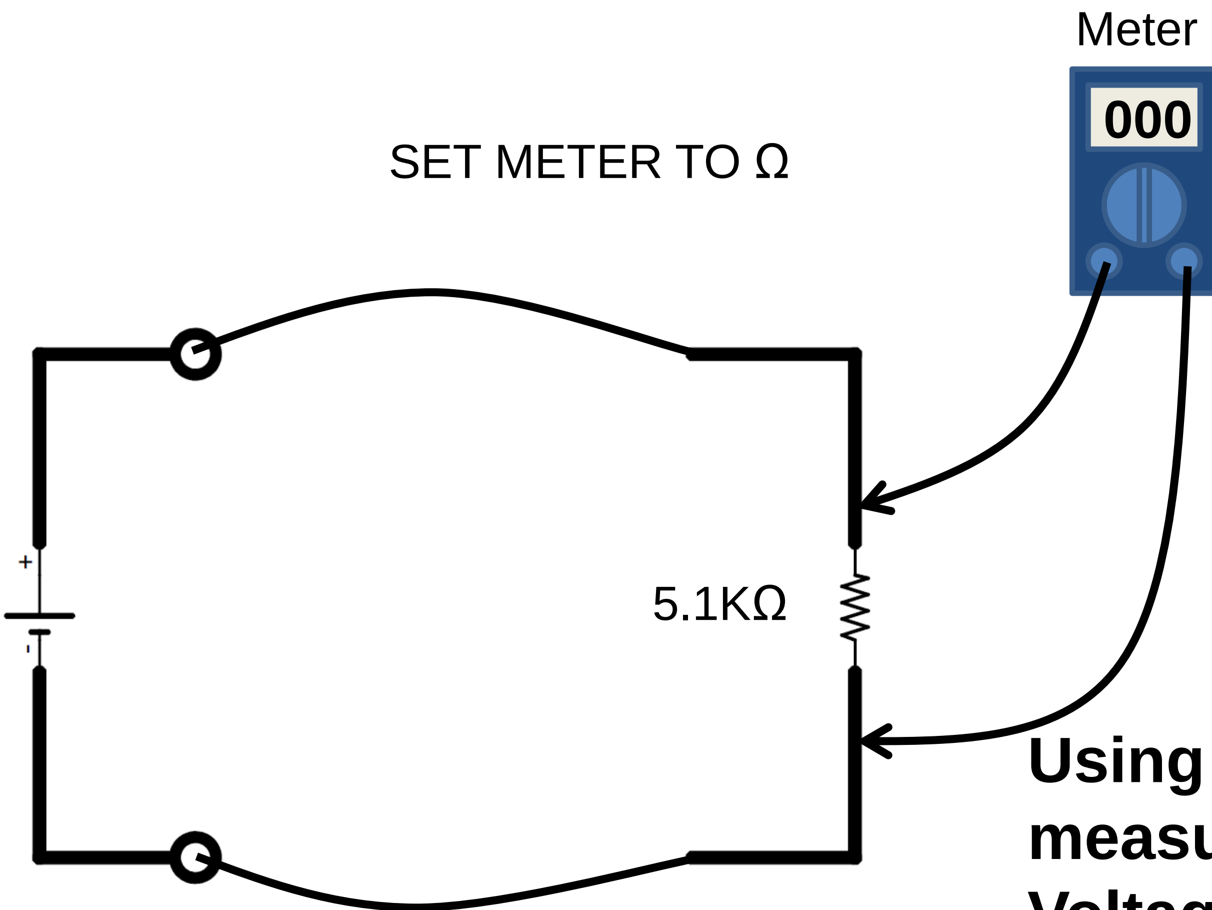
Ohms Law : V = I x R. <- Use this equation.

Note: you will be measuring current on the Ma range, so a value of 3ma needs to be written as .003A when using this equation.

