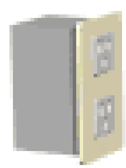
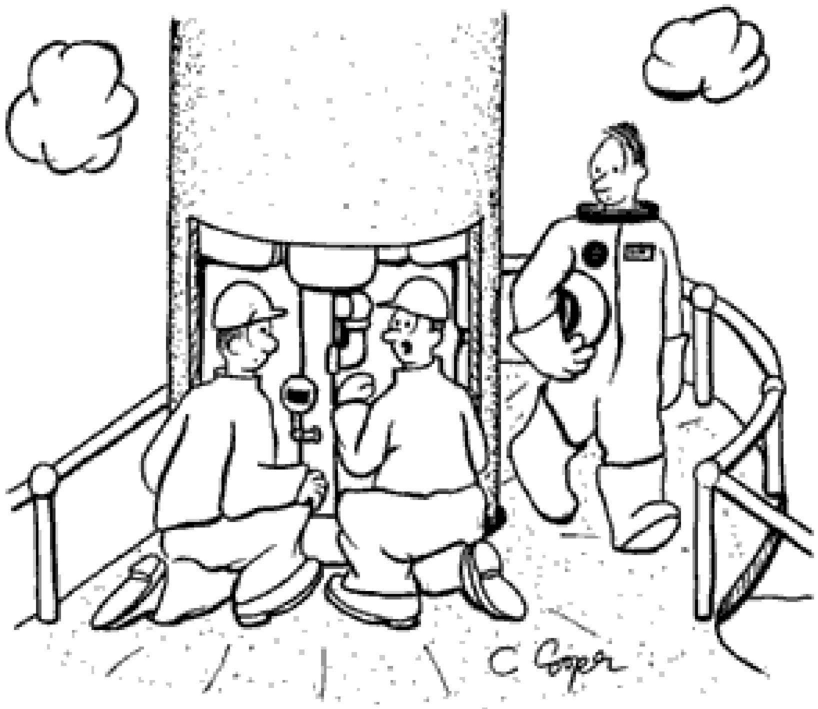
INTERMDIATE SCIENCE 9

UNIT 2: ELECTRICITY

SECTION 2: CURRENT ELECTRICITY



Chapter 8 and 9

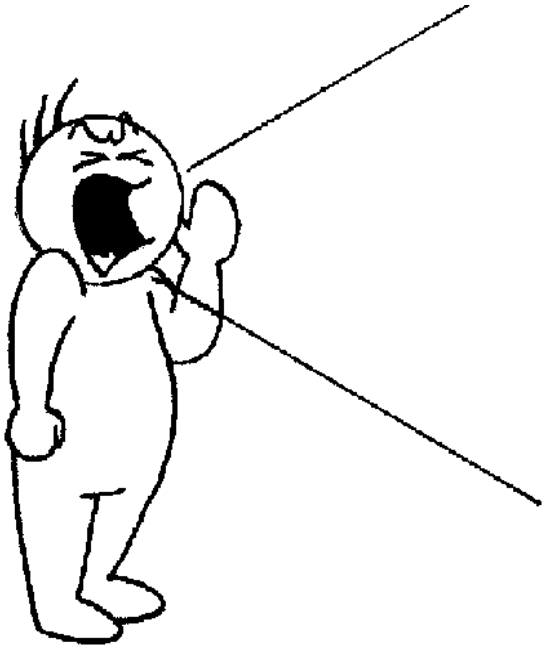


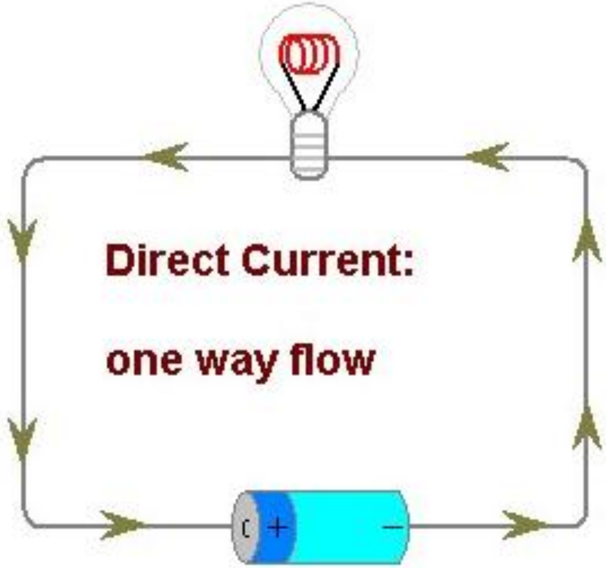
"Don't worry about it. This isn't exactly rocket science, you know."

Science 9

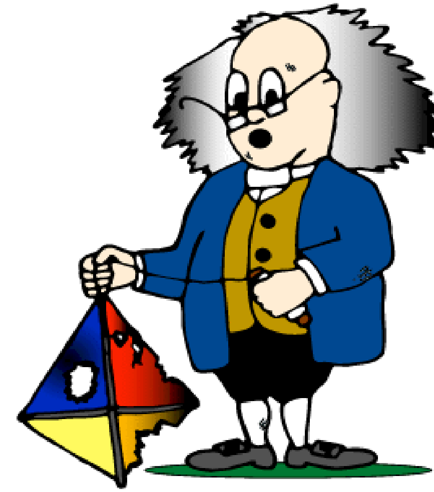
Unit 4 : Current Electricity

Topic 1 : Current and Circuits

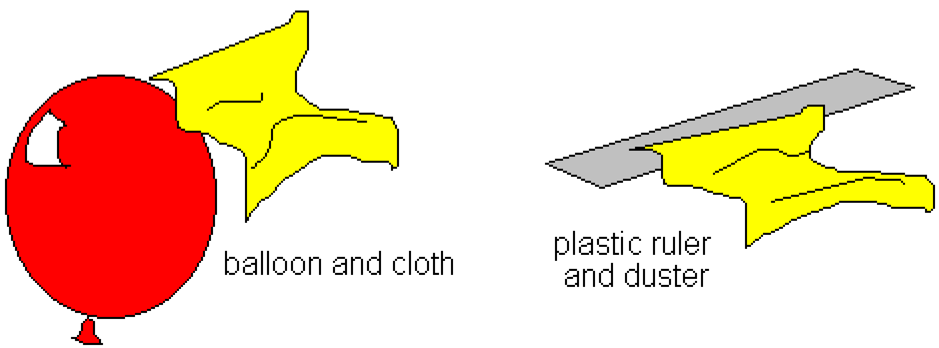




Introduction



Static Electricity is a stationary electric charge that is built up on a material.

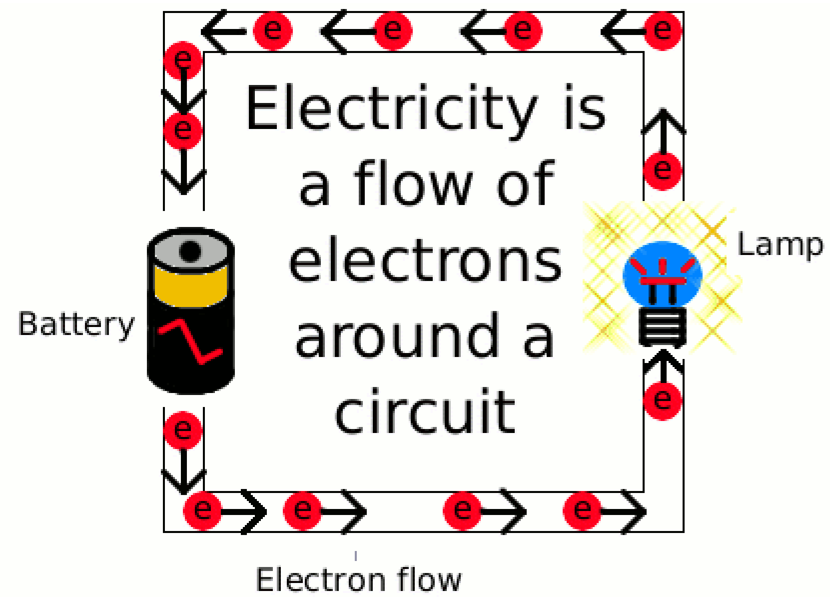


Static Electricity Review

- Occurs with materials which are insulators
- Rubbing adds or removes electrons
- Object becomes charged
- Like objects repel, unlike attract

CURRENT ELECTRICTY

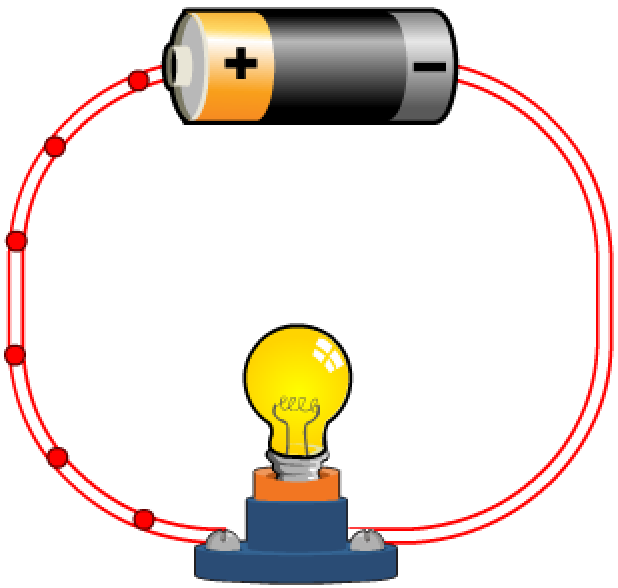
Current Electricity: Electricity produced due to the flow of electric charge from one place to another in a conductor.



Energy from another source is needed to produce current electricity.
(Ex. Chemical Battery, generator).

Electricity model

The charges do not come out of the cell and disappear when they get to the lamp. This idea is wrong. Click Next to see the next idea.

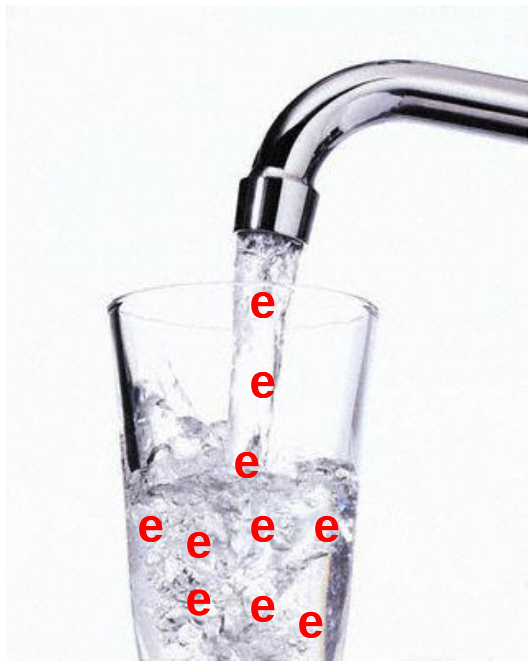


Next

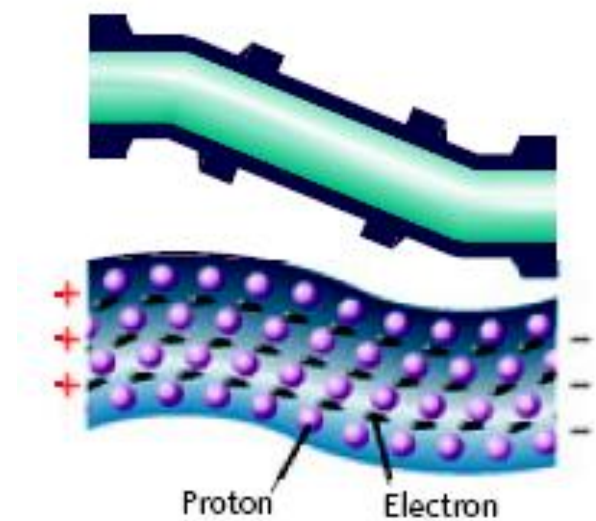
CURRENT

- **Current (I) refers to t**he flow of charges in a circuit.

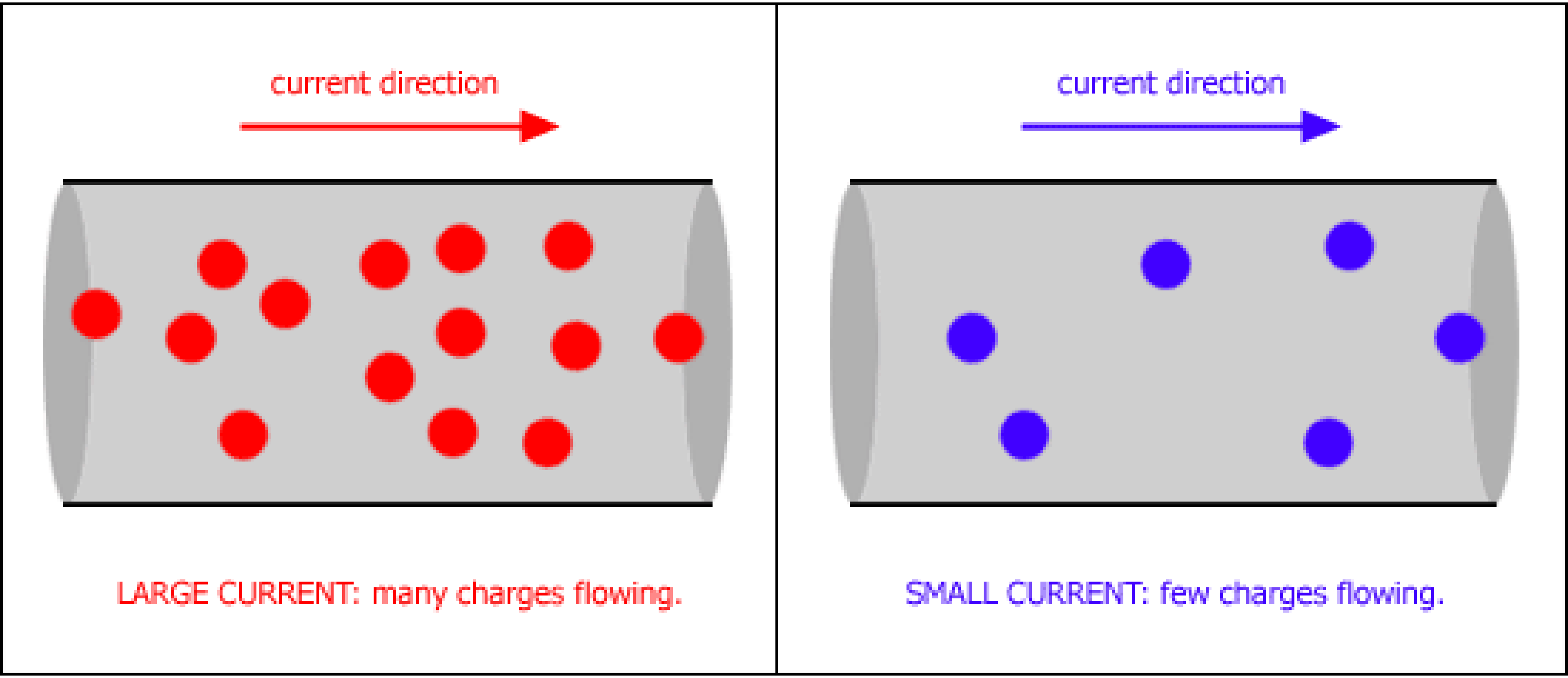
- It is the amount of charge passing a point every second.



Instead of water, we will be looking at the flow of electrons

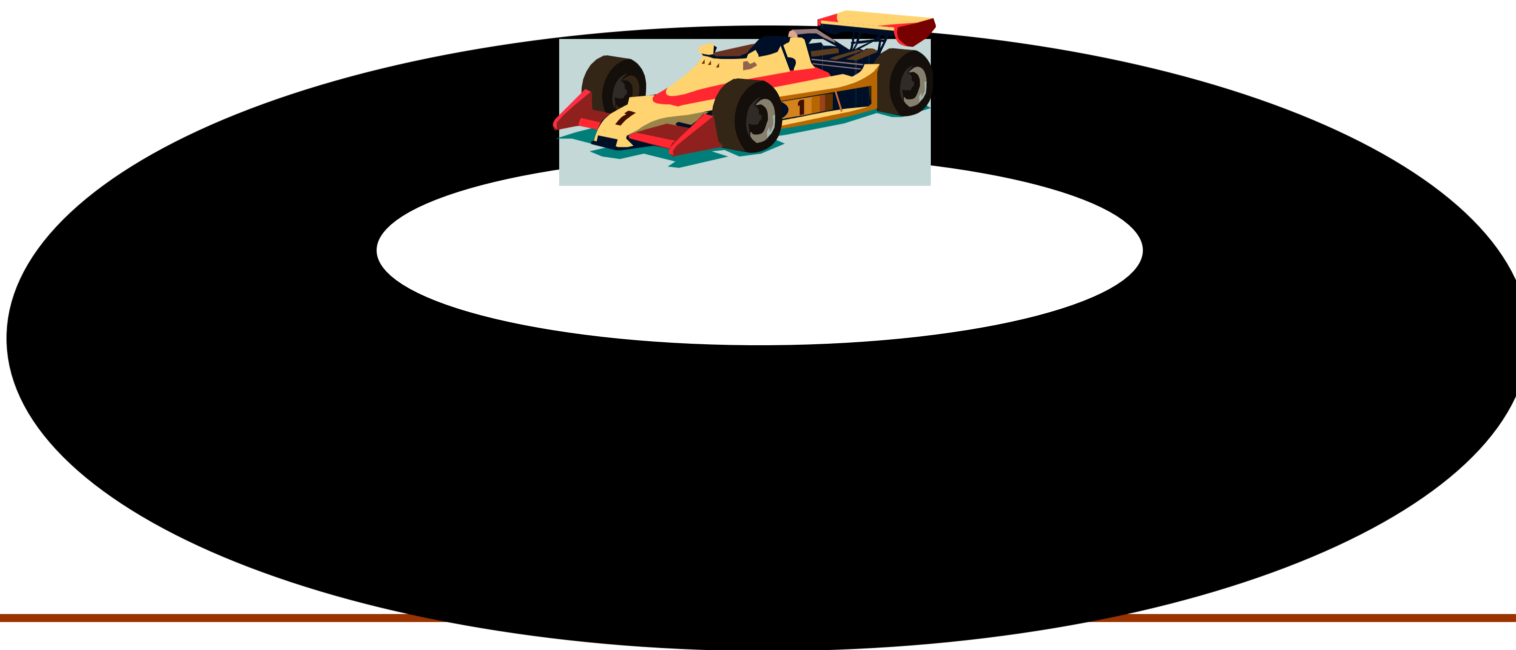


- is measured in Amperes or Amps (A).


current direction
LARGE CURRENT: many charges flowing.
current direction
SMALL CURRENT: few charges flowing.

