Unit 5 Electricity

Section 2 Electric circuits

Objectives:

1) List the components of an electric circuit.

2) Introduce charges.

3) Differentiate between current and voltage.

4) Differentiate between AC and DC power.

5) Differentiate between the different types of connections.

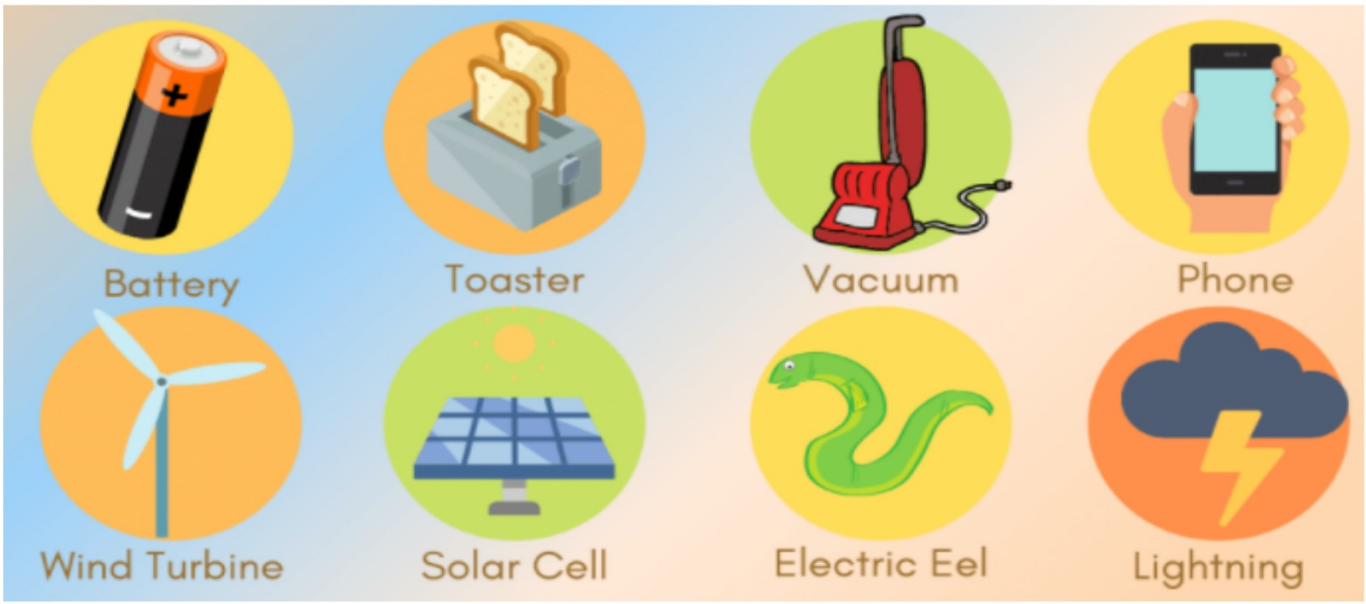
6) Understand how DC voltage and current are measured.

7) Apply the laws of uniqueness and addition.

Outline of the Session

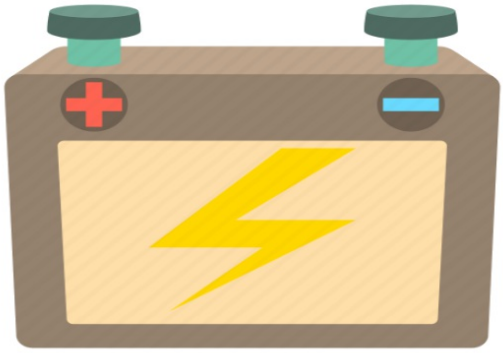
1- Main elements of an electric circuit
2- Electric current
3- Quantity of charge
4- Exercises
5- AC Versus DC

Real-life Examples



What would the world be like without electricity?

1- Circuit Components



Battery or Generator

- What is the role of batteries?

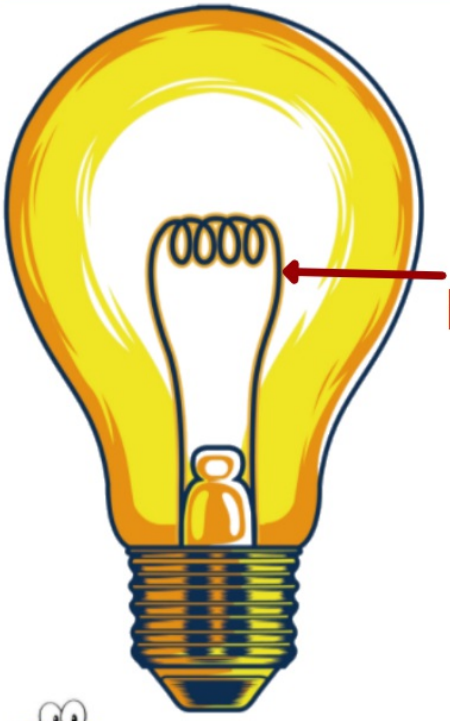
→ Batteries supply the electric current necessary for the operation of devices found in an electrical circuit.

- How many terminals does a battery have?

→A battery has two terminals:

- Positive terminal (+)
- Negative terminal (-)

1- Circuit Components



2 Incandescent Lamp or Load

- The lamp consumes electrical energy & converts it to which other type of energy?