V=.0012A X 5100 Ohms

V=6V

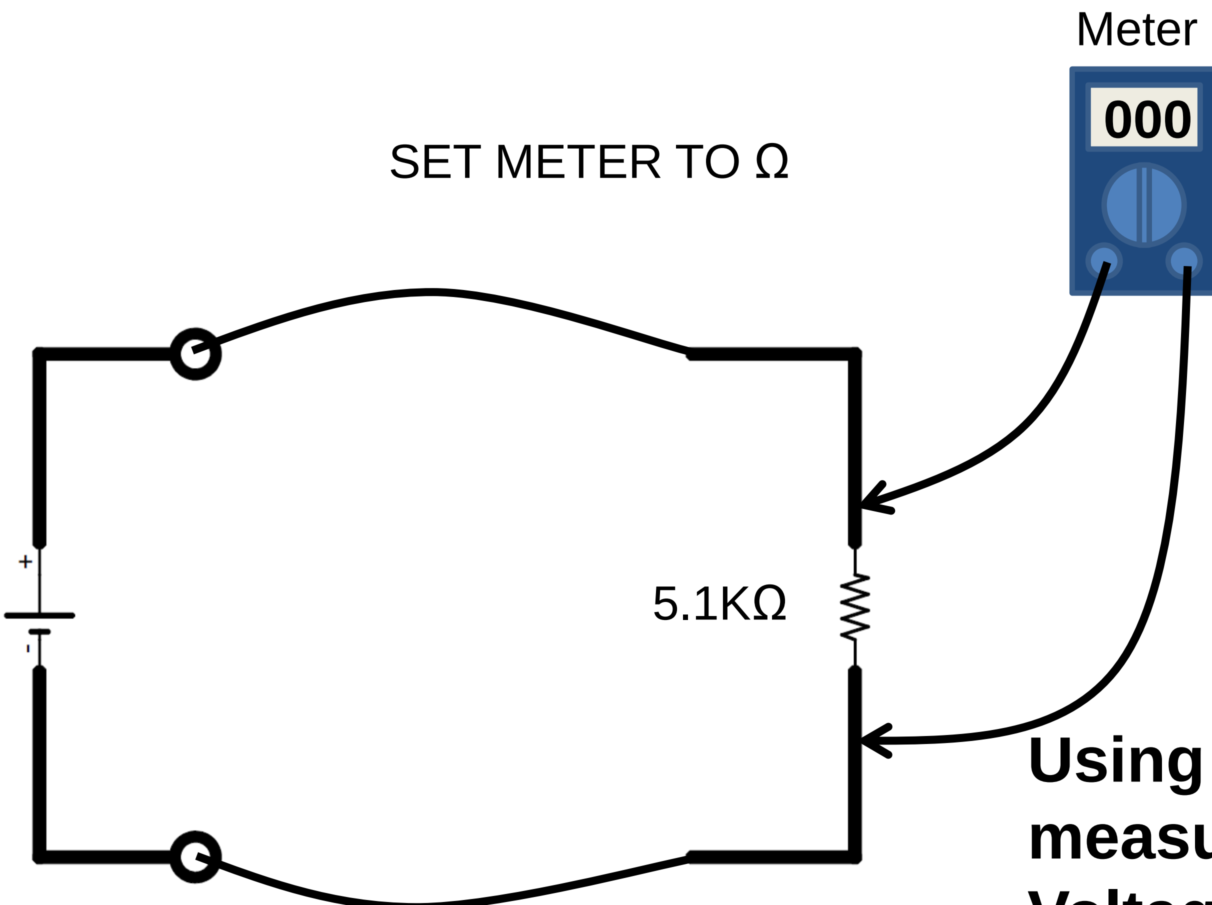
Ohms Law – Step 4



Using the meter, measure the actual Voltage.