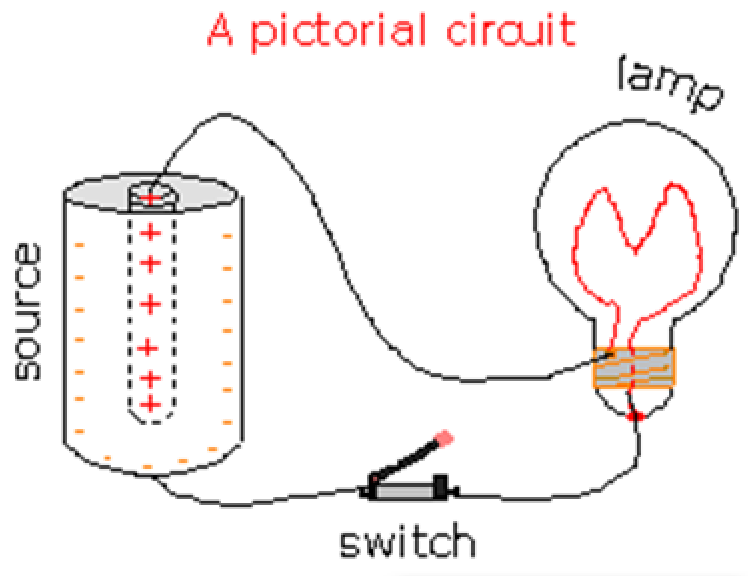
How can we control currents?

- With circuits.
- Circuit: is a path for the flow of electrons. We use wires.



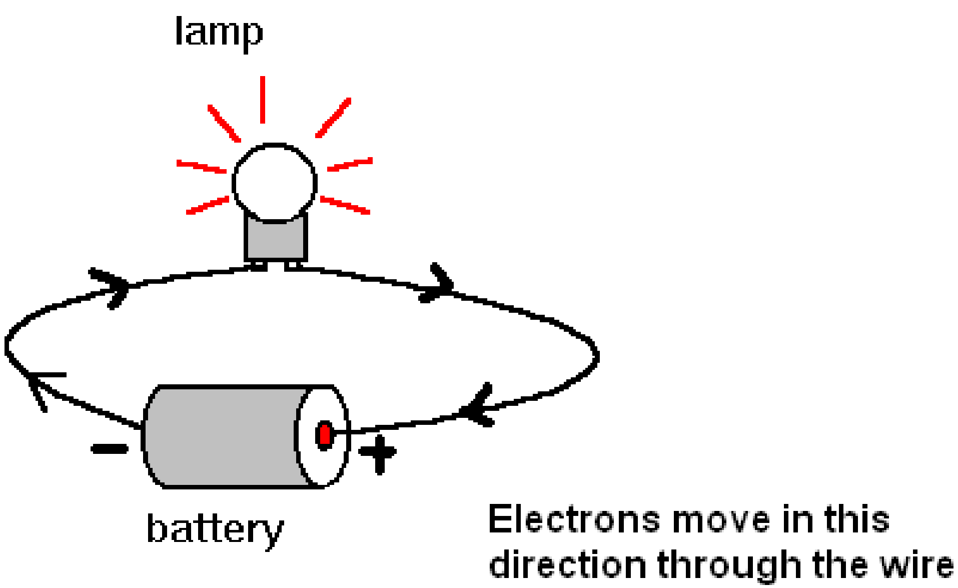
ELECTRIC CIRCUIT

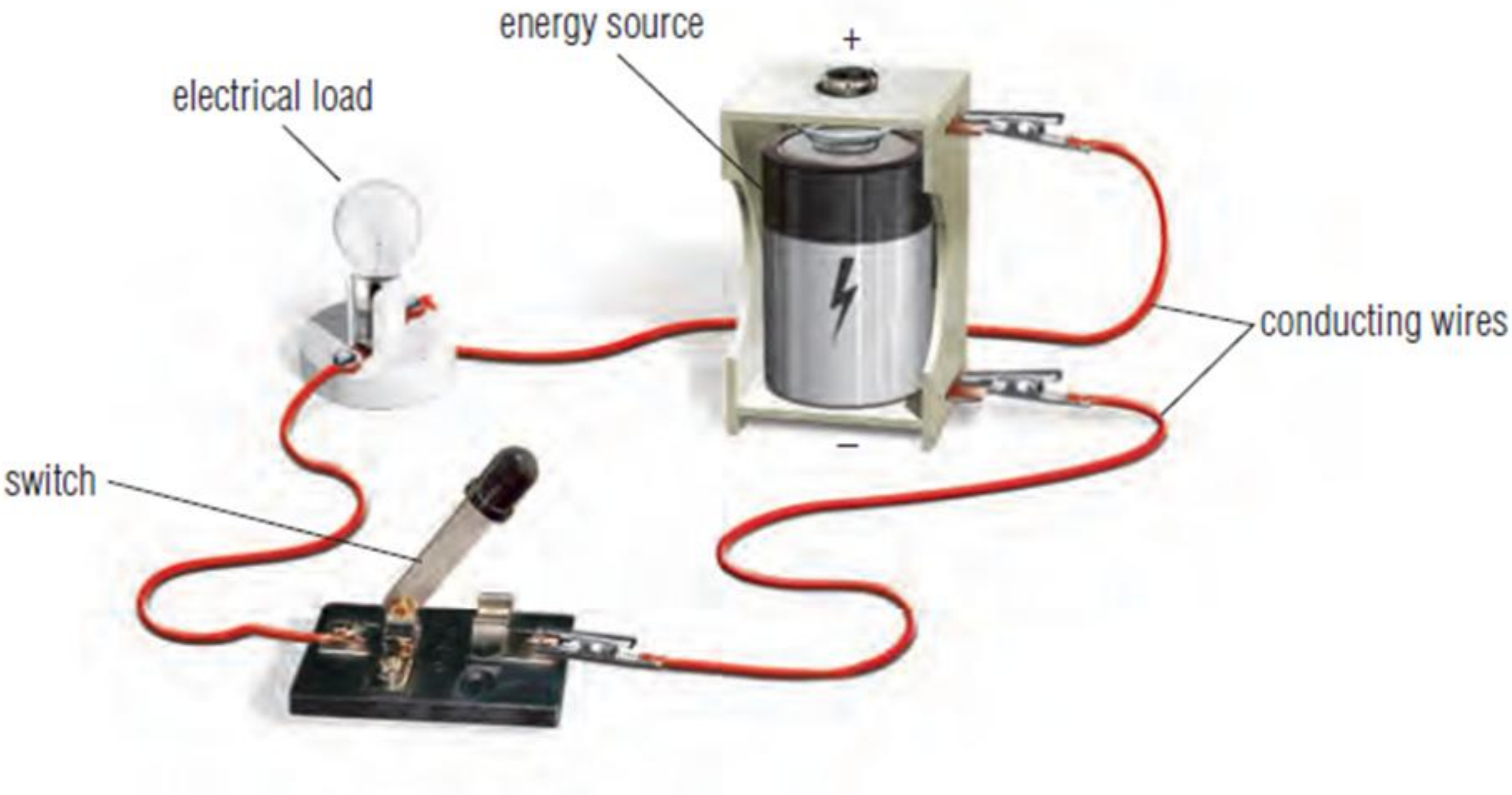
Electric Circuit: a complete pathway that allows electrons to flow from the source and back again



Electric Current: Looking a little closer

• Electric current is the movement of electrons from a negative terminal back to the positive terminal of a battery .




energy source
+
electrical load
conducting wires
switch
–

Fundamental Parts of An Electric Circuit

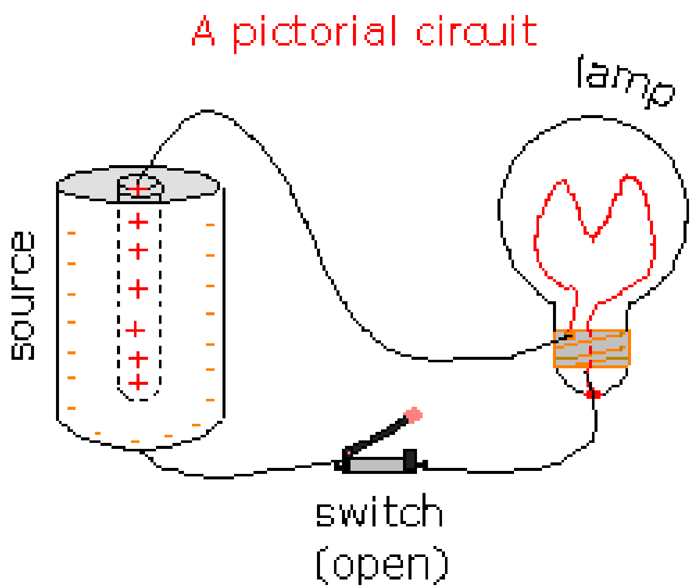
An electric circuit can be considered a system consisting of four subsystems:

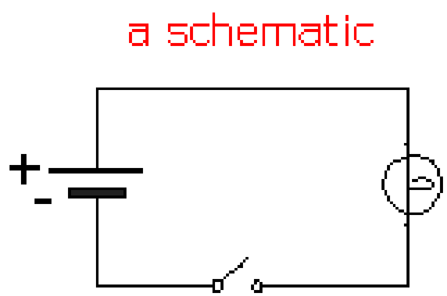
1. *Source*	a device which changes one type of energy into electrical energy, example a chemical cell or generator.
2. *Conductor*	a material which allows electric current (electrons) to pass through it easily, example copper wire
3. *Control*	starts and stops the flow of electrons in an electric circuit, example switch
4. *Load*	the device which changes electrical energy into some other form of energy, example motor, light bulb

ELECTRIC CIRCUIT

Electric Circuit: a complete pathway that allows electrons to flow from the source and back again

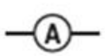
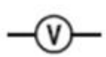
Schematic Diagram: a circuit diagram which shows the logic of the connections rather than the actual layout of the components. A diagram using graphic symbols to show how a circuit functions electrically.



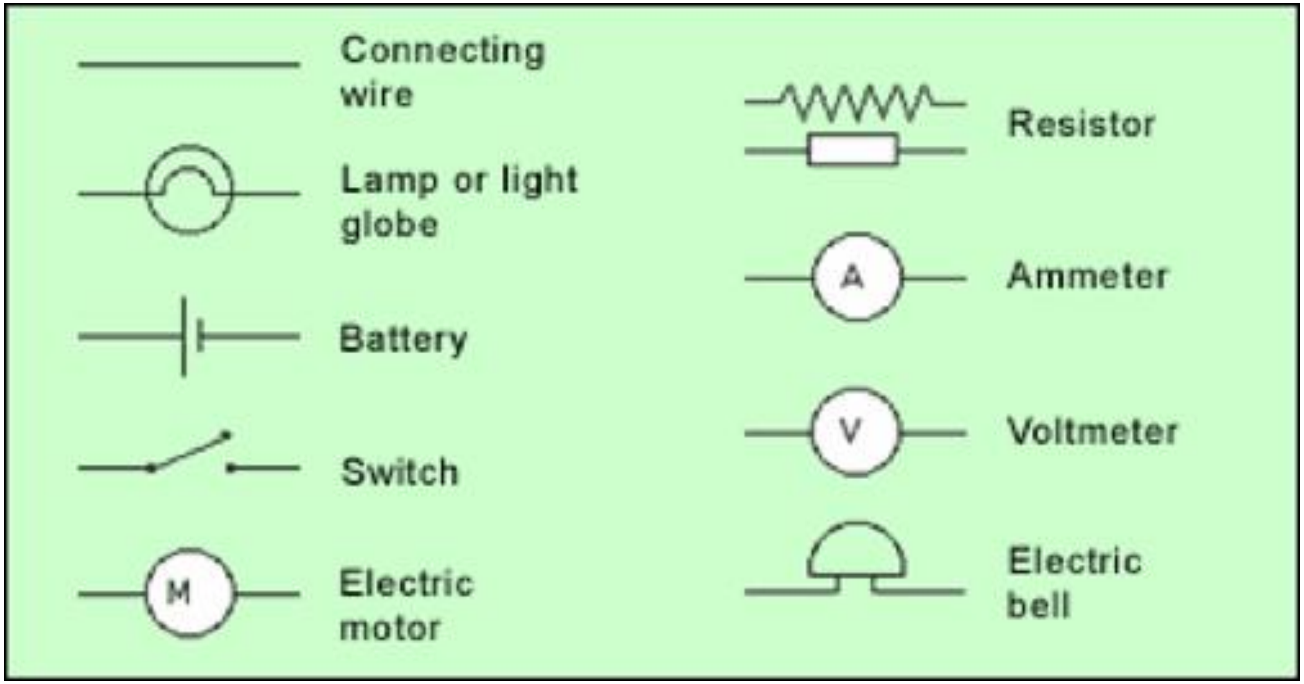


SAMPLE ELECTRICAL CIRCUITS AND SYMBOLS

Table 11.2 Circuit Symbols

Symbol	Component	Function
	wire	conductor; allows electrons to flow
	cell, battery	electrical source; longer side is the positive terminal, shorter side is the negative terminal
	lamp (light bulb)	specific load; converts electricity to light and heat
	resistor	general load; converts electricity to heat
	switch	opens and closes the circuit
	ammeter	measures current through a device, connected in series
	voltmeter	measures voltage across a device, connected in parallel

See p. 262 of your text for more


Connecting wire
Lamp or light globe
Battery
Switch
Electric motor
M
Resistor
Ammeter
A
Voltmeter
V
Electric bell

RULES for Drawing Circuit Diagrams

1. Always use a ruler to draw straight lines for the conducting wires
2. Make right-angle corners (∟) so that your finished diagrams is a rectangle

- Contain 4 basic parts:
  - Electrical source
  - Switch
  - Load
  - Conducting wire

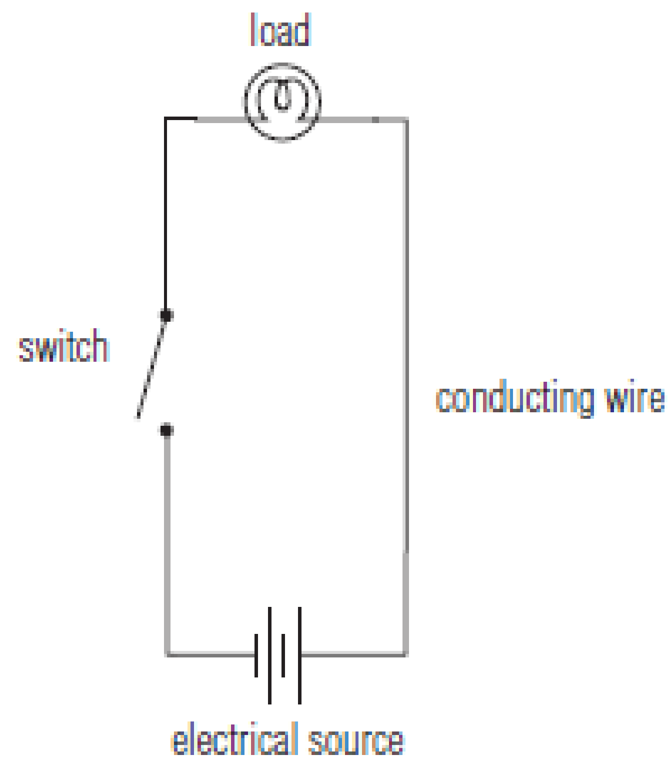


Figure 11.26 The four basic parts of a circuit

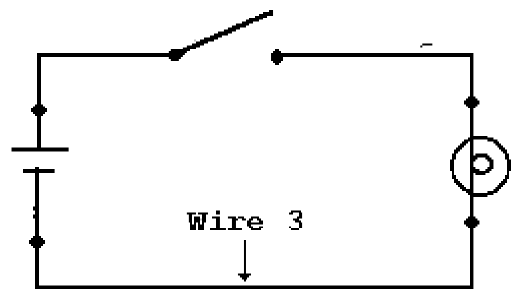
What is the difference between an open circuit and a closed circuit?

A closed circuit is one in which the pathway of the electrical current is complete and unbroken.

An open circuit is one in which the pathway of the electrical current is broken. A switch is a device in the circuit in which the circuit can be closed (turned on) or open (turned off).