→ Light Energy

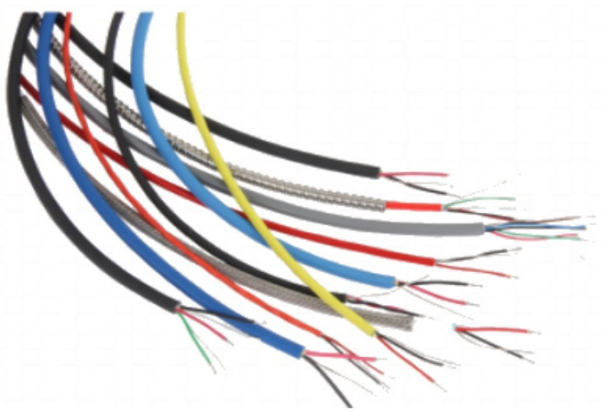
- How does the lamp glow?

→ Electricity heats up the filament to the point where it starts glowing.

- Why doesn't the filament melt on heating?

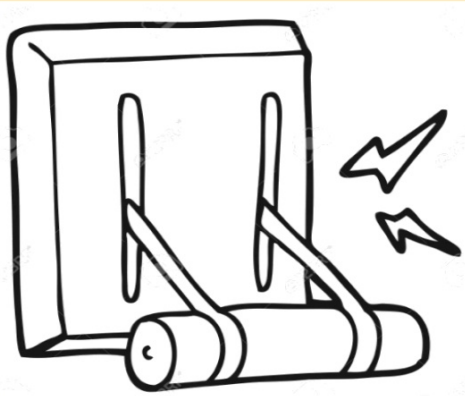
→Filaments are usually made up of Tungeston that has a high melting point ~ 3422^0C.

1- Circuit Components



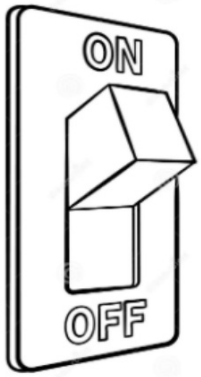
Connecting Wires

1- Circuit Components



- What is the function of a switch?

→ A switch controls current flow.



Switch

1- Circuit Components | Schematic Diagram

Recall the 4 main components of an electrical circuit and draw their symbols.

Battery

+ -

Lamp

Connecting Wires

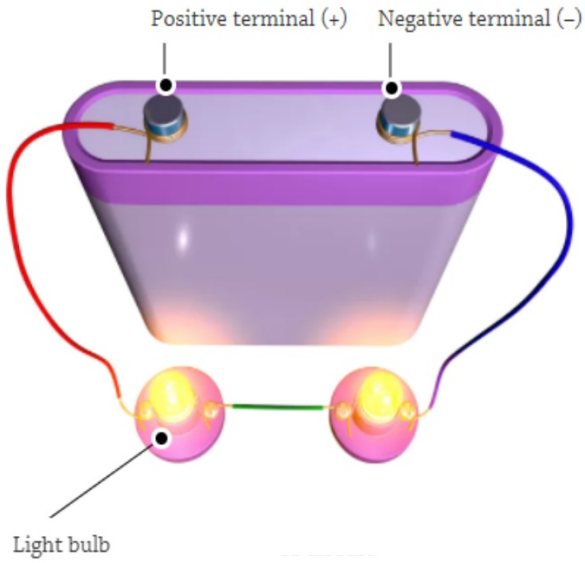
Switch

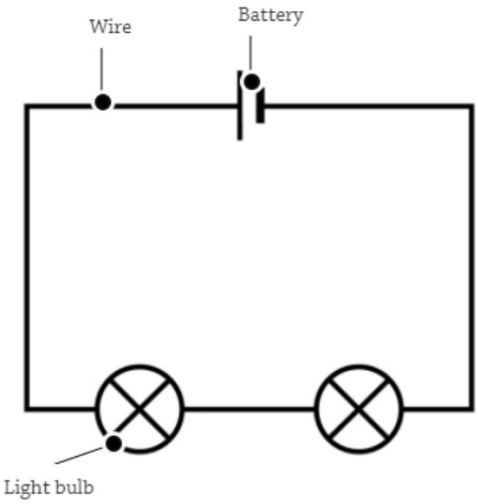
Open

Closed

1- Circuit Components | Schematic Diagram

Represent the electrical circuit below by a schematic diagram.





2- Electric Current Vs. Voltage

Electric current is the flow of charges through a conductor per unit time.

Symbol: I
SI Unit: Ampere A

e.g. If the electric current flowing is 3 Amperes, we write

Current = 3 Amperes
I = 3A

2- Electric Current Vs. Voltage

What keeps the electric charges flowing?

It is common knowledge that water and electricity don't mix very well!

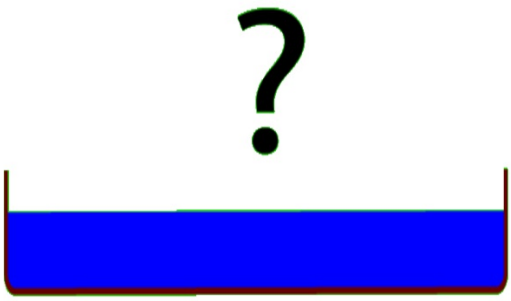
However, it is useful to first understand the behavior of water and then use it to understand electricity.

2- Electric Current Vs. Voltage | Analogy

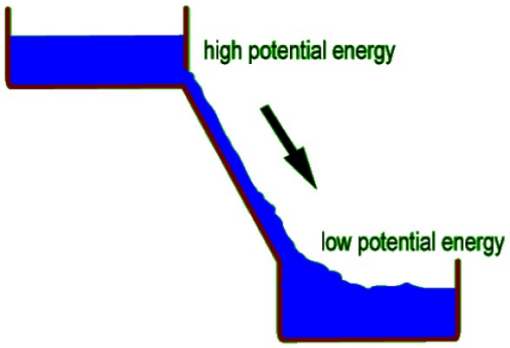
How much does it cost to buy a waterfall?