V = ___________ Volts

Ohms Law – Step 4



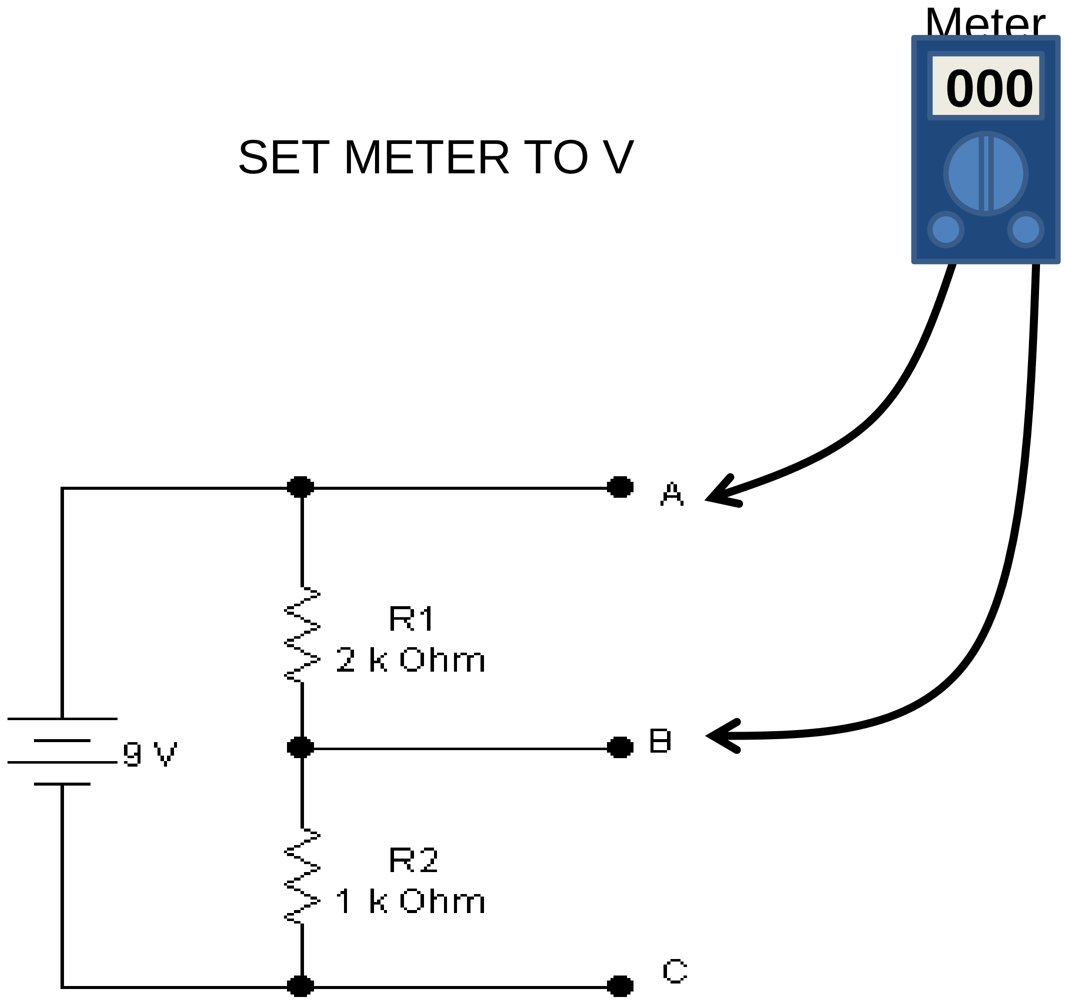
Using the meter, measure the actual Voltage.

V = ____6_____ Volts

How does this compare with your calculated value?