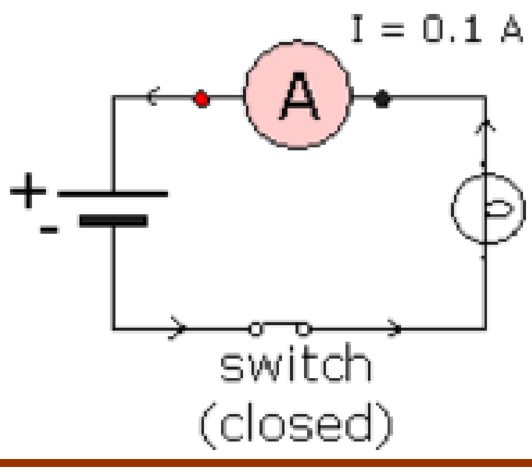
OPEN CIRCUIT AND CLOSED CIRCUIT

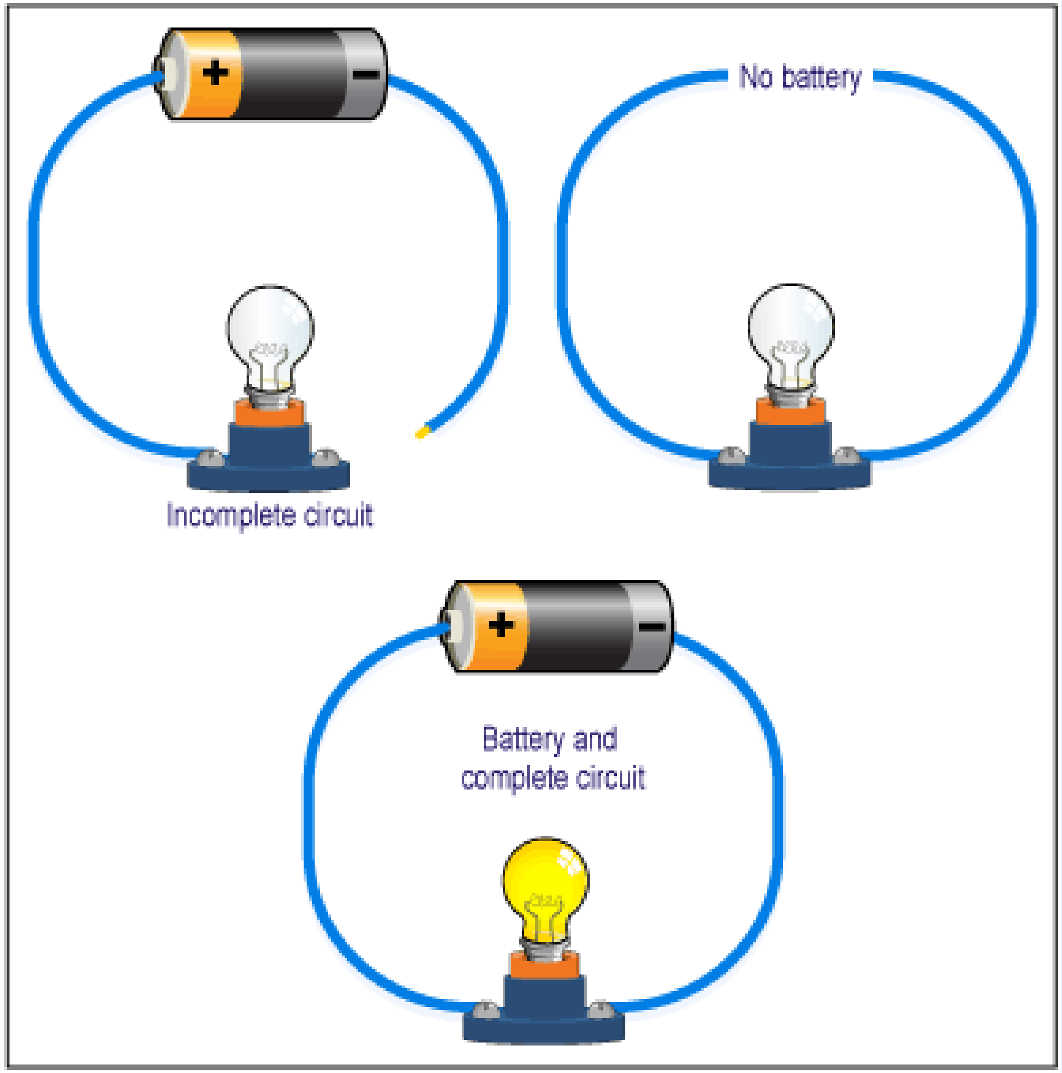
- **Open circuit**: when the flow of electrons is interrupted and the electrons cannot move through the circuit. (Switch Open)



Open Circuit

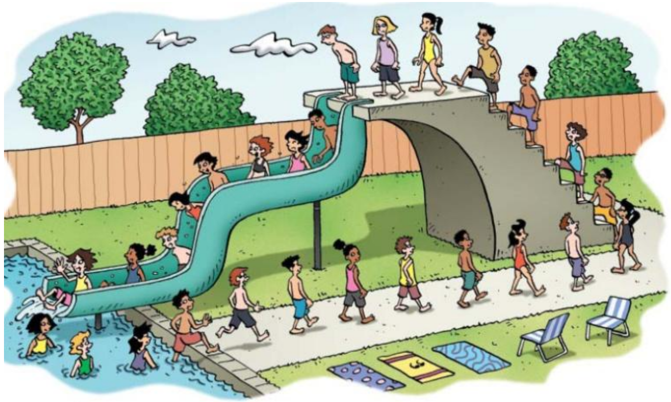
- **Closed Circuit:** when there is a flow of electrons throughout the circuit. (Switch Closed)




No battery
Incomplete circuit
Battery and
complete circuit

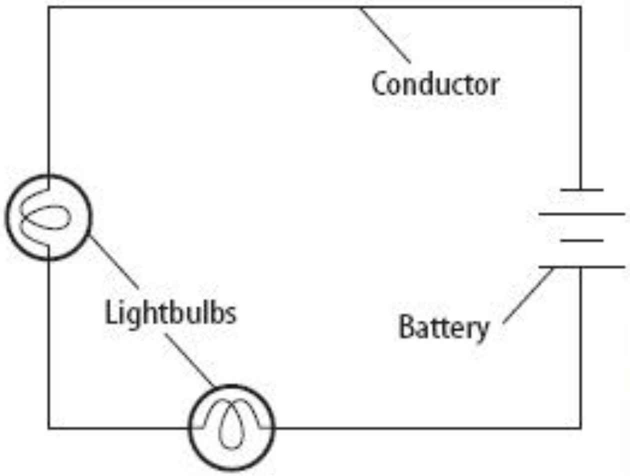
SERIES CIRCUIT

- provides a single pathway for the current to flow.



- If the circuit breaks, all devices using the circuit will fail.

A series circuit provides only one path for the current to follow. *What happens to the brightness of each bulb as more bulbs are added?*

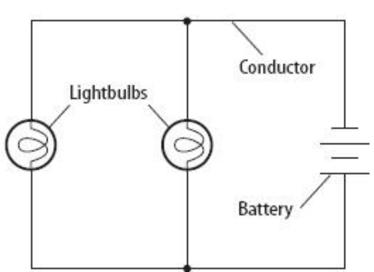


PARALLEL CIRCUIT

- has multiple pathways for the current to flow.

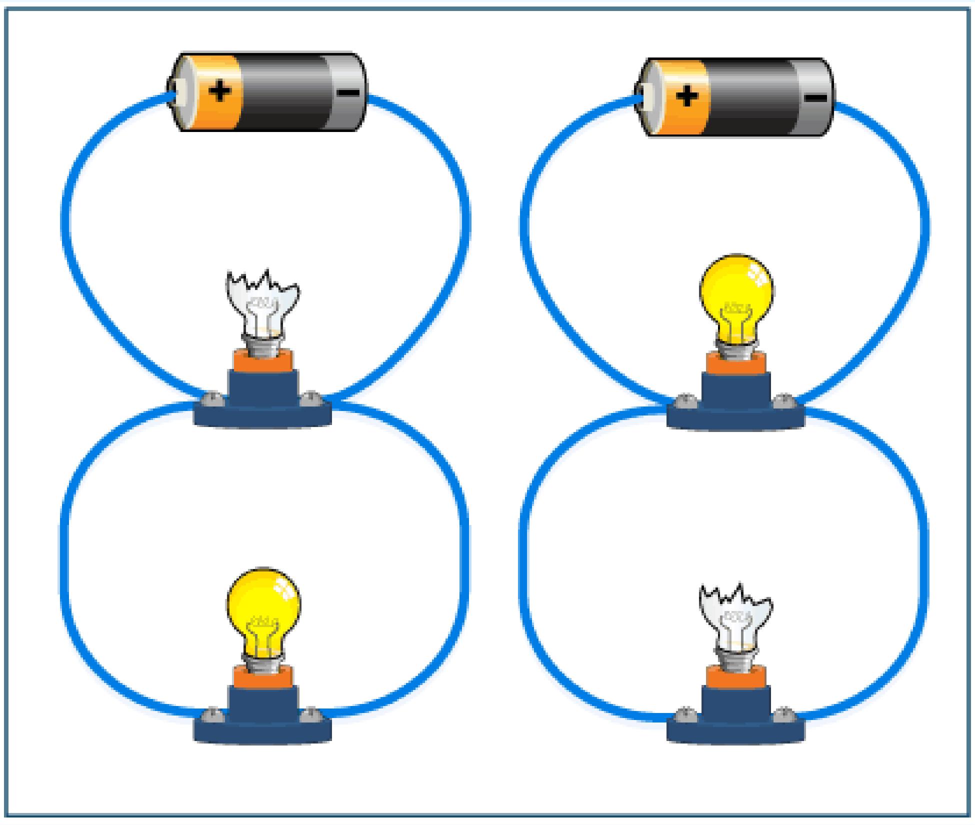
- If the circuit is broken the current may pass through other pathways and other devices will continue to work.

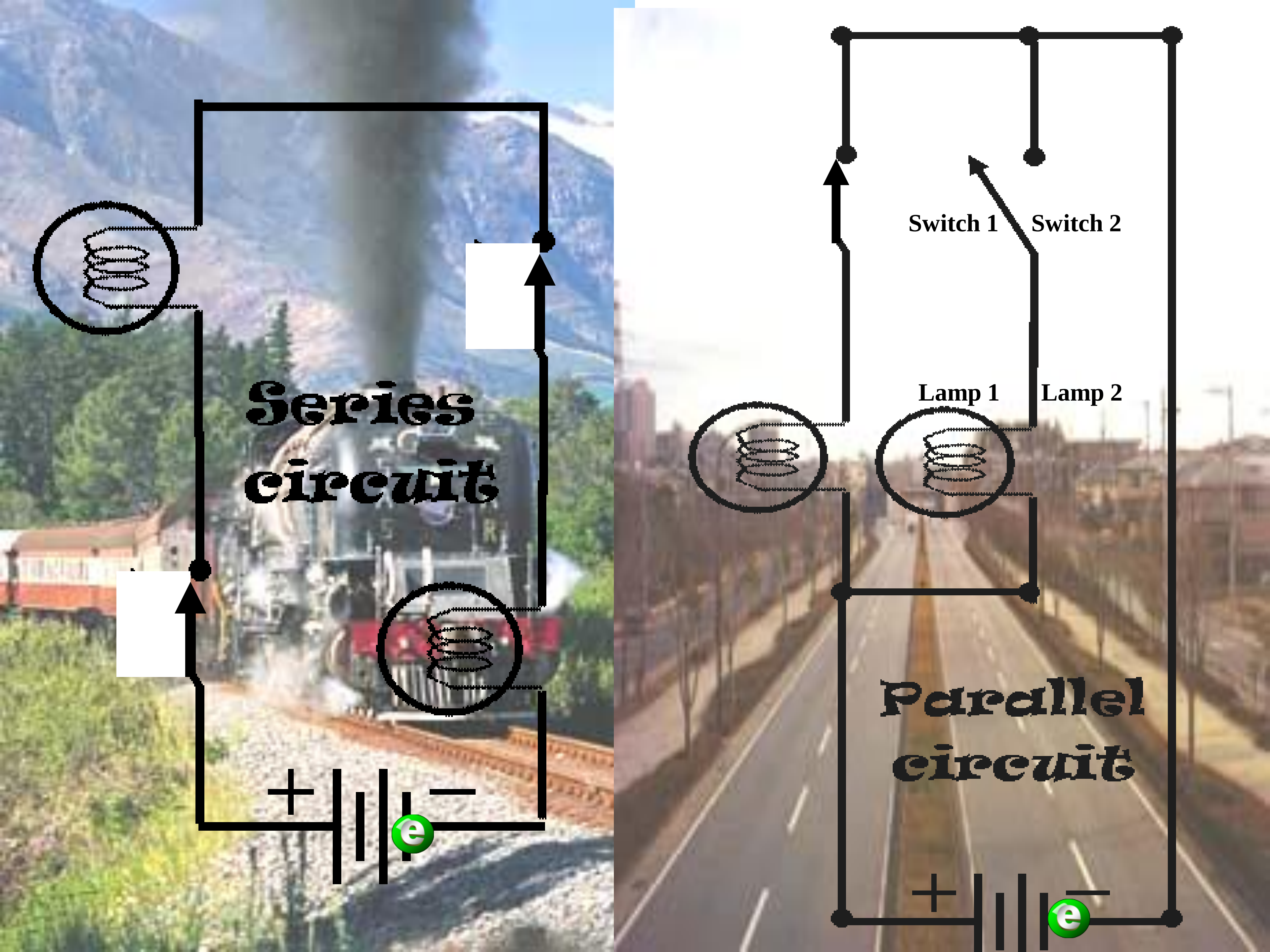
Figure 18
In parallel circuits, the current follows more than one path. *How will the voltage difference compare in each branch?*



Ex. Expensive Christmas lights, If you remove a bulb from a the string they remain lit !

PARALLEL CIRCUIT



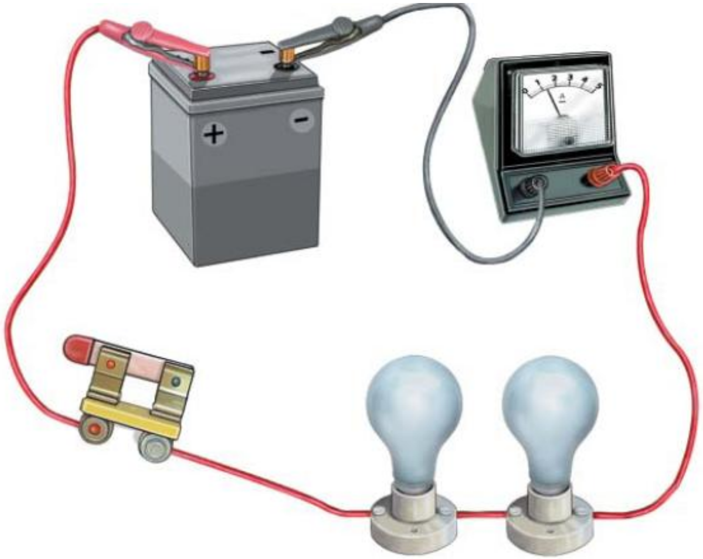


Series circuit
+
−
e
Switch 1
Switch 2
Lamp 1
Lamp 2
Parallel circuit
+
−
e

MEASURING CURRENT

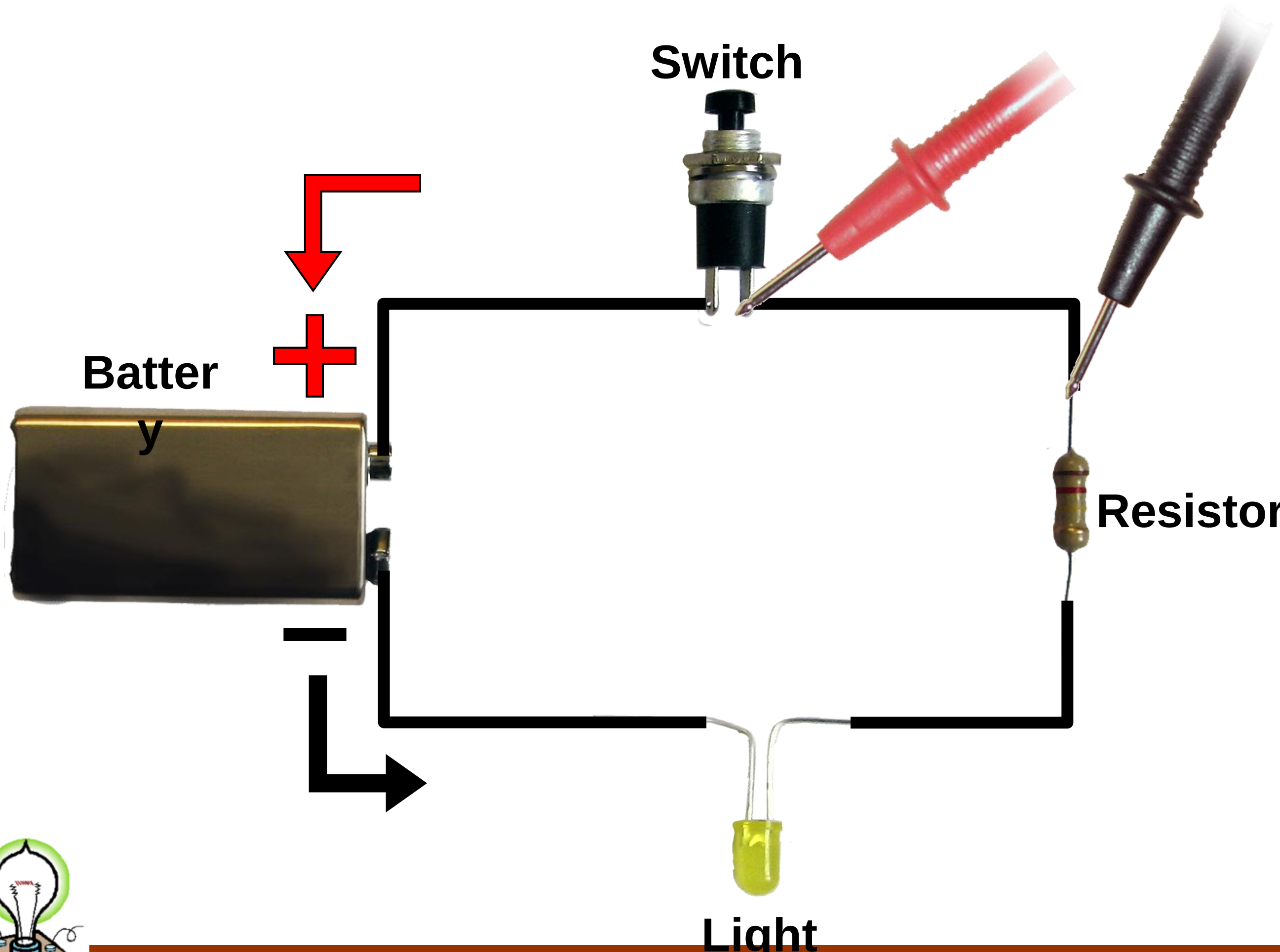
- Current is measured with an instrument called an ammeter.

- the ammeter is always connected in series with the other elements of the circuit. An ammeter typically has a red terminal and a black terminal. Connect the red terminal to the positive terminal of the battery.