Waterfall Costs by Size

Size of Waterfall	Average Cost
Small **(Up to 3 square feet)**	**$100 - $1,000**
Medium (Up to 12 square feet)	$250 - $10,000
Large (Over 12 square feet)	$1,000 - $20,0000



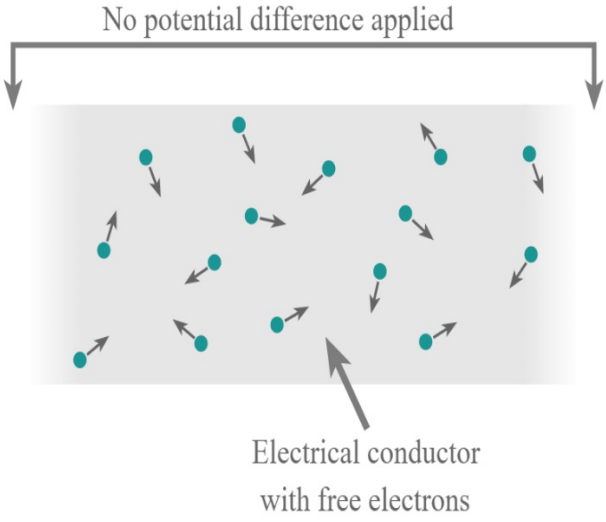
Why isn't water flowing?

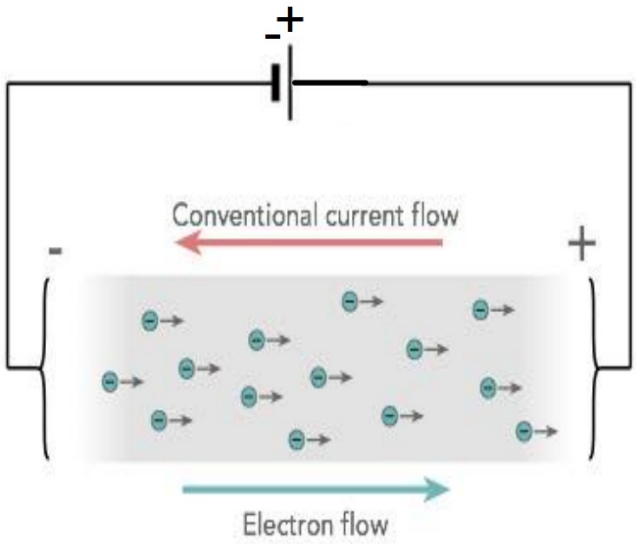


There needs to be a gravitational potential energy difference.

2- Electric Current Vs. Voltage

Similarly:



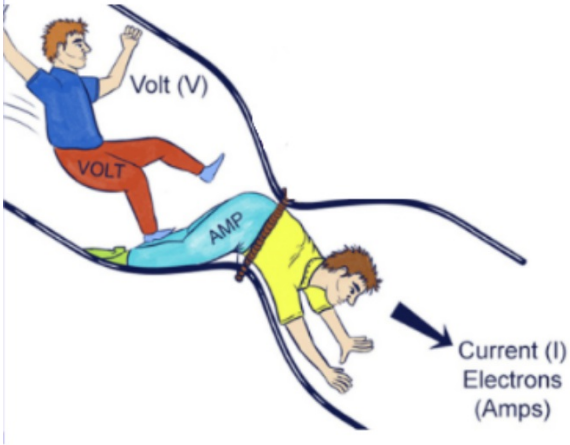


-Electrons flow from the negative to the positive terminal.

-Current flows from the positive to the negative terminal.

2- Electric Current Vs. Voltage

Voltage (Potential Difference) is the difference in electric potential energy between two points. It is an electrical force that causes charges to move in a closed path.