Ohms Law – Extra Credit

SET METER TO V

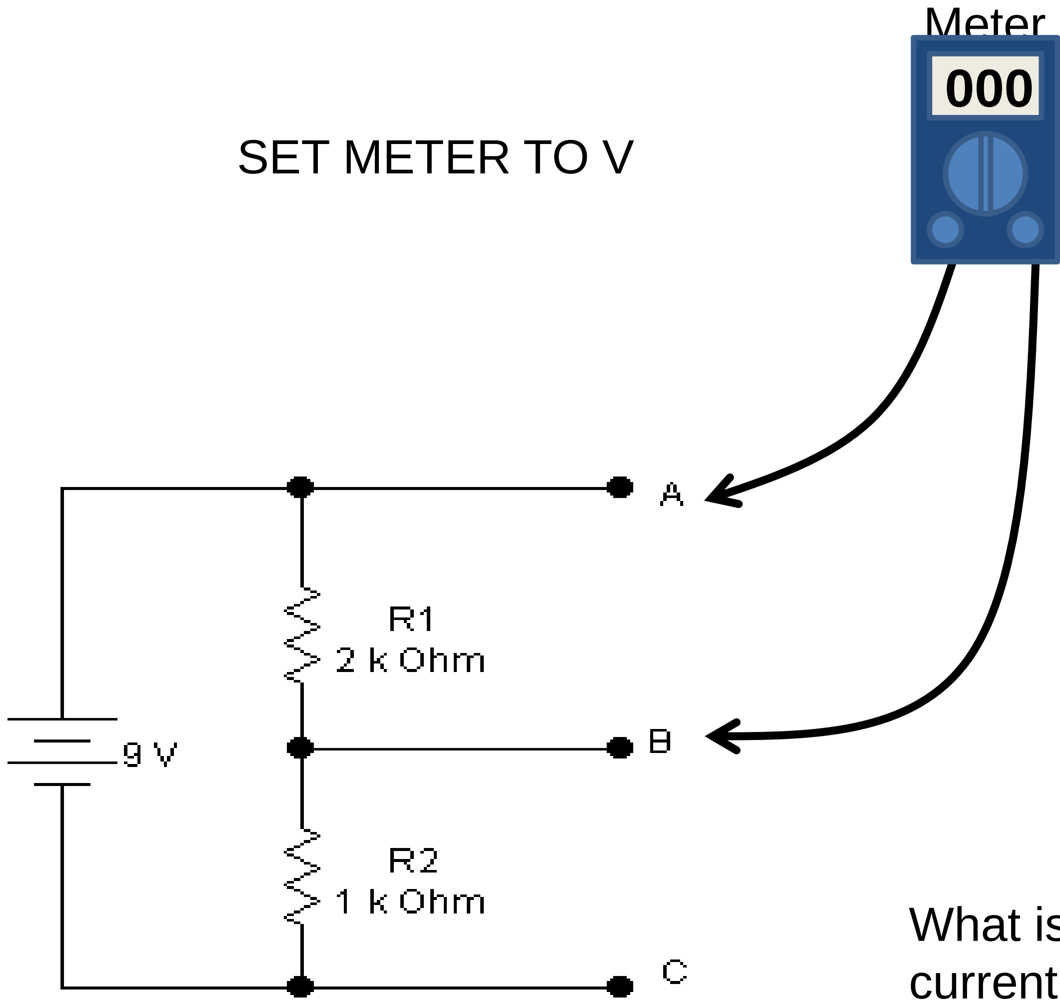


In this circuit, what would be the voltage present across R1? R2?

What is the total current flowing through the whole circuit

Ohms Law – Extra Credit

SET METER TO V



V=1xR

R=V/I

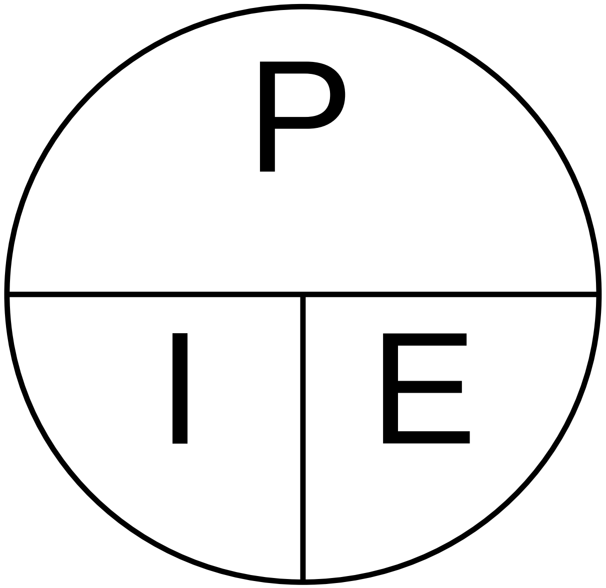
I=V/R

What is the value of total circuit current? What is the voltage across each f the Resistors?