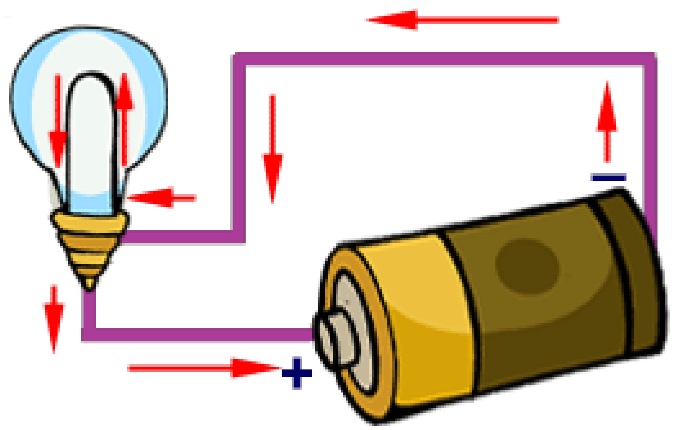
Measuring Current

Circuit flow must go through the meter.



Current Electricity

- Electrons flow through a conductor
- Circuit = continuous loop for electrons to flow
- Needs energy supply
- Negative to positive
- Energy user



Electricity

Electricity occurs in 2 different forms

- Static
- Is stationary

E.g. Brush your hair

Wool socks in tumble drier

- Current
- Flows around circuit

E.g. turn on light

using a toaster

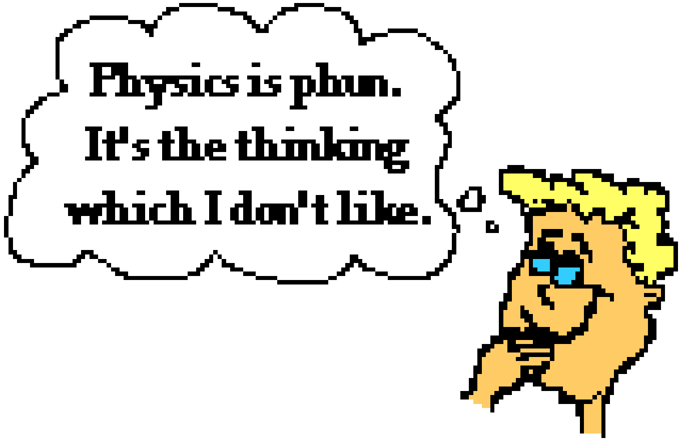
EDUCATIONAL MOVIE

BILL NYE CURRENT ELECTRICITY

BellAliant

Bell Aliant Learning Centre

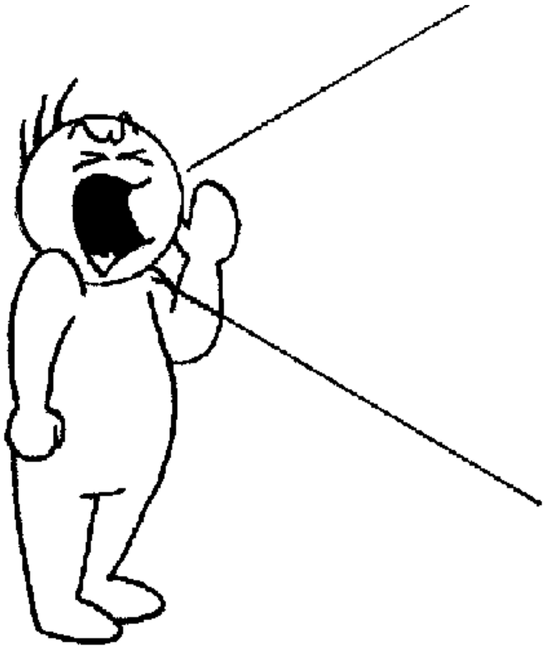
STUDENT WORKSHEET 1

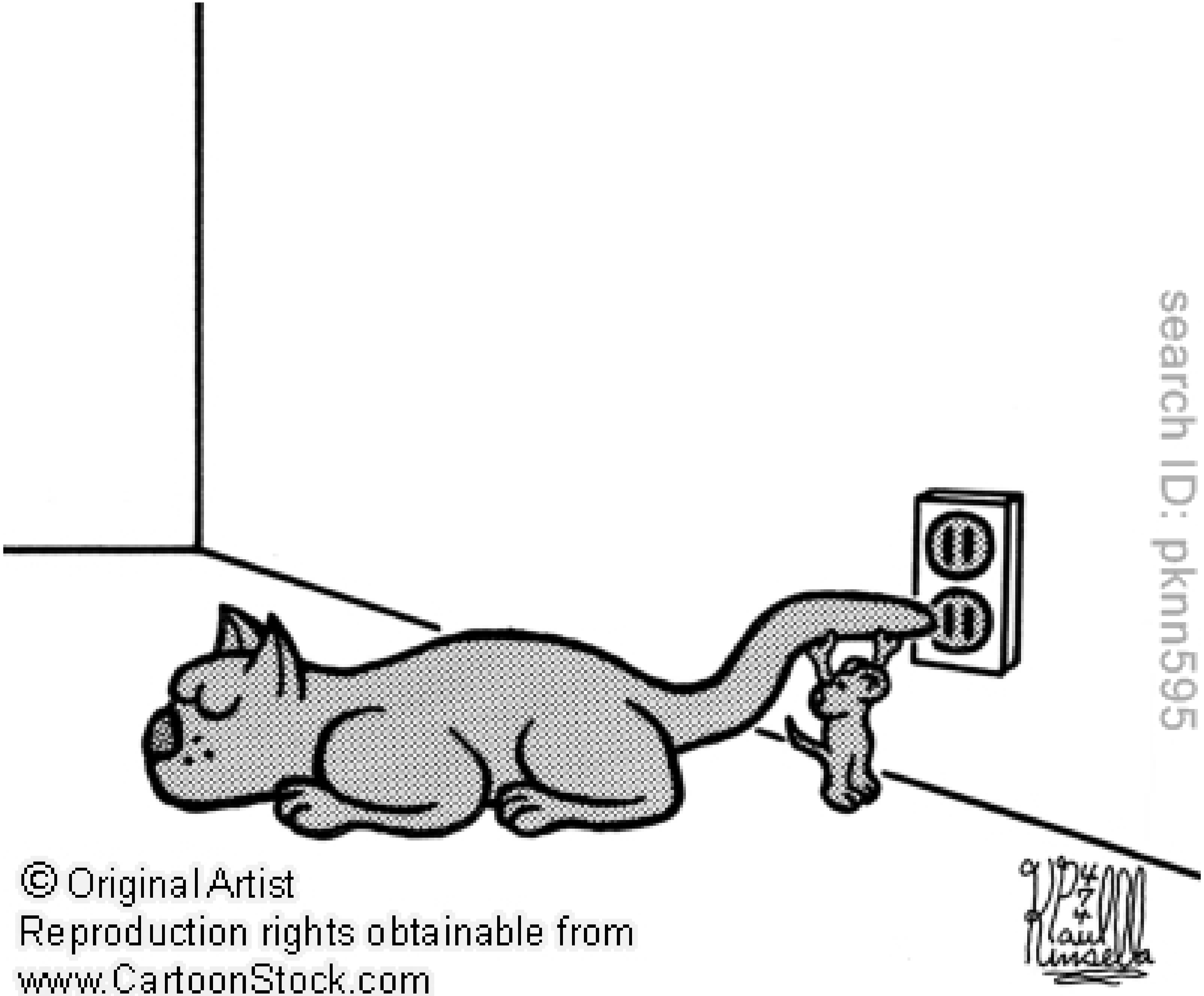


Science 9

Unit 3 : Current Electricity

Topic 2 : Electric Voltage

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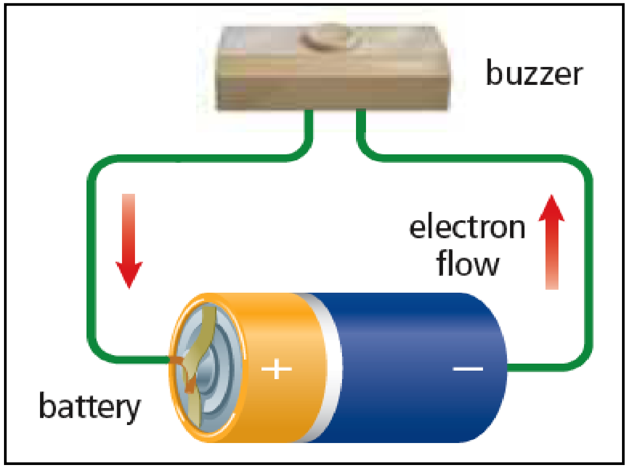
Electrons Are So Pushy

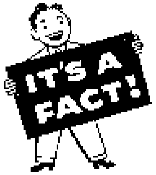
- So far you have learned that a source like a battery supplies the energy to push electrons.
- Electrons are pushed from a negative terminal of the battery, along conducting wires through the load (light bulb).
- Electrons apply an action-at-a-distance force.



Electric Potential Energy

Electric Potential Energy refers to electric energy stored in the battery that can be given to electrons to enable them to do work within a circuit.

Electric Potential Energy is measured in Joules



Electric potential energy is another name for work (W) when we are dealing with electricity is the change in.

Electric Potential (Voltage)

Electric potential refers to the amount of energy per unit charge.

$$\text{Electric Potential} = \frac{\text{Electric Potential Energy}}{\text{Charge}}$$

$$= \frac{\text{Joules}}{\text{Coulomb}}$$

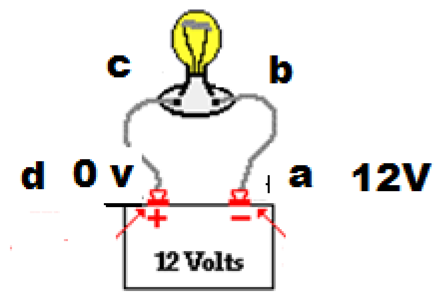
$$= \text{Volts}$$

Voltage is just another name for electric potential (V) and the units are volts. (named after Alessandro Volta (1745-1827).

Electric Potential Difference

Electric potential difference refers to the difference in electric potential from one location in a circuit to another.

The units are still volts.



Voltage at point A is 12 V

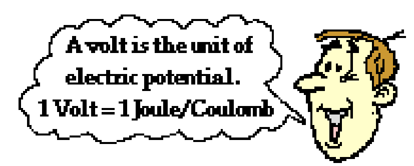
Voltage at point B is 0 V

Electric Potential Difference = Voltage at A - Voltage at B

= 12 V - 0 V

= 12 V

To produce an electric current in a circuit, a d
in potential is required



What is Electrical Potential Energy, Electrical Potential, Electrical Potential Difference Confused??

Money represents the amount of energy you have!

Money = Electrical Potential Energy

People represent Charge

More People = More Charge

battery 1

Energy 6 J

Charge = 2 C

battery 2

Energy 12 J

Charge = 6 C

Electric Potential = 6 /2 = 3V

Electric Potential = 12 /4 = 2V

The amount of money per person is like electric potential. However, in a circuit electric potential represent the amount of energy per charge.

What is electric potential difference?

Remember battery 1, each person had $3 dollars per person or 3 V.

ELECTIC POTENTIAL DIFFERENCE $= V_{IN} - V_{OUT}$

$= 3V - 1V$

$= 2\ V$

Figure 8.16A Both ends of the tube are at the same potential (height). The marbles in the tube do not all flow in the same direction.

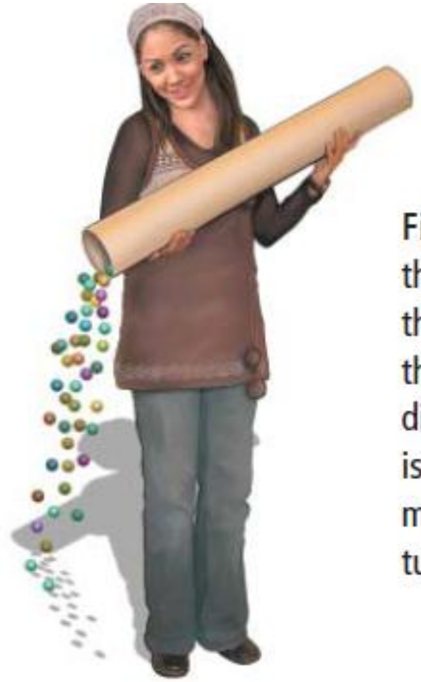


Figure 8.16B Because of the difference in height of the ends of the tube in (B), there is a greater potential difference than in (A). There is a greater "current" of marbles in tube (B) than in tube (A).

Sources of Potential Difference (Voltage)

Friction

Rubbing two materials together, such as acetate and paper, or rubber and wool, can separate charge. These separated charges now have electrical energy. Some of the work done by rubbing is converted into the electrical energy stored in the separated charge.

Piezoelectric crystals

A barbecue lighter has no battery inside to produce the electric spark. The electricity comes from a tiny crystal. When certain types of crystals, such as quartz, are squeezed, positive and negative charges are separated on either side of the crystal. A small hammer in the lighter hits the piezoelectric crystal, generating a burst of thousands of volts of electricity. The prefix "piezo-" means pressure or push.

Photo-electrochemical cells

Solar panels and many calculators use photo-electrochemical cells or solar cells as a source of power. Photo-electrochemical cells are made of semi-conducting material such as silicon. When light hits the cell, some of the light energy breaks electrons off the surface of the cell. These separated electrons now have the electrical energy needed to operate a calculator, a phone booth, or the International Space Station.

Thermocouples

A thermocouple is a device used to transform heat energy into electrical energy. A thermocouple consists of a loop of two wires of different metals joined at both ends. If one end of the loop is heated or cooled, charge is separated and a voltage is created across the thermocouple. Individual thermocouples can produce only a small amount of electrical energy. If a larger amount of electricity is needed, several thermocouples must be joined together. We use a thermocouple in a kitchen oven to control the temperature.

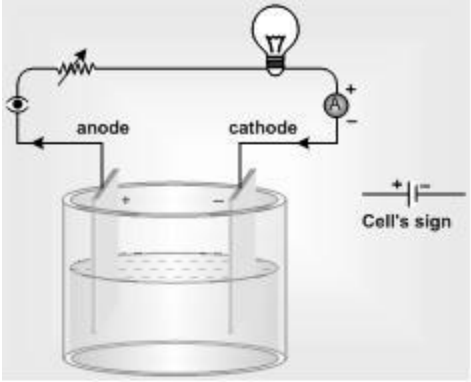
Generators

The electricity that enters most of our homes is produced by a generator. Generators work on the principle that when a wire moves close to a magnet or a magnet moves close to a wire, a voltage is created across the wire. All that is needed is an energy source to provide the wire or the magnet with the necessary motion. In Newfoundland and Labrador, we use hydroelectric energy, the energy of water to generate electrical energy.

Cells and Batteries

Current can not be produced or electrons can not flow on their own, some force has to get the electrons moving. One way that we looked at was through the use of an electrochemical cell.

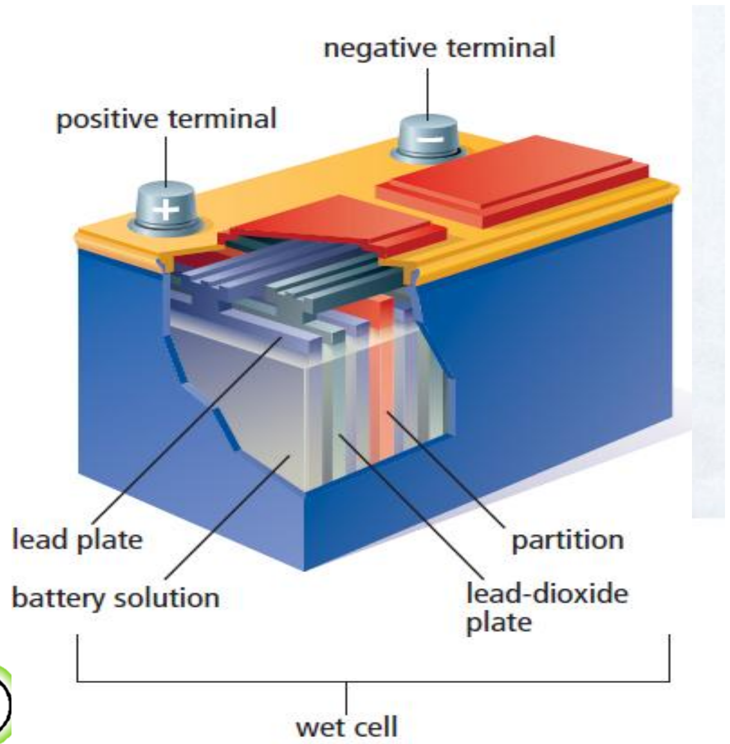
Cell: a device that converts chemical energy into electrical energy. Generally speaking the "batteries" that you buy in the store to run your portable appliances are chemical cells.

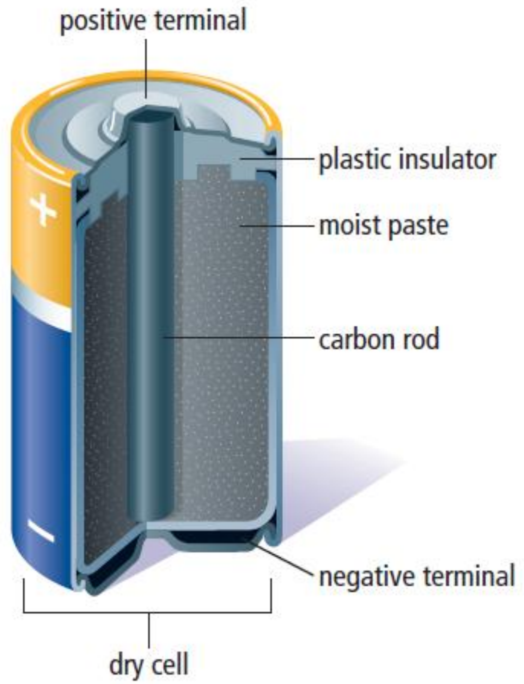


TWO TYPES OF CELLS

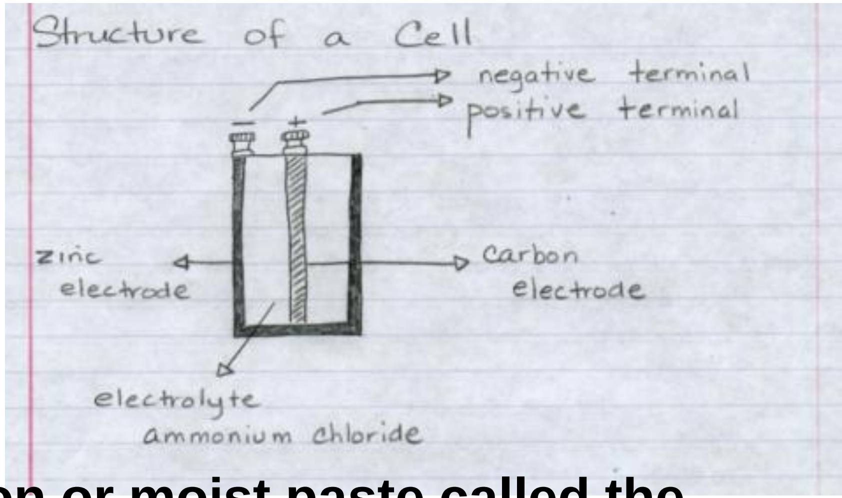
WET CELL An electric cell in which the chemicals producing the current are in the form of a liquid. Used in cars, motorcycles, ski doo

DRY CELL the solution is in the form of a paste. Used in flashlights, mp3 players,





How does a Cell Work?