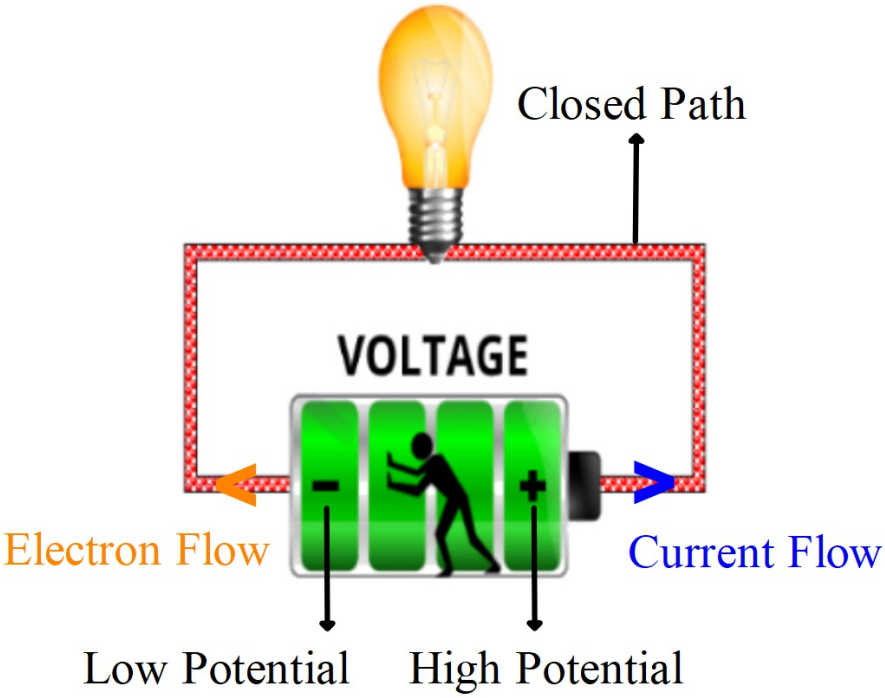


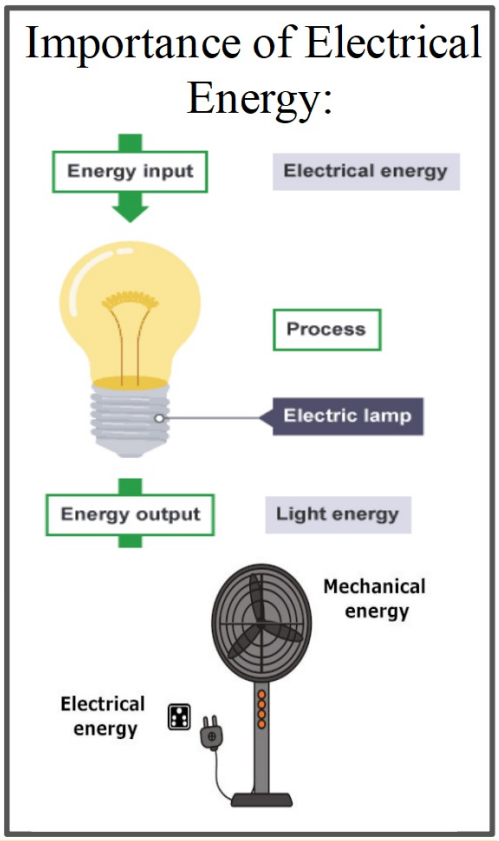
Symbol: V
SI Unit: Volts V

e.g. If the voltage is 3 Volts, we write

$V = 3V$

2- Electric Current Vs. Voltage | Wrap up

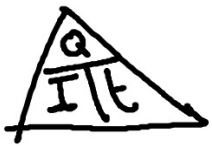




3- Charges

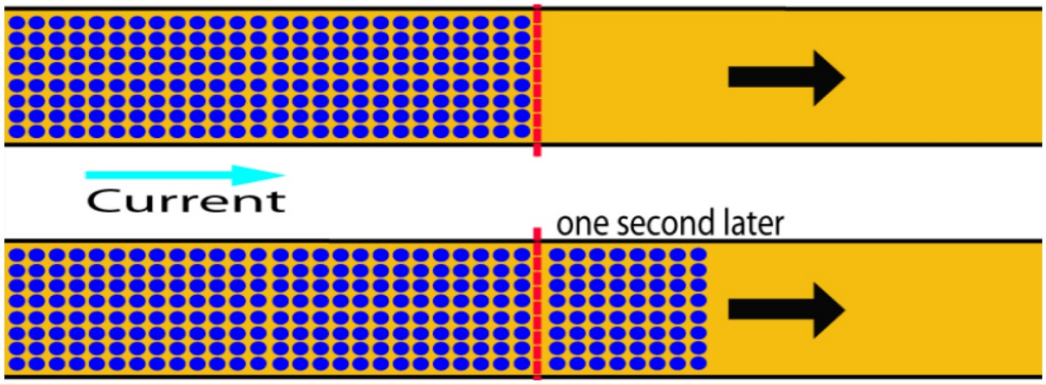
Recall: Current is the flow of charge.
We measure current by counting the amount of charge passing through a boundary in one second.

$$\text{Current } I = \frac{\text{quantity of charge}}{\text{time taken } t}$$



$$I = \frac{Q}{t}$$

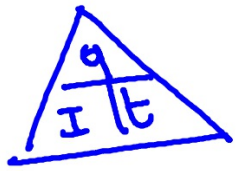
in Ampere A ← I | Q → in Coulombs C | t → in seconds s



3- Charges | Practice Problems

Application 1:

A charge of 12 C flows past a given point in the time Δt. If the current produced by the charge is 0.15 A, what is Δt?



$t = \frac{q}{I}$

$= \frac{12}{0.15} = 80s$

I = Q/t

t = Q/I = 12C/0.15A = 80s

Application 2:

A battery with an emf of 1.5 V delivers a current of 0.44 A to a flashlight bulb for 64 s (see Figure 21.3). Find the charge that passes through the circuit

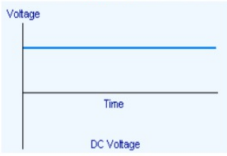
I = Q/t

Q = I x t = 0.44A x 64s = 28.16C

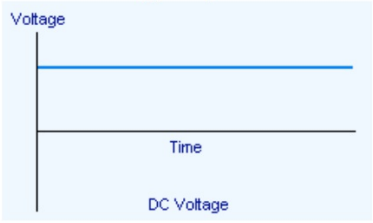
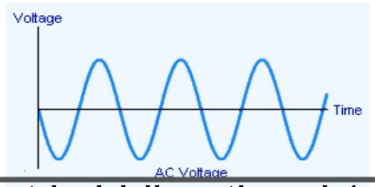
4- AC Versus DC Activity 15 mins

Watch the video below (0:00-1:22|2:05-2:27) to sort the statements below in the correct column.