Ohms Law – Extra, Extra Credit

Power = Current x Voltage

P = I x E



P Power Measured in Watts

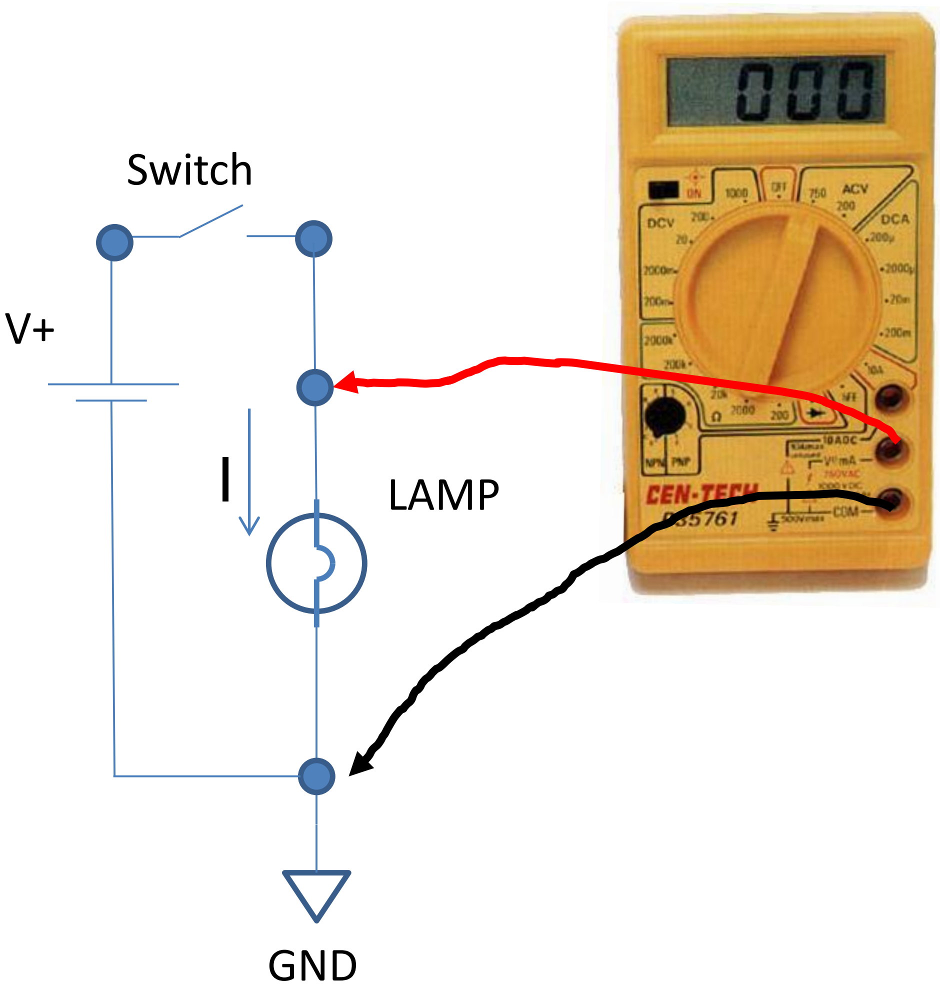
I Current Measured in Amps

E Voltage Measured in Volts

Example: *If the Current goes UP but the Voltage remains the same, then the Power used by the circuit goes UP*

Ohms Law – Extra, Extra Credit

Worksheet



Part 1: Calculate the Current

E = 9 Volts
Lamp Resistance R = 3 Ohms
I = ? Amps

Solve using:
E = I x R so E / R = I

____/_____ = ______ Amps

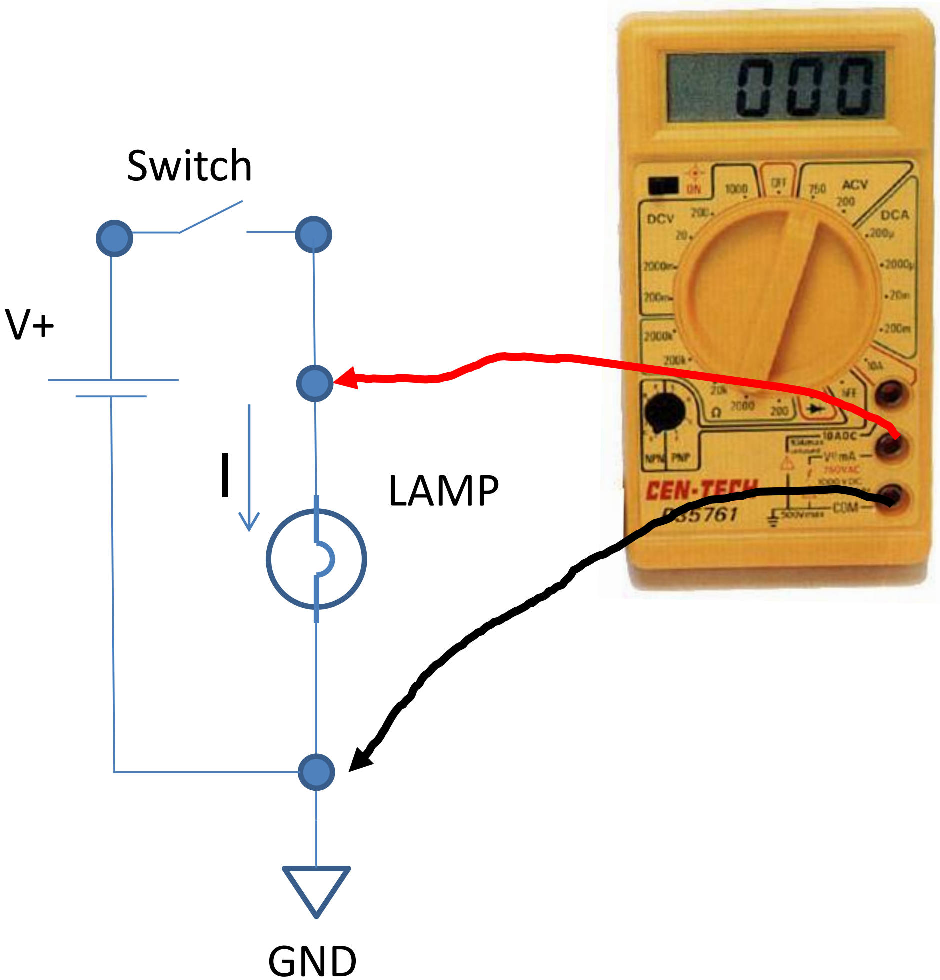
Part 2: Calculate Power (Watts)