- All chemical cells consist of two different metals. (Ex. Zinc and carbon). These metals are called **electrodes** .

- In between the electrodes is a solution or moist paste called the **electrolyte**.
(Ex. Ammonium Chloride)

- A chemical reaction takes place within the cell causing a build up of electrons (e) on the zinc electrode. This becomes negative terminal.

- On the carbon electrode , electrons are taken away, make the carbon electrode the positive terminal.

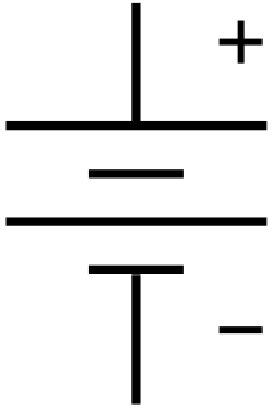
- When a wire is connected between the two electrodes (i.e. The two terminals) electrons flow from the zinc (negative) to the carbon (positive)

- This produces an electric current.

The parts are a little different from the old zinc-carbon cells;
A - combination zinc powder/alkaline electrolyte paste where electrons are released (anode).
B - brass conducting rod where the released electrons are collected.
C - hard to see in the above diagram, but this is a fabric that separates anode from cathode.
D - mixture of manganese dioxide and carbon, where the electrons are absorbed (cathode).
E - the negative terminal, where the electrons leave.
F - the positive terminal, where the electrons return.

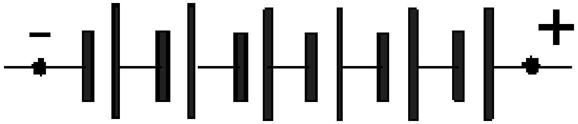
What is a Battery

Battery: made up of one or more electrochemical cells that are joined together to provide an electric current.



SYMBOL FOR BATTERY

9 V battery



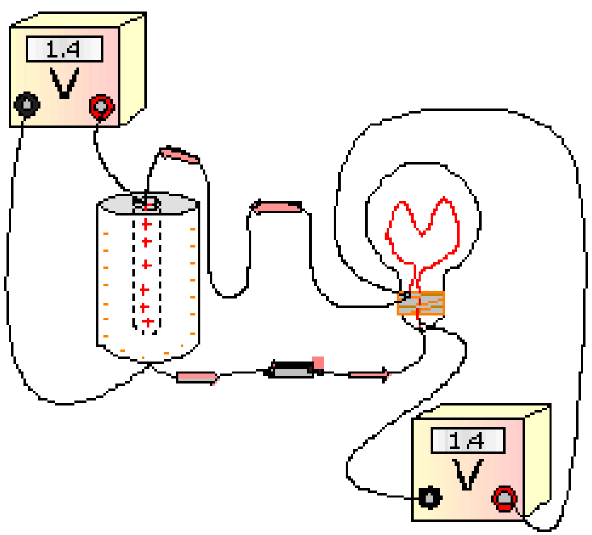
6 x 1.5 V cells

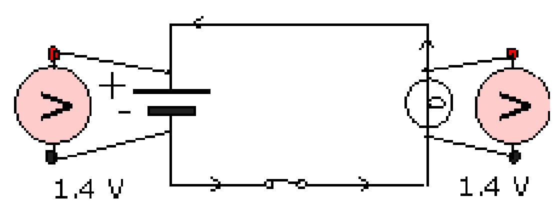
MEASURING VOLTAGE

The instrument used to measure voltage is called a **voltmeter**.

A voltmeter can measure the increase in potential at the terminals of the dry cell, and the decrease in potential as the electrons give up their energy in the lamp.

Voltmeters must be hooked up in parallel

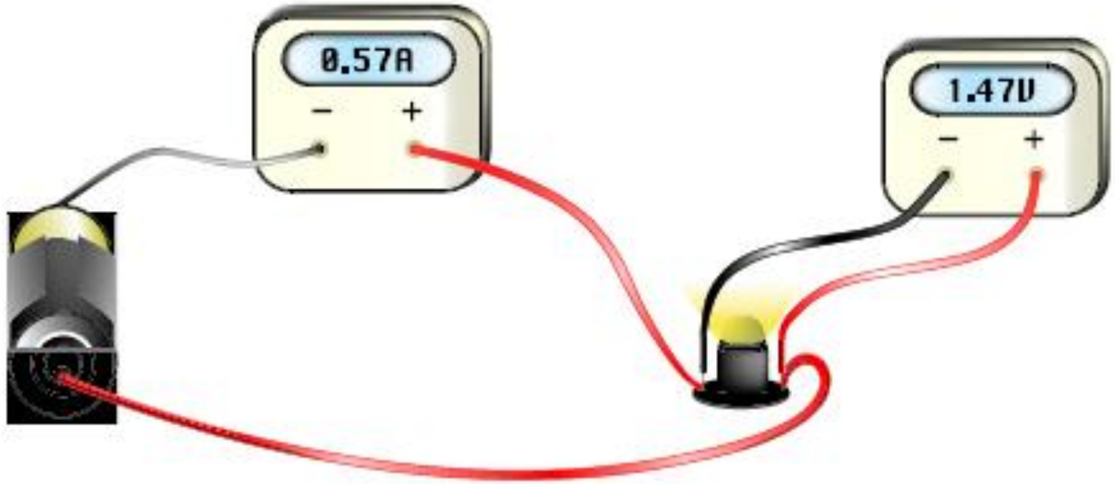




Unlike the ammeter the circuit is not broken to connect a voltmeter.

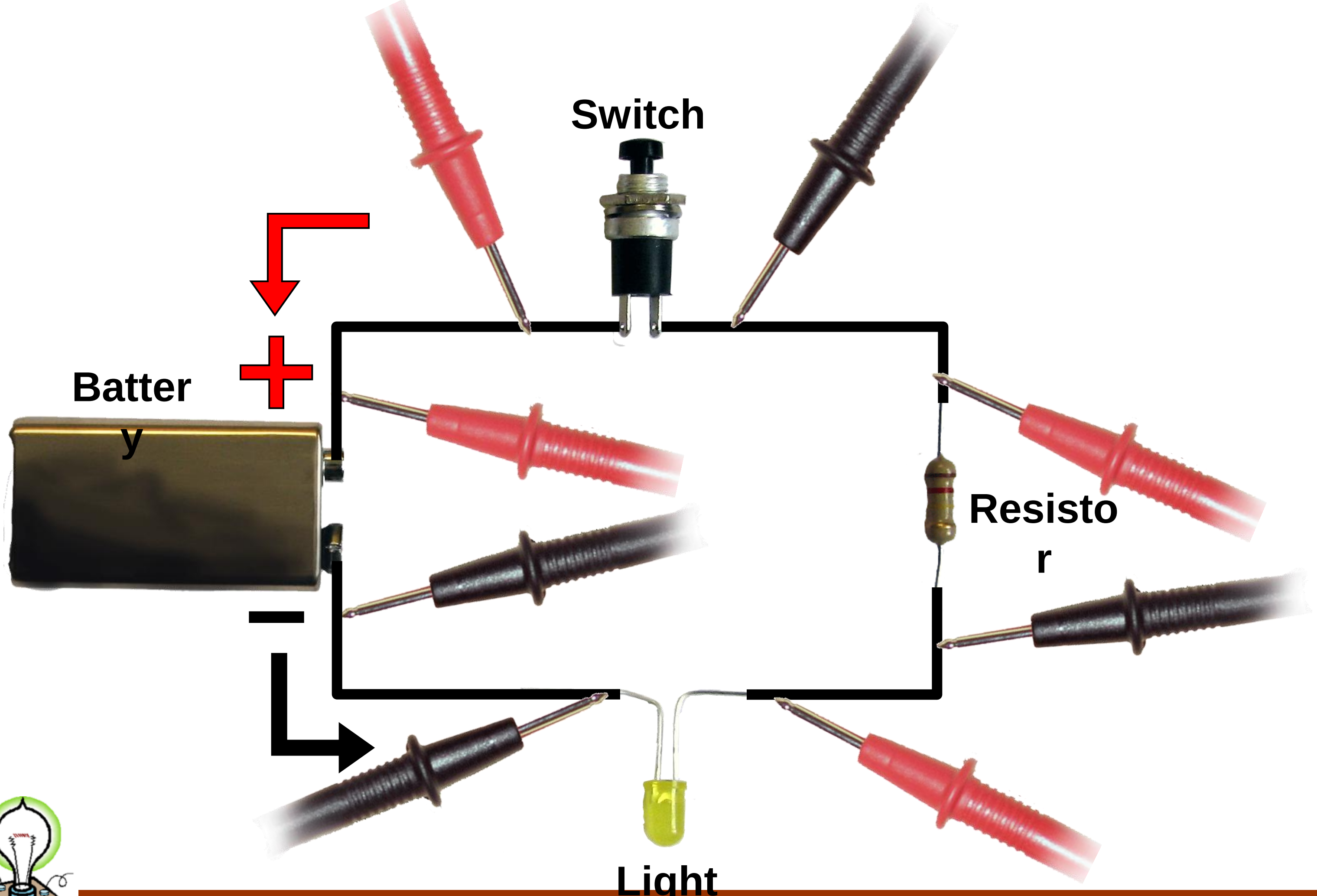
- The red terminal of the voltmeter is connected to the positive terminal of the cell. (However, the red terminal of the voltmeter must be connected to the terminal of the bulb that is towards the positive terminal of the dry cell.)
-

a)



Measuring Voltage

Measure across a component.



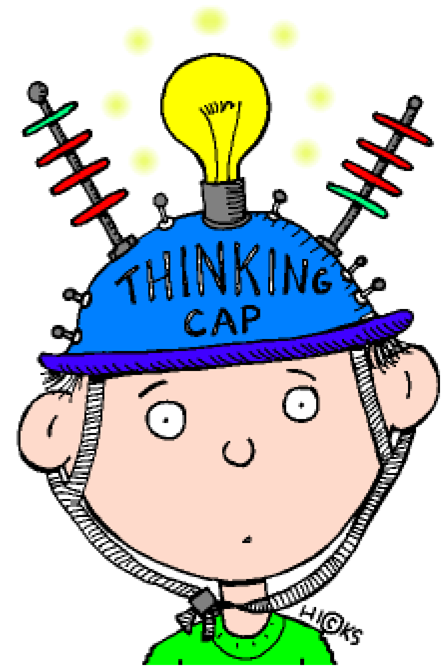
	Current	Voltage
Measured in	Amps, A	Volts, V
Measured with	Ammeter in series	Voltmeter in parallel
Circuit symbol of measuring devise		


Yes, I know you want it to keep going, but I have to stop now. It's over ...
FULL
LOW
© 2001
a Rick London and Rich Diesslin Cartoon for
London's Times

Student Activity

A PENNY FOR A BATTERY PAGE 251 TEXTBOOK

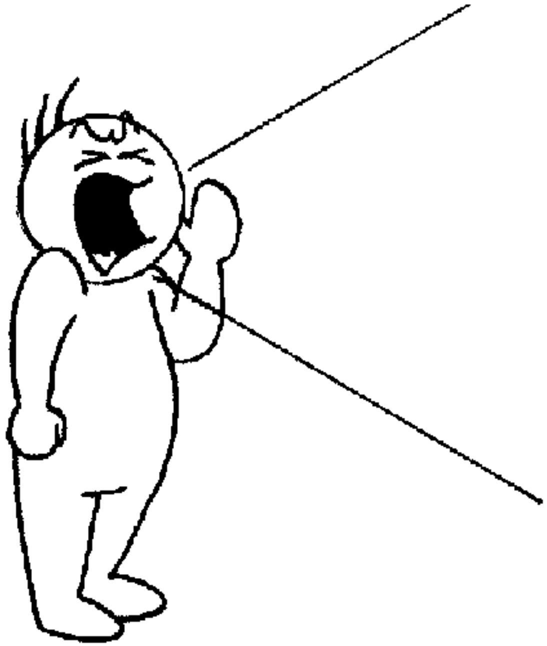
STUDENT WORKSHEET 2

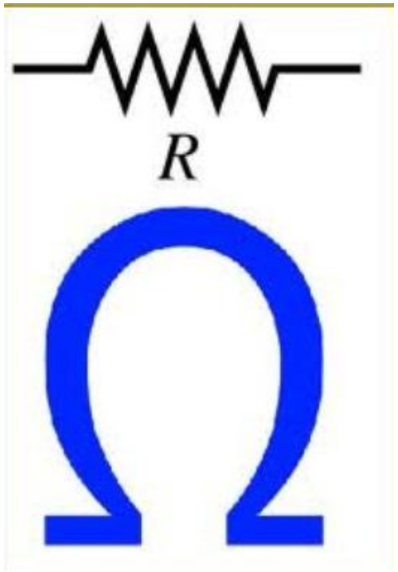


Science 9

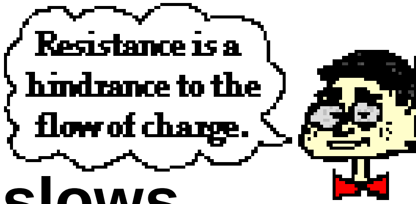
Unit 4 : Current Electricity

Topic 3 : Electrical Resistance





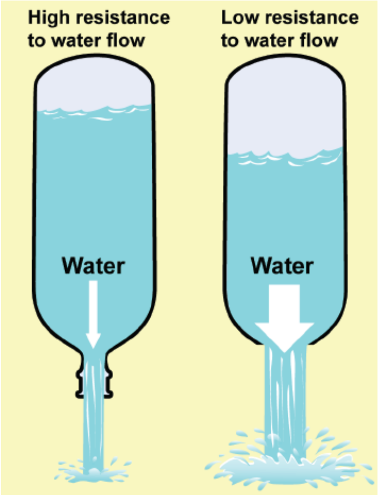
RESISTANCE



Resistance is the property of any material that slows down the flow of electrons and converts electrical energy into other forms of energy.

Electrical resistance is measure in ohms (Ω). The symbol for ohm is an omega ,

Resistance is like an obstacle in the road. Electrons like to going to places of least resistance.

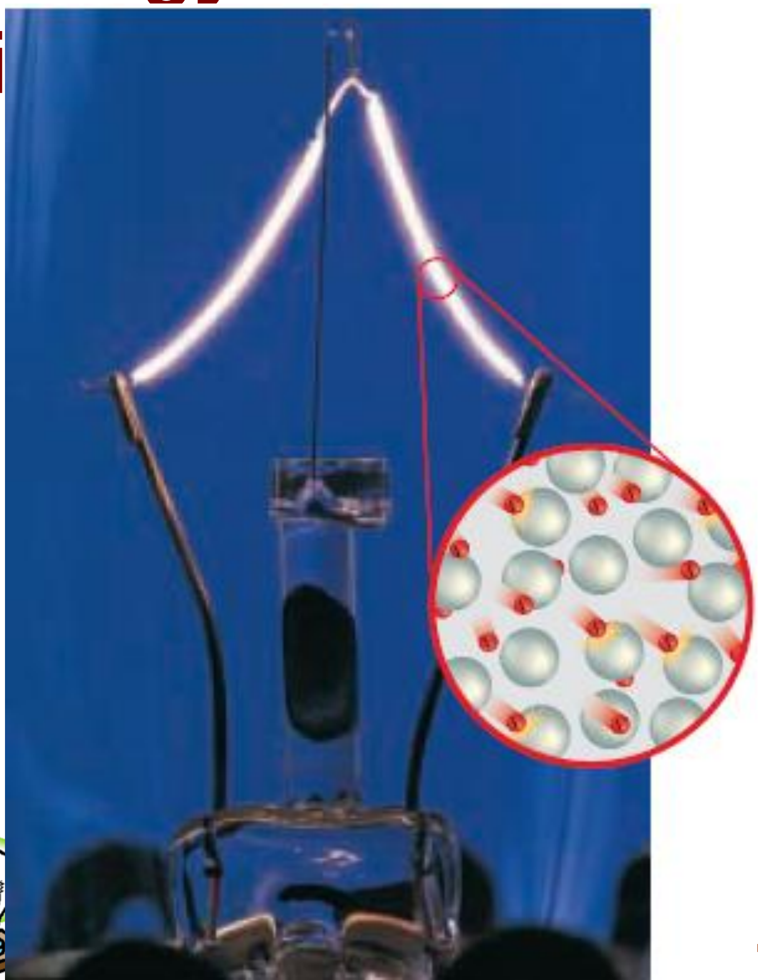


The wire that connects the battery to the light bulb has very little resistance, and therefore the electrons travelling through this wire lose almost no electrical energy


JOIN THE RESISTANCE!
OHMMMMM...