https://www.youtube.com/watch?v=tJSga2YamDc

Caused by a DC voltage (e.i. batteries) whose value is fixed as shown in the graph below: 	Caused by an AC voltage (e.i. power stations) whose value varies periodically as shown in the graph below: 
Its production is costly	Its production is cheap
Not easily transmitted over large distances	Easily transmitted over large distances
Current is unidirectional (flows in one direction)	Current is bidirectional (alternates its direction periodically)

4- AC Versus DC

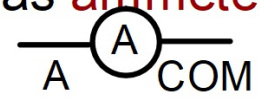
DC Current	AC Current
Caused by a DC voltage (e.i. batteries) whose value is fixed as shown in the graph below: 	Caused by an AC voltage (e.i. power stations) whose value varies periodically as shown in the graph below: 
Current is unidirectional (flows in one direction)	Current is bidirectional (alternates its direction periodically)
Its production is costly	Its production is cheap
Not easily transmitted over large distances	Easily transmitted over large distances

This year, we are interested in DC voltage.

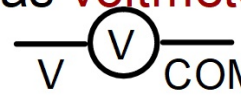
5- Measurements

The multimeter is a device that has several uses including:

- Measuring current - In this case, the multimeter is referred to as ammeter of symbol:

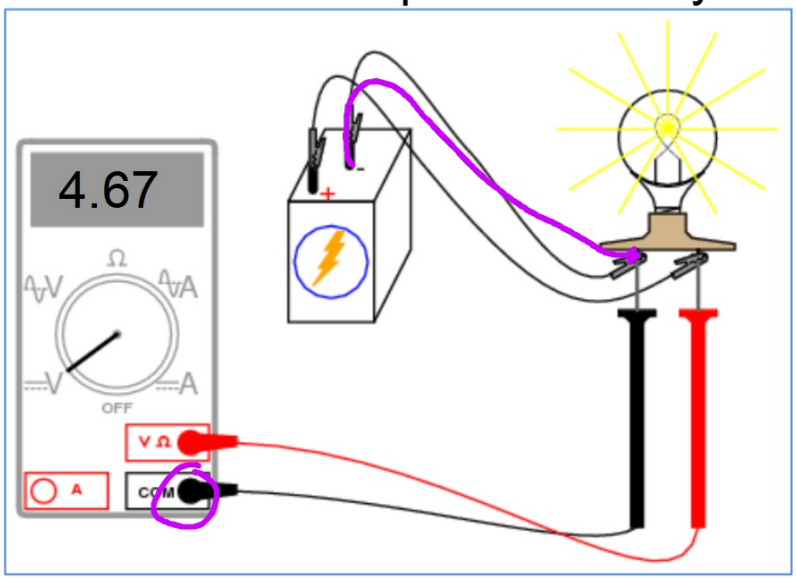


- Measuring voltage - In this case, the multimeter is referred to as voltmeter of symbol:

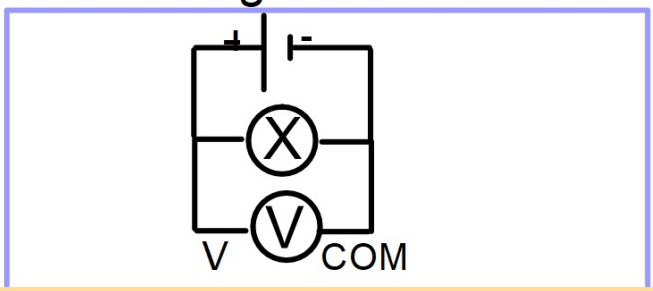


5- Measurements

Consider the circuit below composed of a dry cell, lamp and voltmeter:



1- Draw a schematic diagram of the above circuit.



5- Measurements

2- Is the voltmeter connected in series or in parallel with the dry cell?

The voltmeter is connected in parallel with the dry cell.

3- What does the displayed value 4.67V represent?

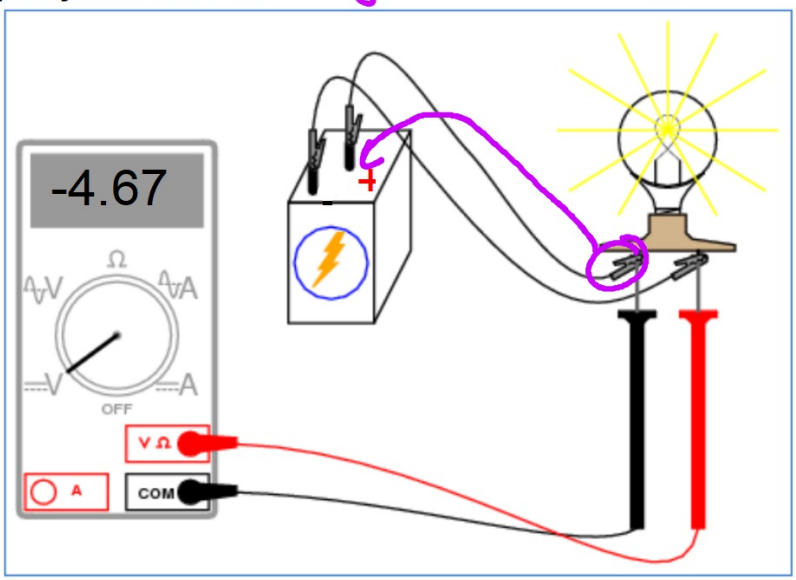
It represents the voltage across the dry cell.

4- Which terminal of the voltmeter is connected to the negative terminal of the dry cell? To the positive terminal of the dry cell?

The COM terminal is connected to the negative terminal of the dry cell while the V terminal is connected to the positive terminal of the dry cell.