P = E x I (from Part 1)

P = ____x ____= _____Watts

Ohms Law – Extra, Extra Credit

Worksheet



Part 1: Calculate the Current

E = 9 Volts
Lamp Resistance R = 3 Ohms
I = ? Amps

Solve using:
E = I x R so E / R = I

__9_ /__3__ = __3___ Amps

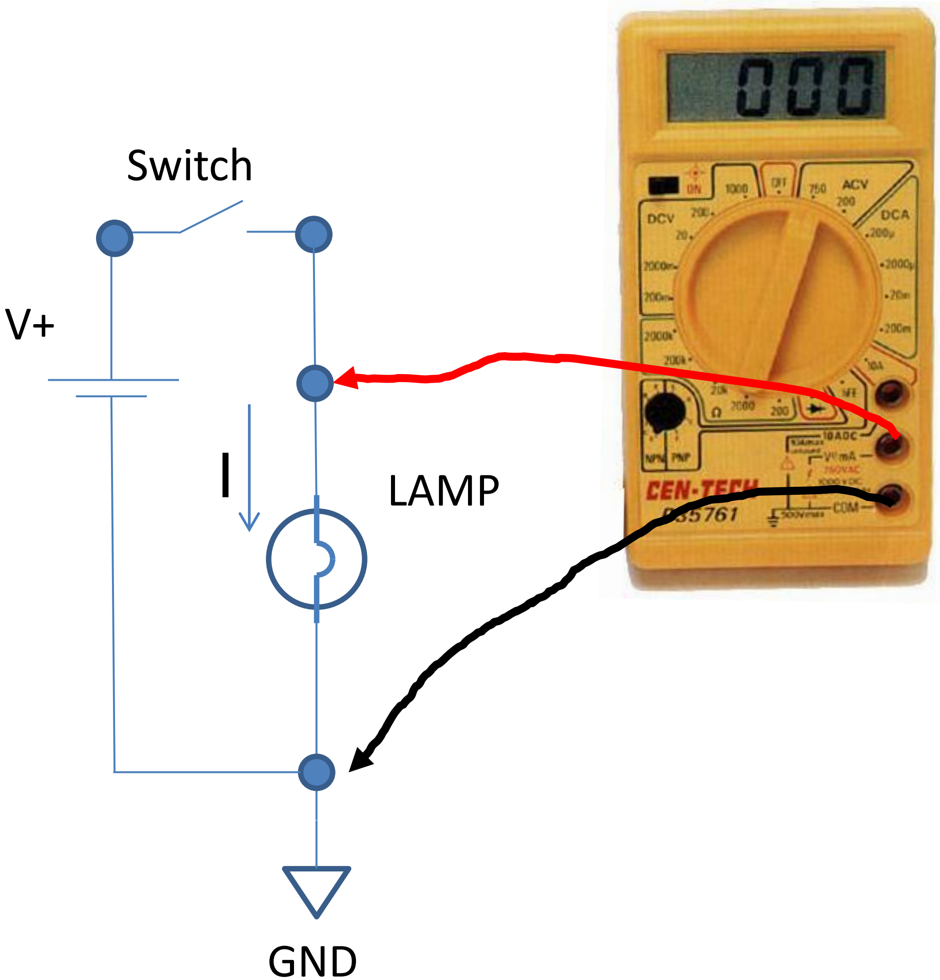
Part 2: Calculate Power (Watts)

P = E x I (from Part 1)

P = ____x ____= _____Watts

Ohms Law – Extra, Extra Credit

Worksheet



Part 1: Calculate the Current

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I = ? Amps

Solve using:
E = I x R so E / R = I

__9_/__3__ = __3___ Amps

Part 2: Calculate Power (Watts)

P = E x I (from Part 1)

P = __9_x __3_= __27_Watts

Electronics Merit Badge

Class 1