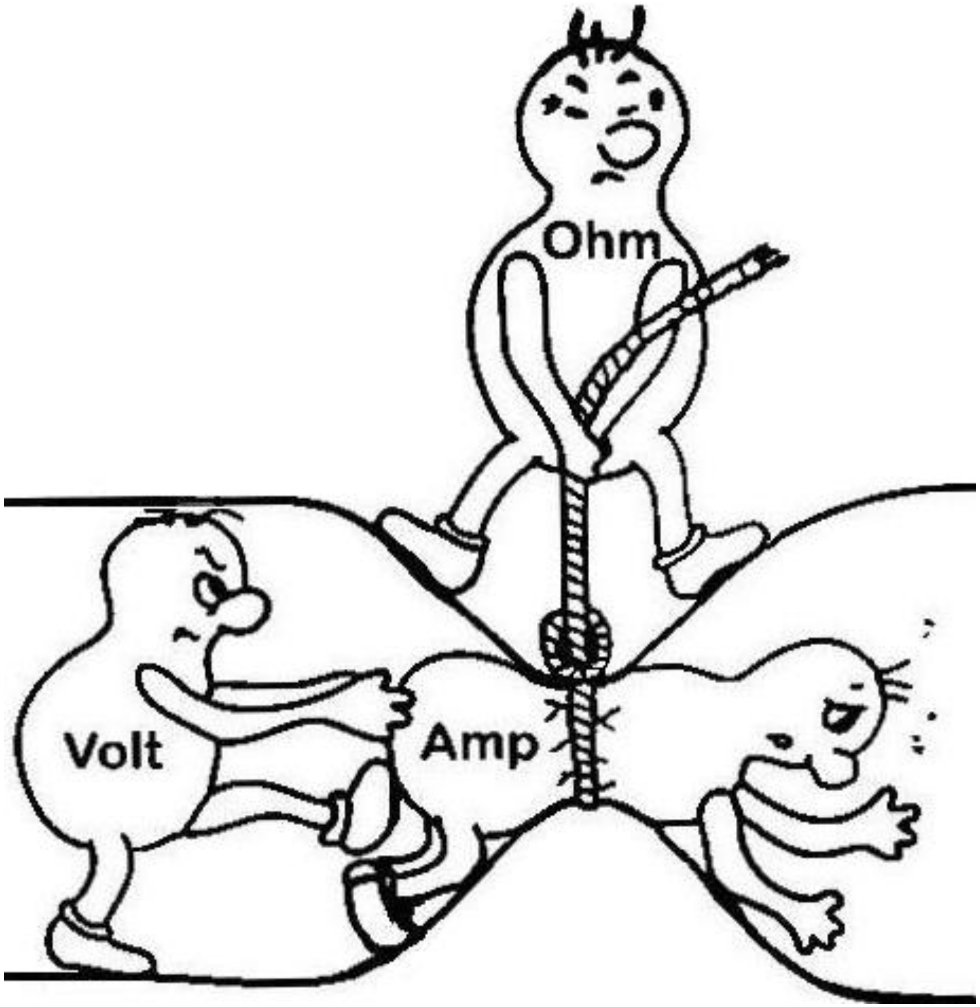
What is electrical *resistance*?

Resistance (R)is the opposition to the flow of an electric current, causing the electrical energy to be converted to thermal energy or li



As electrons move through the filament in a lightbulb, they bump into metal atoms. Due to the collisions, the metal heats up and starts to glow.

The metal which makes up a light bulb filament or stovetop eye has a high electrical *resistance*. This causes light and heat to be


Ohm
Volt
Amp

Four Factors That Affect Resistance:

1) TEMPERATURE.

Higher the temperature, larger is the resistance.

2) LENGTH

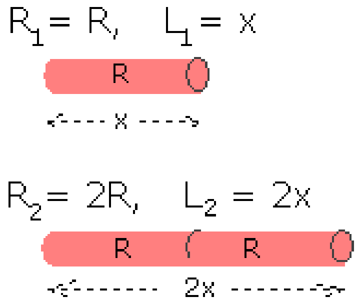
longer the wire greater will be the resistance and shorter the wire smaller will be the resistance.

Think about a water pipe. As water scrapes along the inside of the pipe, water traveling through a long pipe will experience greater drag than through a short pipe.

$R \alpha L$ or $R = kL$ where k is some constant of proportionality.

Write $R_1 = kL_1$ and $R_2 = kL_2$, and divide one equation by the other so that the k's cancel:

$$\frac{R_1}{R_2} = \frac{L_1}{L_2}$$



identical resistors except for length (same diameter, same material, same temp.)

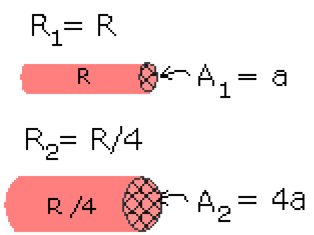
3) THICKNESS OF WIRE

Think: Will water run more freely through a fat pipe or a skinny one?

Answer:

The water will run through the pipe with the larger cross-sectional diameter. The larger the cross-sectional area the easier the flow. In other words: large cross-sectional area (A) means small resistance (R). Double the area and the resistance becomes one-half of what it was; triple the area and the resistance becomes one-third of what it was;

Thinner the wire, greater the resistance and thicker the wire, lower the resistance.

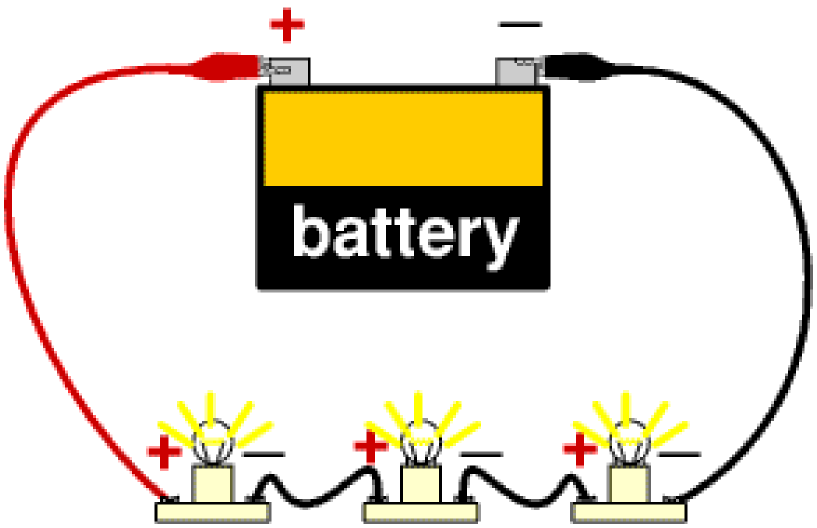


identical resistors except for cross-sectional area (same length, same material, same temperature)

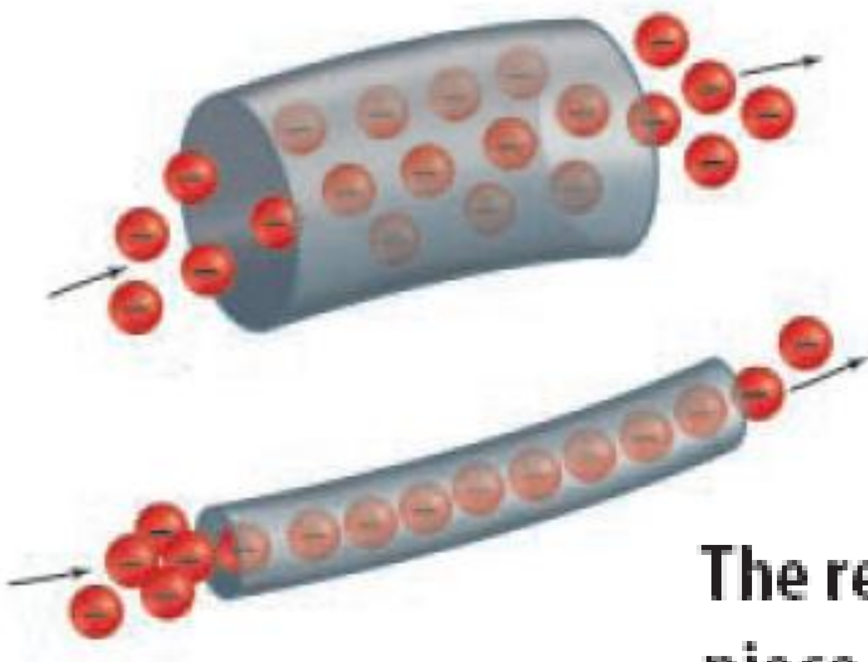
4) TYPE OF MATERIAL.

Good conductors have low resistivity

Silver and copper are extremely good conductors. Glass and hard rubber are non-conductors or insulators.



Which wire has the greatest resistance?



The resistance of a short, thick piece of wire is less than the resistance of a long, thin piece of wire.

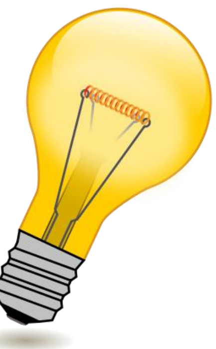
In Summary….

Factors that affect Resistance

Factor	Description	Proportionality
Length	The longer the conductor, the greater the resistance.	If the length is doubled, then the resistance is doubled.
Cross-sectional areas	The larger the cross-sectional area or thickness of the conductor, the less resistant is has to charge flow.	If the cross-sectional area is doubled, the resistance goes to half its originals value.
Type of material	Some materials are better conductors than others. The general measure of the resistance of a substance is called the resistivity. Resistivity has units Ωxm	If the resistivity(p) is doubled, then the resistance is also doubled.
Temperature	Since moving charge is impeded by molecules, greater molecular motion at higher temperatures tend to increase the resistance.	An increase in temperature of the conductor usually contributes to an increase in the resistance, but not for all substances.

Electric load provided resistance in a circuit. It transforms electrical energy into other forms of energy.

Examples:



Term	Symbol	Definition	Measured in (Units)
CURRENT	I	- the flow of electrons through a conductor	Amperes (A)
VOLTAGE	V	- also known as "Potential Difference" - "push/force" of electricity - Potential energy per quantity of electrons	Volts (V)
RESISTANCE	R	- measures how easily electricity flows along a certain path	ohm

Confused?? Look at it this way: The Mouse Cheese Analogy

Negative charges are attracted to positive charges the same way mice are attracted to cheese. The negative charges (mice) will gladly do work in order to get to the positive charges (cheese).

Voltage:

The amount of work that each charge (mouse) will do as it goes through the circuit. Can also be thought of as the amount of push on the charges or how hungry the mice are.

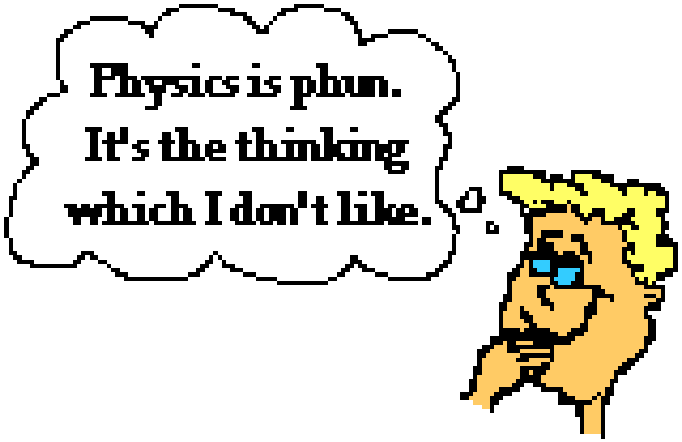
Current:

The number of charges (mice) passing a point per second. The rate of flow of charges.

Resistance:

The opposition to the flow of charge. Any appliance that asks the charge (mouse) to do work will slow it down.

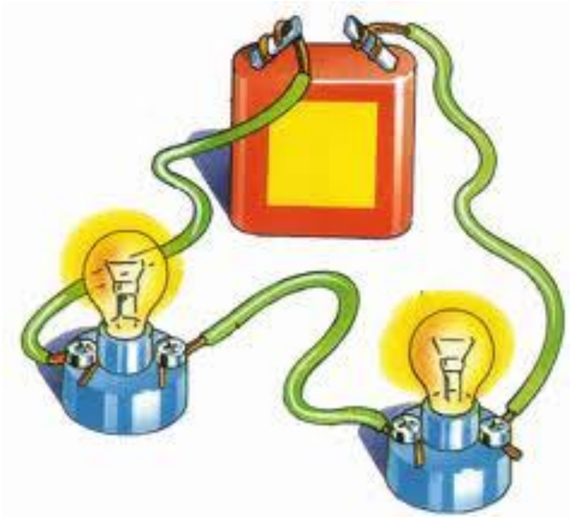
STUDENT WORKSHEET 3



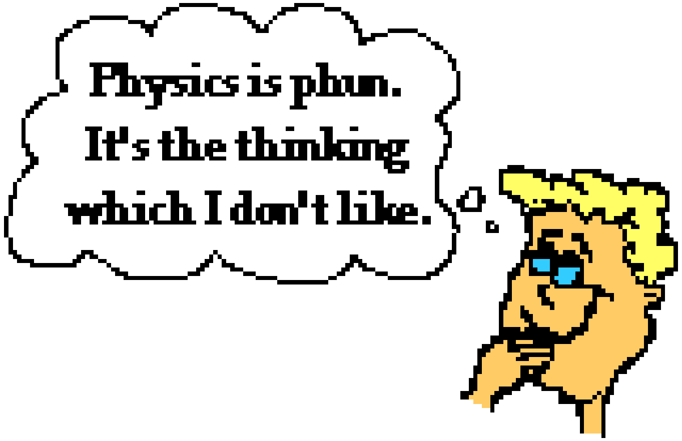
"And what makes you think this classroom wasn't wired properly?"

Student Activity

Allow students to construct series circuit and parallel circuit using virtual electricity lab



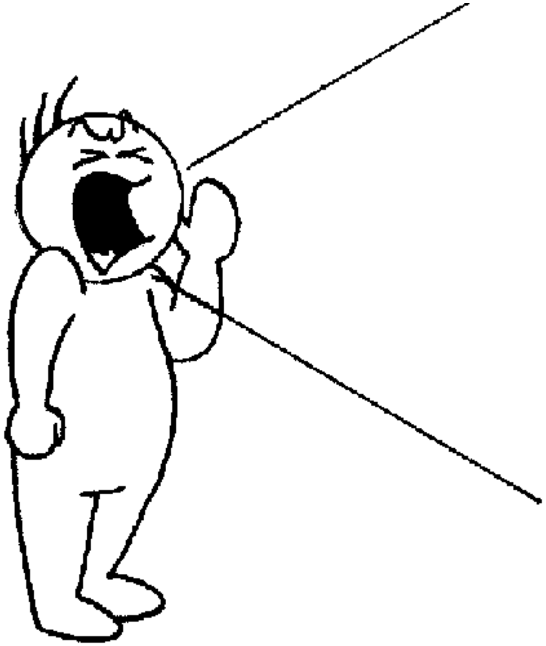
STUDENT WORKSHEET 4



SCIENCE 9

Unit 2 : Current Electricity

Topic 4 : Ohm's Law



OHM'S LAW: RESISTANCE:

Georg Simon Ohm 1789-1854

German Physicist / School Teacher

Discovered the mathematical relationship between current, voltage, and resistance

Ohm's Law

$$V = I R$$

Potential
In volts
(joules / coul)

Current
In amperes
(coul / second)

Resistance
In ohms
(volts / amp)

Drop across a resistance

Current passing Through the resistor

Ohm's Law Chart

Cover the quantity that is unknown.

Solve for V

V=IR

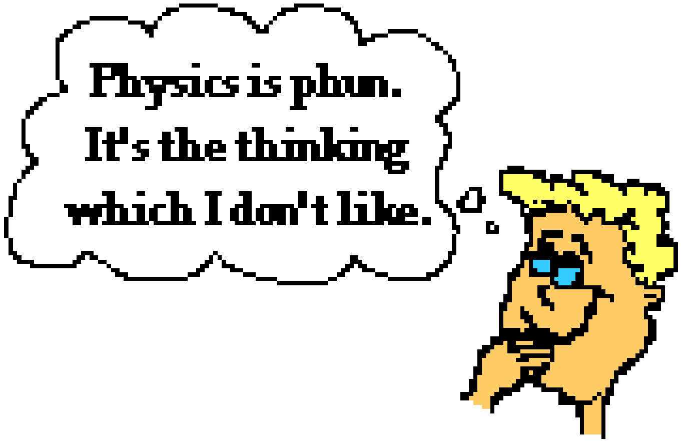
EXAMPLE 1 FIND VOLTAGE

If a circuit has 2A of current running through it and the total resistance in the circuit is 19Ω, then what is the total voltage?

EXAMPLE 2: FIND VOLTAGE

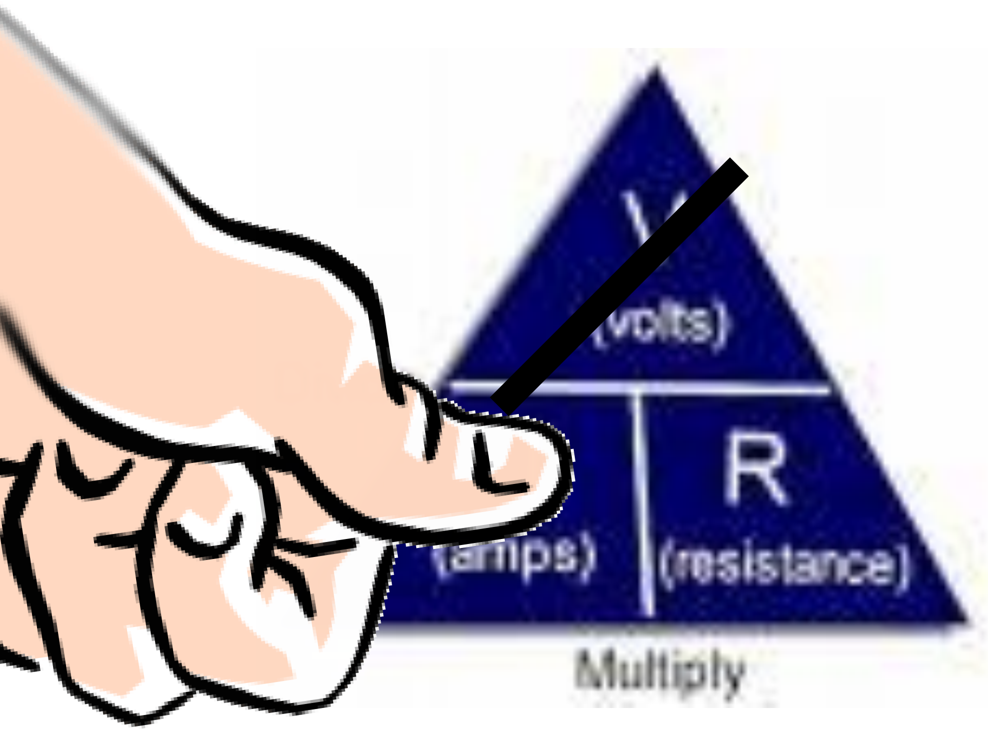
A circuit uses 0.5A of current and has total resistance of 18Ω. How much voltage is the circuit supplied with?