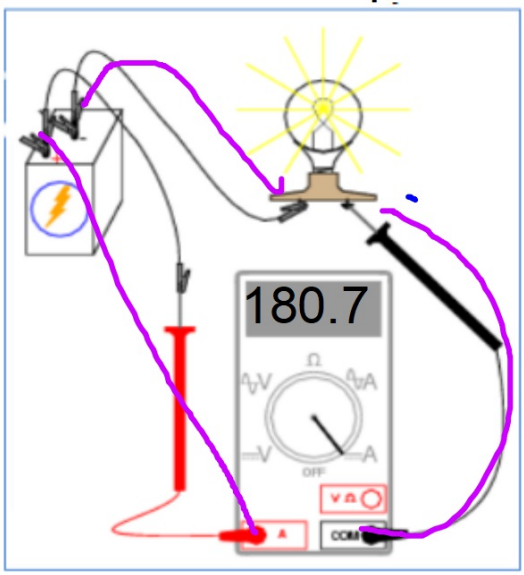
5- Measurements

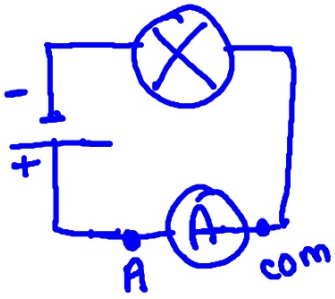
5- We reverse the connections of the voltmeter. What does the voltmeter display now? a negative value



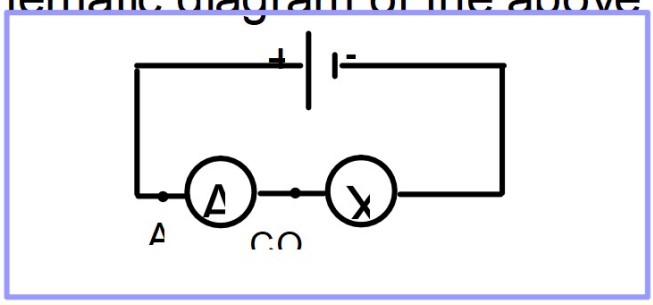
5- Measurements

Consider the circuit below composed of a dry cell, lamp and ammeter:





1- Draw a schematic diagram of the above circuit.



5- Measurel

2- Is the ammeter connected in series or in parallel with the dry cell and the lamp?

The ammeter is connected in series with the dry cell and the lamp.

3- What does the displayed value 180.7mA represent?

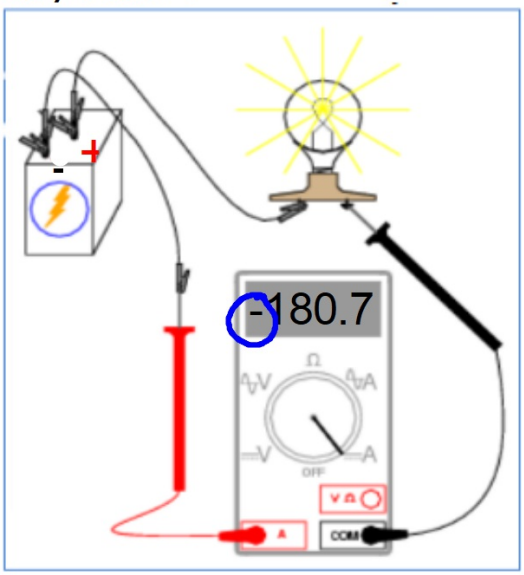
It represents the current flowing through the lamp.

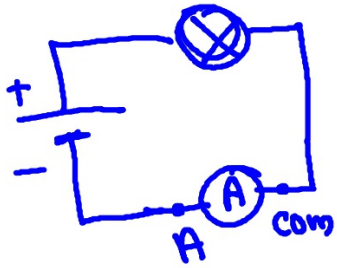
4- Which terminal of the ammeter is connected to the negative terminal of the dry cell? To the positive terminal of the dry cell?

The COM terminal is connected to the negative terminal of the dry cell while the A terminal is connected to the positive terminal of the dry cell.

5- Measurements

5- We reverse the connections of the ammeter. What does the ammeter display now?





The ammeter displays a negative current (-180.7mA).

5- Measurements | Wrap Up

A multimeter is a device that has multiple functions.

1) Acts as a Voltmeter → Reads voltage
   (Note: A voltmeter is connected always in parallel.)
2) Acts as an Ammeter → Reads current
   (Note: An ammeter is connected always in series.)

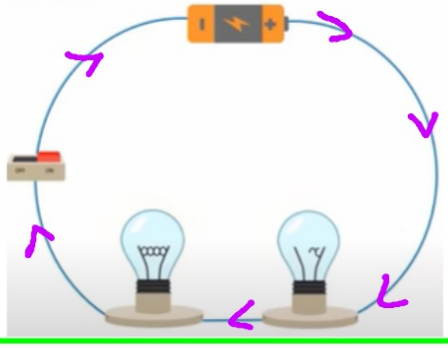
If the value displayed by the multimeter is positive →
The COM terminal of the multimeter is connected to the negative pole.

If the value displayed by the multimeter is negative →
The COM terminal of the multimater is connected to the positive pole.

6- Types of Connections | Brain Storming Strategy

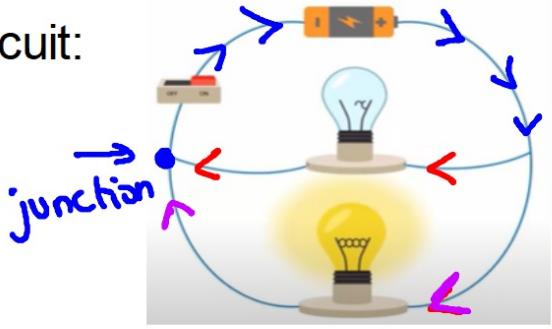
Series Circuit

- The components are connected end to end or one next to the other.
- A single loop is formed.
- A break in any part of the circuit stops the flow of current in the entire circuit. E.i. Decoration Lights
- Circuit:



Parallel Circuit

- The components' terminals are connected to each other.
- More than one loop is formed.
- A break in one loop of the circuit doesn't affect the flow of current in the other loops.
- There are junctions
- Circuit:



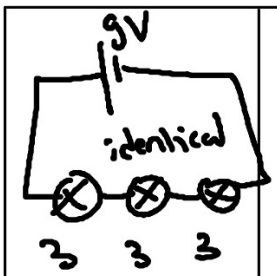
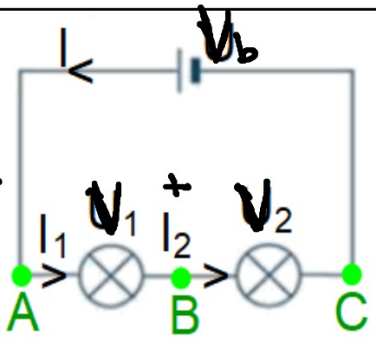
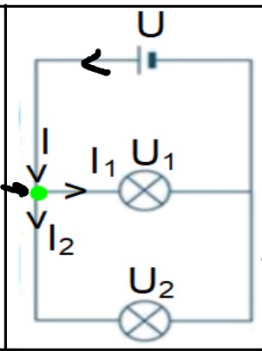
https://www.youtube.com/watch?v

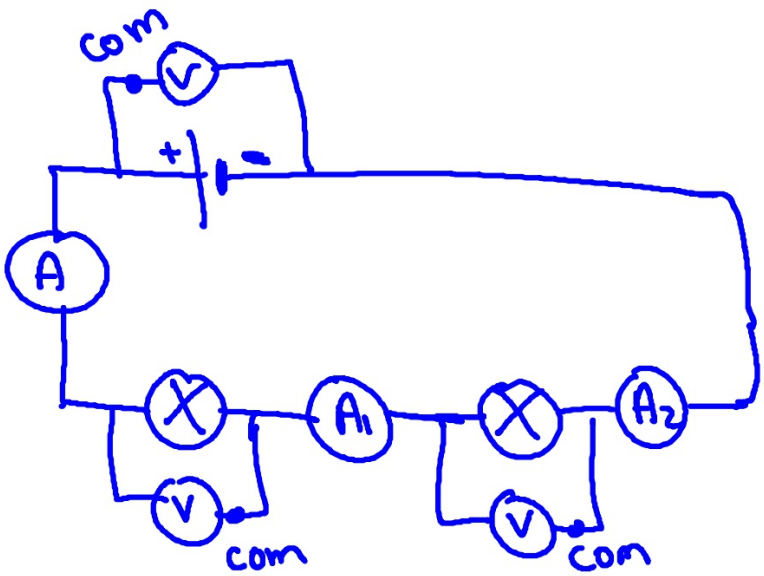
6- Types of Connections

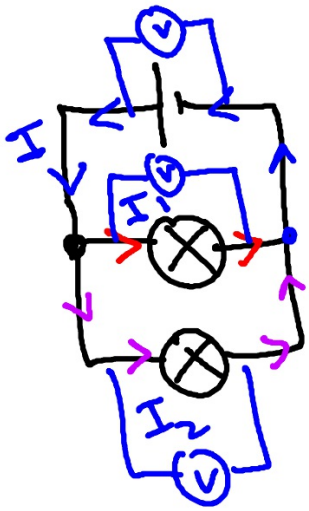
https://phet.colorado.edu/sims/html/circuit-construction-kit-dc-virtual-lab/latest/circuit-construction-kit-dc-virtual-lab_all.html

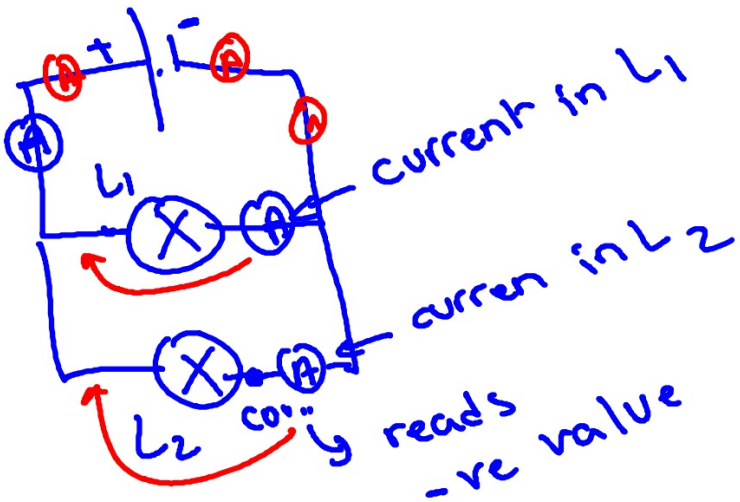
- Build a series circuit with battery and two lamps
- connect an ammeter in series with Lamp 1
  - " " " " L2
  - what do you conclude