STUDENT WORKSHEET 5



Ohm's Law Chart

Cover the quantity that is unknown.



Solve for I

I=V/R

EXAMPLE 3: FIND CURRENT

A toaster oven has a resistance of 12 ohms and is plugged into a 120-volt outlet.

How much current does it draw?

Electric toaster

1. Looking for:
   – …current in amps
2. Given
   – …R = 12 Ω; V = 120 V
3. Relationships:
   – $I = \frac{V}{R}$
4. Solution
   – $I = \frac{120\ V}{12\ \Omega}$ **= 10 A**

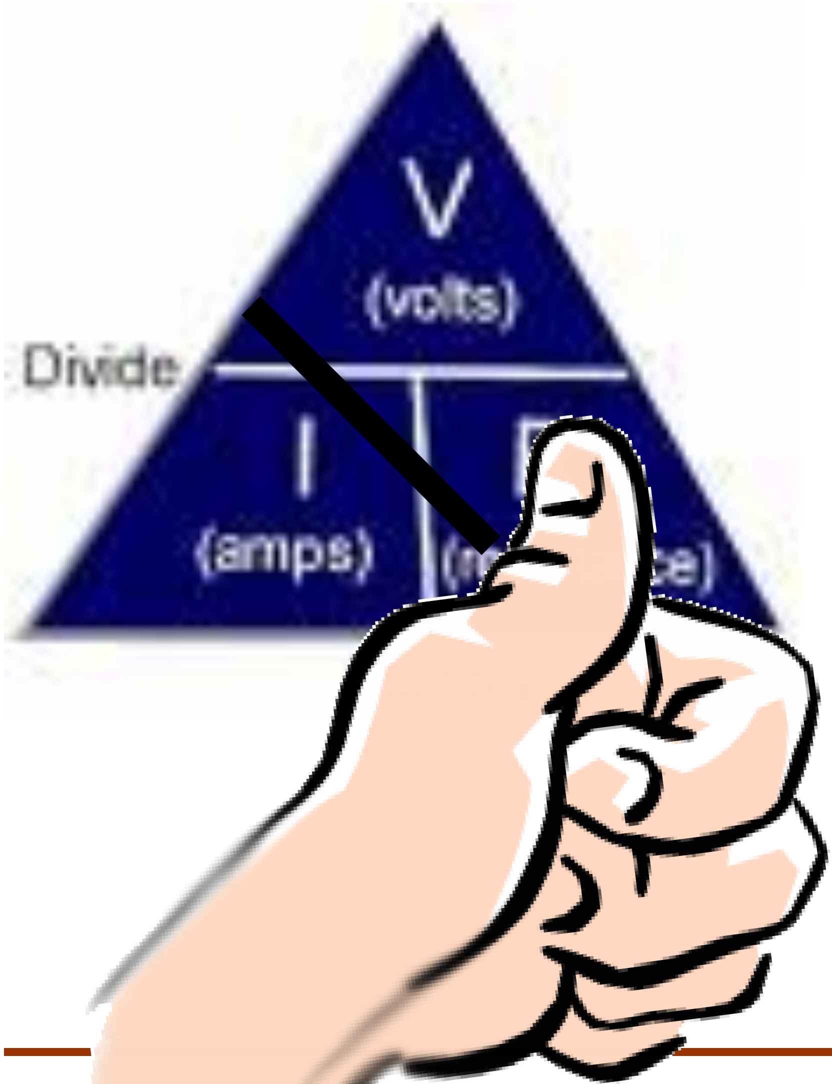
Electric toaster

EXAMPLE 4 : FIND CURRENT

A house is supplied with voltage of 120V. If the total resistance is 60Ω how much current is running through the wires?

Ohm's Law Chart

Cover the quantity that is unknown.



Solve for

R

R=V/I

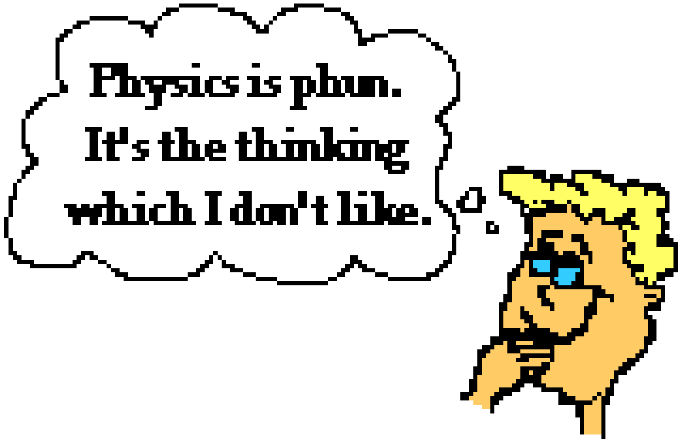
EXAMPLE 5: FIND RESISTANCE

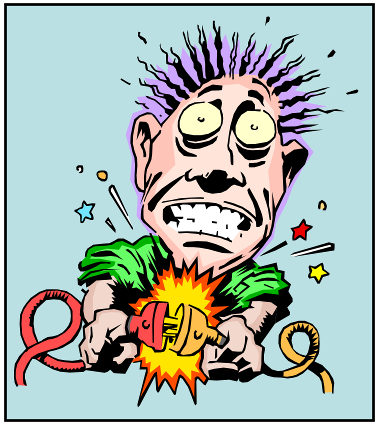
A circuit is supplied with 15V of voltage and has current of 3A. What is the total resistance in the circuit?

EXAMPLE 6: FIND CURRENT

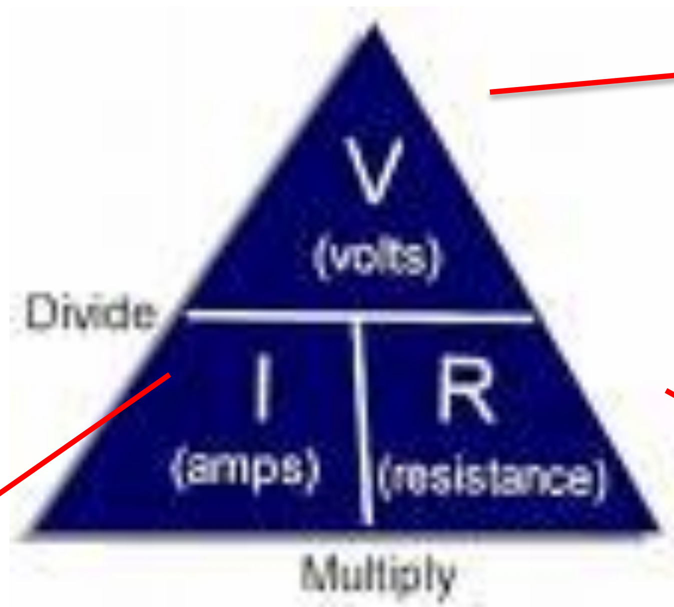
If a computer uses 5A of current and is supplied with 120V of voltage, then what is the total resistance of the computer?

STUDENT WORKSHEET 6





SUMMARY



$V = I \times R$

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

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

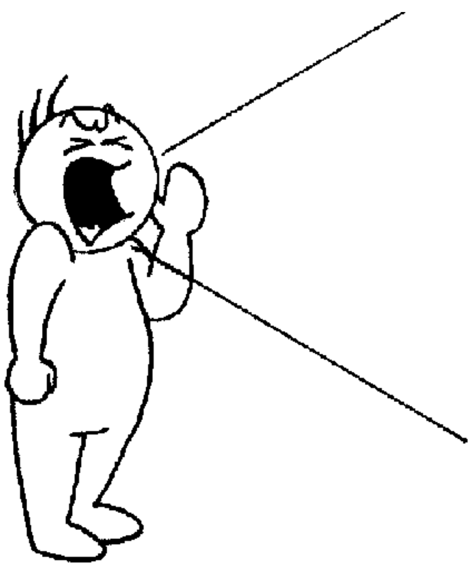
Practice with Ohm's Law

Ohms	Volts	Amps
	100	25
	150	10
	30	15
9		5
6	48	

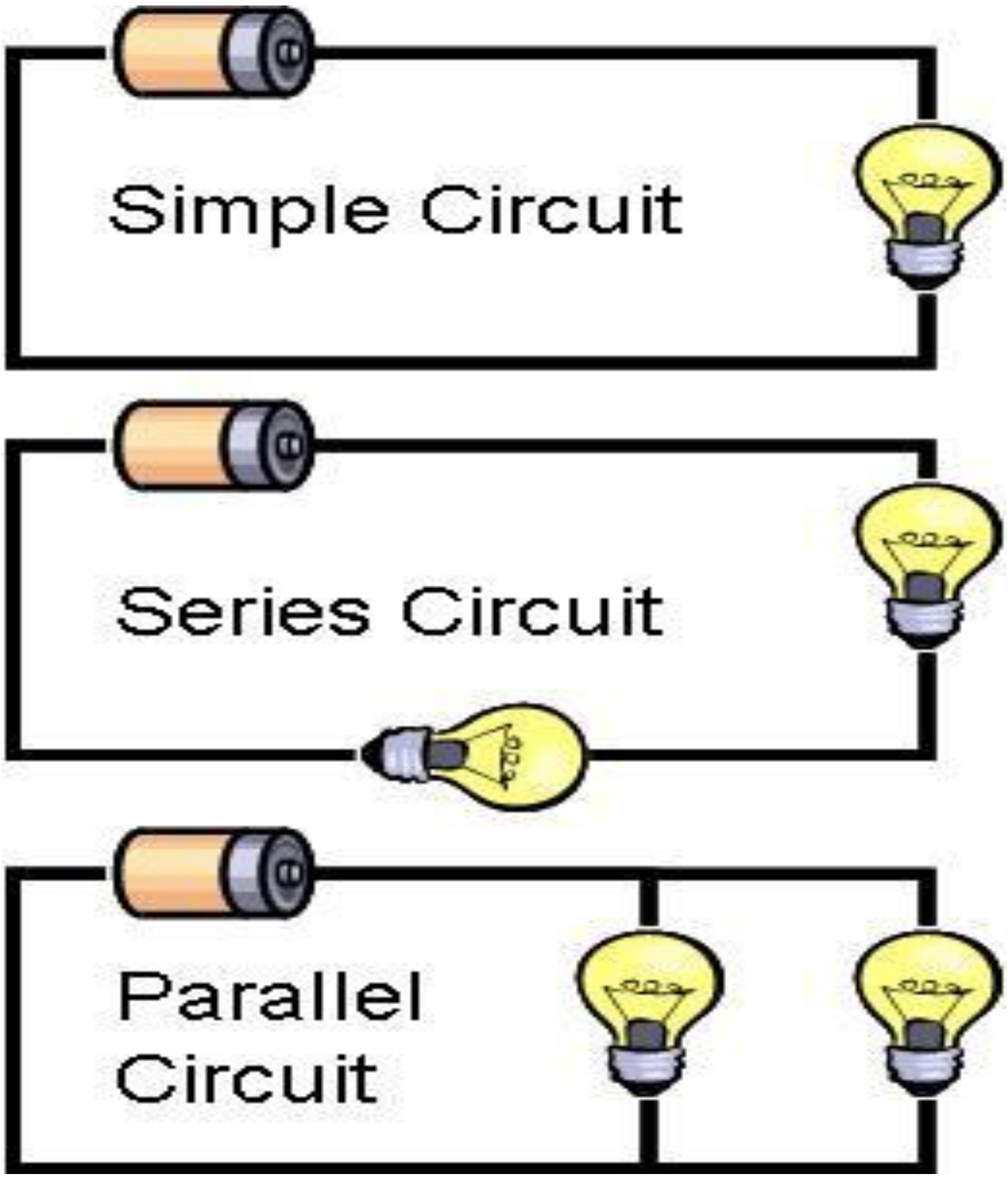
Science 9

Unit 4 : Section 2 – Current Electricity

Topic 5 : Studying Series and Parallel Circuits

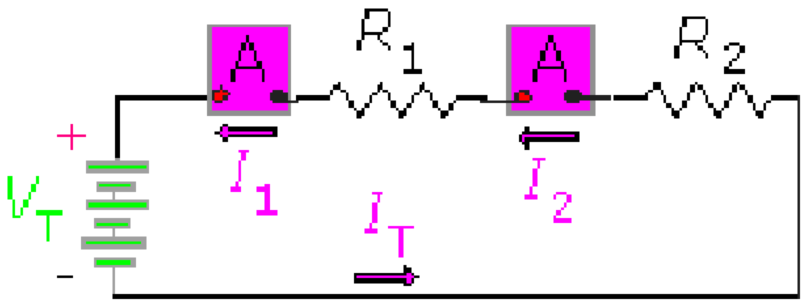


TYPES OF CIRCUITS



Current in a Series Circuit

In a series circuit, the current is the same everywhere in the circuit.

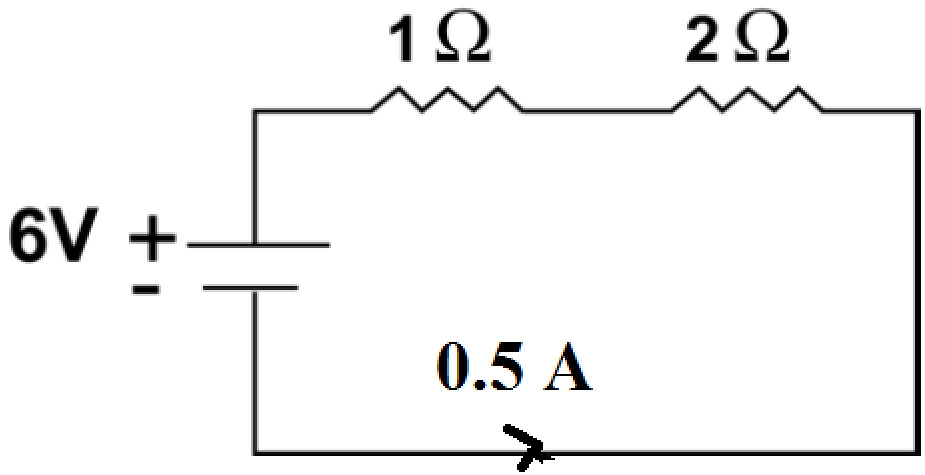


Series (a single path)

Same current passes through every element of a series circuit

Example : Current In a Series Circuit

A current of 0.5 A leaves the negative terminal of the battery.



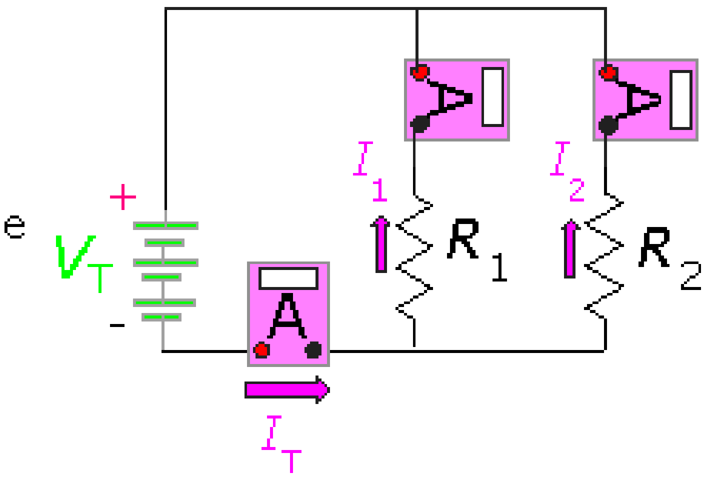
What amount of current:

(A) Passes through the 2 Ω resistor?
(B) Passes through the 2 Ω resistor?
(C) Returns to the battery?

Current in a Parallel Circuit:

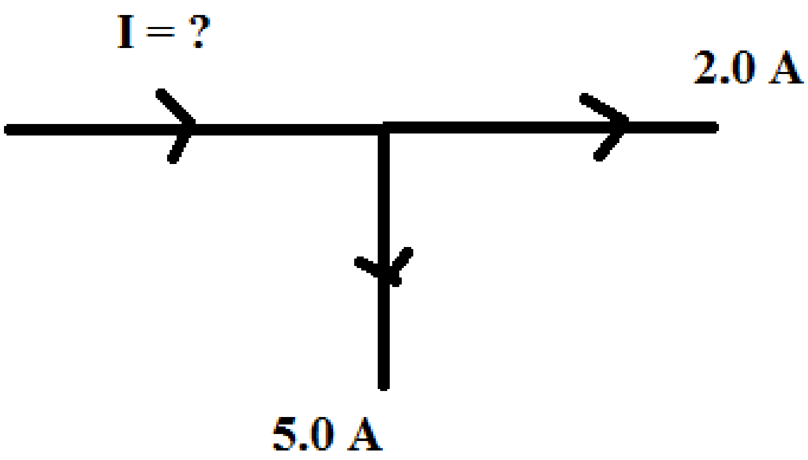
The current entering any junction is the same as the current leaving the junction.

$I_T = I_1 + I_2 + \dots .$



Example : Current In a Parallel Circuit

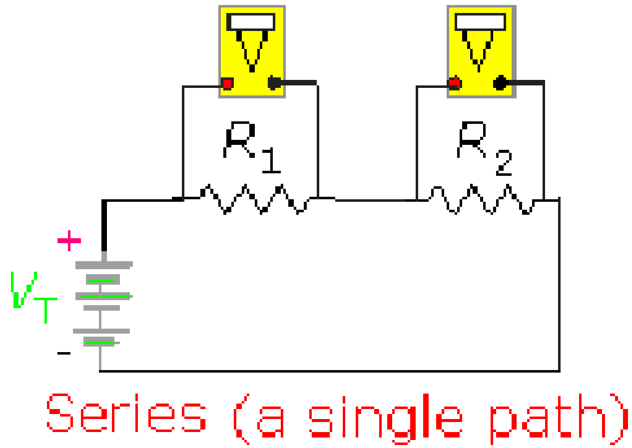
What is the value of I?