6- Types of Connections

	 **Series**	 **Parallel** I = 10A 10 lamps (I_L = 1) $I_1 = I_2 = \frac{I}{2}\left(\frac{I}{n}\right)$
Current	Law of Uniqueness $I = I_1 = I_2$	Law of Addition $I = I_1 + I_2$
Voltage	Law of Addition $V = V_1 + V_2$ if lamps are identical $V_1 = V_2 = \frac{V}{2}$ $\left(\frac{V}{\text{number of lamps}}\right)$	Law of Uniqueness $U = U_1 = U_2$


Com
V
+
-
A
X
A1
X
A2
V
com
V
com


V
I
A
I_1
I_2
V


+
-
A
A
A
A
L_1
L_2
current in L_1
curren in L_2
reads
-ve value

6- Types of Connections | Exercises

Calculate the intensity of the current I_3 in the figures below :

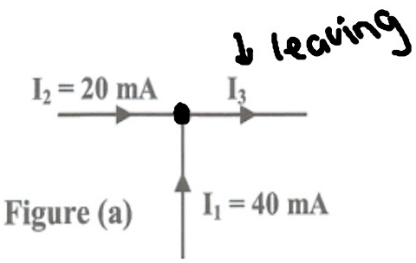


Figure (a)

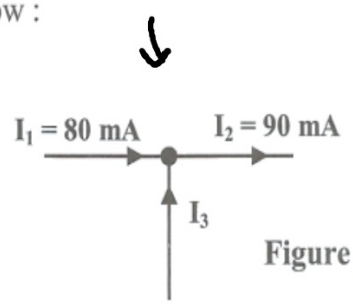


Figure (b)

↓ leaving

$\Sigma I_{entering} = \Sigma I_{leaving}$

$I_1 + I_2 = I_3$

$40 + 20 = I_3$

$I_3 = 60$ mA

↓

$I_1 + I_3 = I_2$

$80 + I_3 = 90$

$I_3 = 10$ mA

Notes:

the voltage across a connecting wire is zero

" " " a closed switch is zero

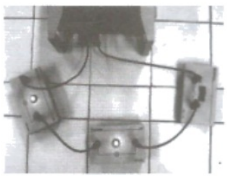
" " " an opened switch is <u>not zero</u>.

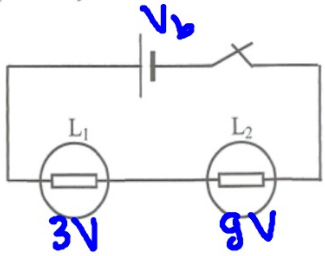
<u>No</u> current flows in an open circuit

6- Types of Connections | Exercises

Studying the voltage in a series circuit

Consider the electric circuit of the adjacent figure.
The voltages across L_1 and L_2 are respectively 3 V and 9 V.

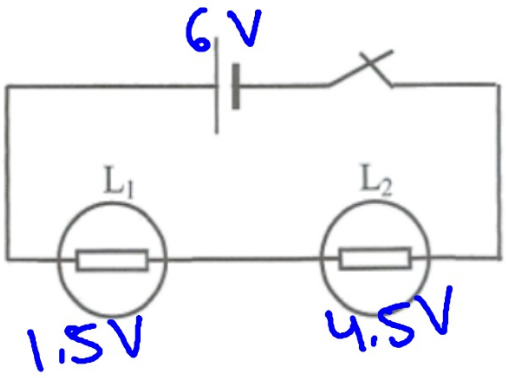




1) Name the instrument that is used to measure the voltage and indicate and indicate the type of its connection in the circuit. voltmeter - in parallel
2) Determine, while mentioning the used laws, the voltage across the terminals of the battery.
3) The switch is opened. Give the values of the voltages across the battery and the lamps.
4) We replace the battery by another one of voltage 6 V and the switch is closed. Knowing that the voltage across L_2 is triple that across L_1. Calculate the voltages across L_1 and L_2.

2) $V_b = V_1 + V_2 = 3 + 9 = 12$ (law of addition of voltages in series connection)

3) $V_b = 12$ $V_{L_1} = 0$ $V_{L_2} = 0$



$V_{L_2} = 3V_{L_1}$

$V_b = V_1 + V_2$

$6 = V_1 + 3V_1$

$6 = 4V_1$

$V_1 = 6/4 = 1.5V$

$V_2 = 3 \times 1.5 = 4.5$

6- Types of Connections

Studying the intensity of the current in a series circuit

We consider the electric circuit in the previous exercise.

1) The switch is open. Give the value of the intensity of the current delivered by the battery.

2) The switch is closed. The battery delivers a current of intensity 0.3 A.

a) Name the instrument that is used to measure the intensity of the current and indicate the type of its connection in the circuit.

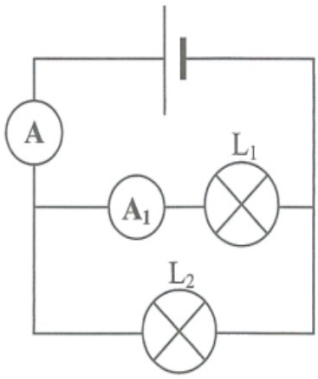
b) Represent on the figure, the direction of the electric current in the circuit.

c) Give, listing the laws used, the intensities of the currents in the lamps.

6- Types of Connections

Study of a parallel circuit

We consider the electric circuit in the adjacent figure:



The battery delivers a voltage of 6 V.

The ammeters A and A_1 indicate 600 mA and 280 mA respectively.

1) Represent on the figure, the direction of the electric current in the different branches of the circuit.
2) Place in the electric circuit an ammeter A_2, which measures the intensity of the current in L_2.
3) Determine the intensity of the current in the lamp L_2.
4) Find the voltages across the terminals of the lamps.