Voltage in a Series

The sum of the voltage gains (battery) must equal the sum of the voltage lost

.



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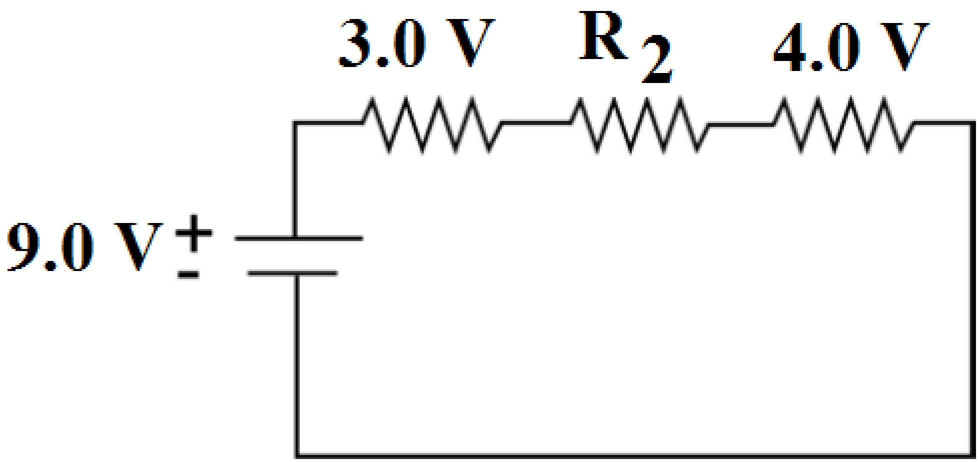
$$V_T = V_1 + V_2$$

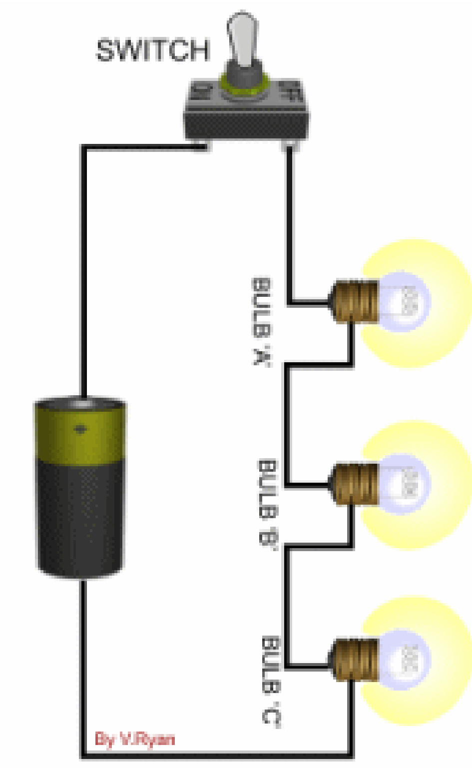
Example : Voltage in Series

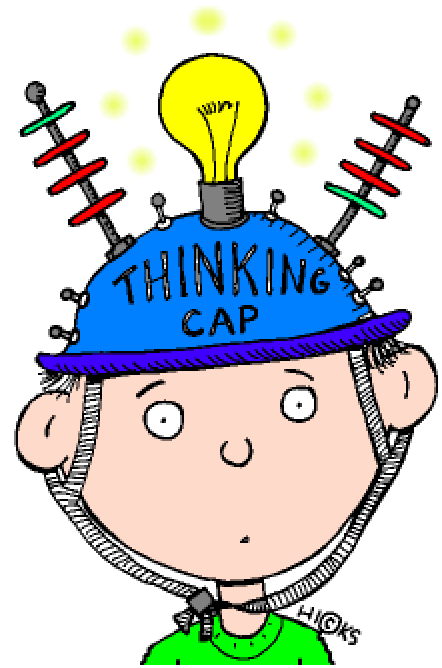
What is the voltage of R_2 ?



Question

The picture below is of a series circuit. What happens to the brightness of the bulbs, if more bulbs are added to the circuit?

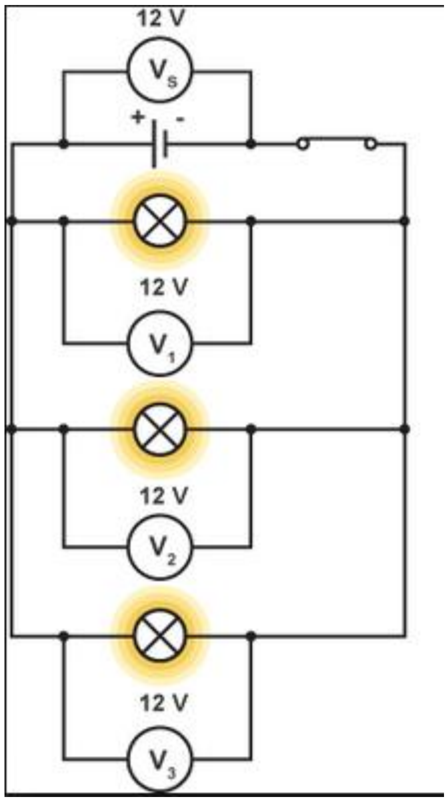




Voltage in Parallel

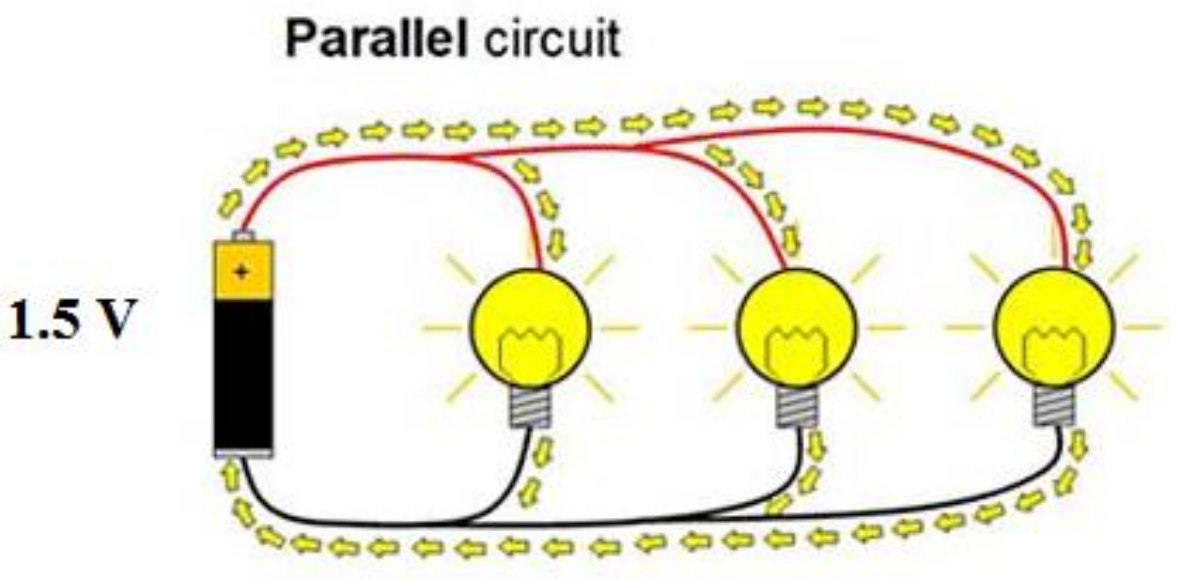
Voltage loss is the same across all components

.



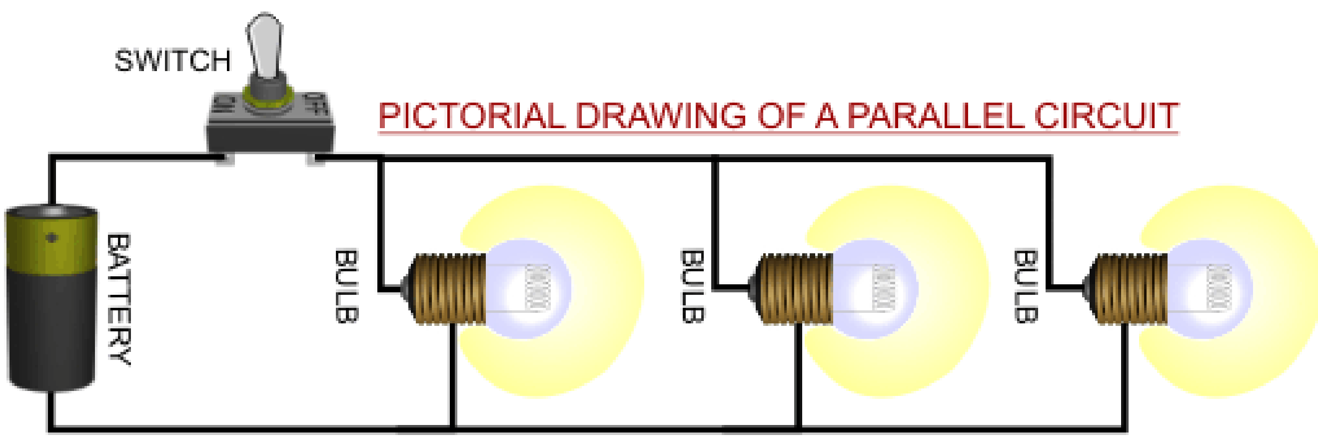
Example : Voltage in Series

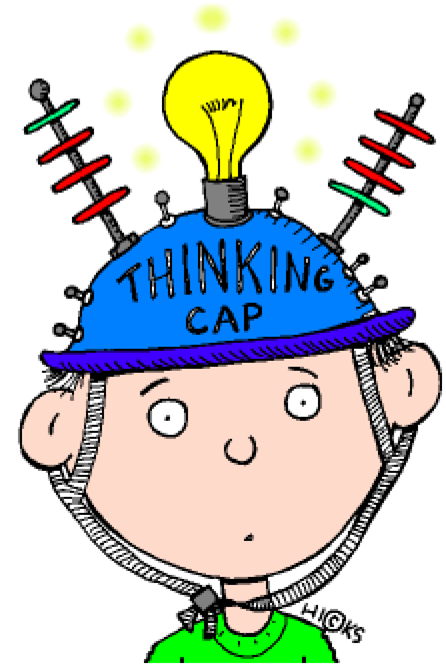
What is the voltage for each bulb?



Question

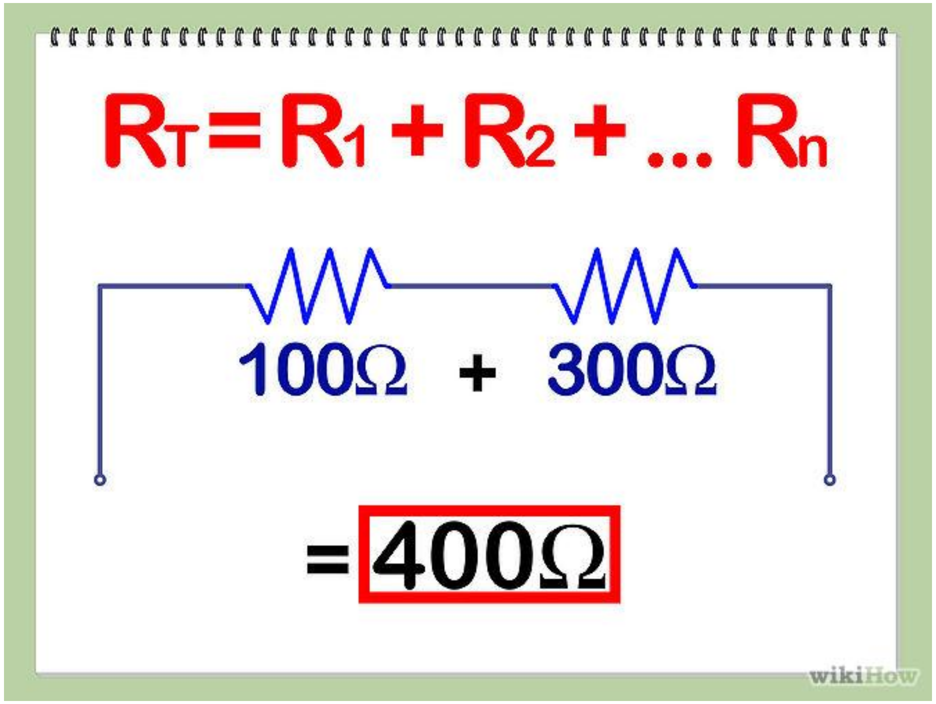
The picture below is of a parallel circuit. What happens to the brightness of the bulbs, if more bulbs a to the circuit in parallel?





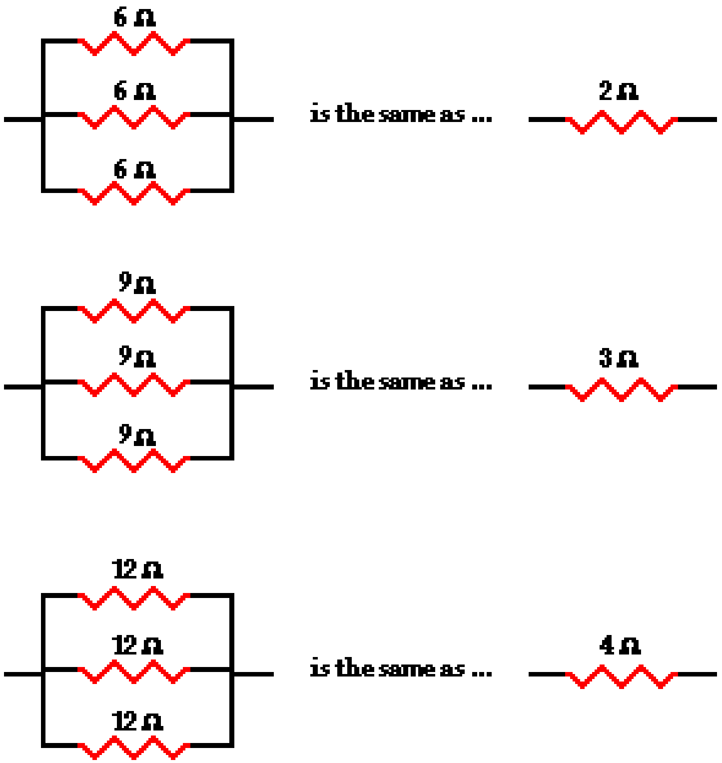
RESISTANCE IN SERIES

In a series circuit, resistance is increased as more loads or resistors are added.



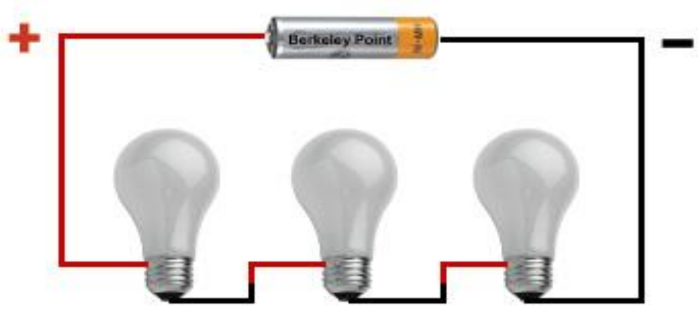
RESISTANCE IN PARALLEL

In a parallel circuit, resistance is decreased as more loads or resistors are added.



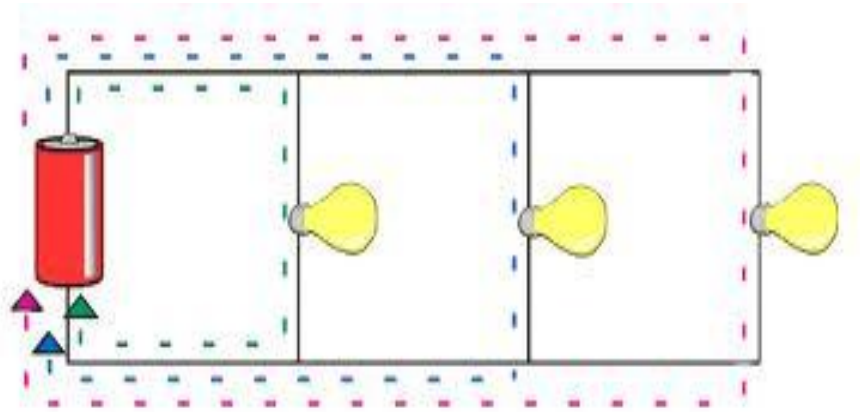
Series circuit

- Has a single loop for electrons to travel round
- Components are connected one after another
- Current has to travel through all components
- Current is the same at all points
- Voltage is shared between components
- Used in cheap Christmas lights



Parallel Circuit

- Has two or more paths for electrons to flow down
- Current is shared between the branches
- Sum of the current in each branch = total current
- Voltage loss is the same across all components
- Used in most electrical vehicle and household circuits.



SERIES VERSUS PARALLEL

Table 9.1 Series and Parallel Circuits

	Series Circuits	Parallel Circuits
Number of paths for electron flow	One	Multiple
Effect of removing a load from the circuit	Electrons cannot flow. (The circuit is broken.)	Electrons continue to flow through the remaining paths. (The circuit is not broken.)
Voltage (potential) drop	The sum of the voltage lost in the loads or resistors in the *entire* circuit equals the total voltage supplied by the battery.	The sum of the voltage lost in the loads or resistors in *each branch* of the circuit equals the total voltage supplied by the battery.
Current	• The current is the same throughout the circuit. • The current is dependent on the total resistance in the circuit.	• The total current entering or leaving a junction point is equal to the sum of the current in the individual paths. • The current in each of the paths is dependent on the total resistance in that path.
Resistance	• The total resistance of the circuit is increased when resistors or loads are added in series, since the total resistance is the sum of the resistances of each of the resistors or loads. • When the total resistance is increased, the overall current will decrease, since $V = IR$.	• The total resistance of the circuit is decreased when resistors or loads are placed in parallel. • When the total resistance is decreased, the overall current will increase, since $V = IR$.
Connecting cells to form a battery	• When cells are connected in series, the effective voltage is the sum of the voltages of each of the cells. • The maximum overall lifespan of the battery is the same as the lifespan of each of the individual cells.	• When cells are connected in parallel, the effective voltage is the same as the voltage of a single cell. • The maximum overall lifespan of the battery is the sum of the lifespan of each of the cells combined.

Student Activity

Allow students to construct series and parallel circuits