Chapter #4

Electric current & circuits

We will discuss:-

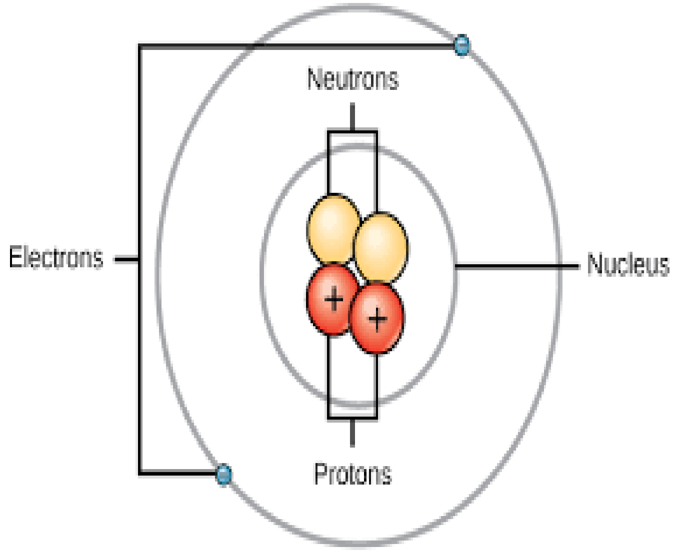
- Electric charges.
- The flow of charges.
- How charges interact.
- Electricity , circuit, current ,electricity, repulsion and attraction.
- Capacitance.
- Medical use of capacitors.
- Potential difference (voltage)
- Power
- Conventional current direction.
- Resistance.
- Ohm’s law.
- Series and parallel circuits.
- Capacitors in series and parallel.

Electric charges.

- The atom is made up of three main parts:-

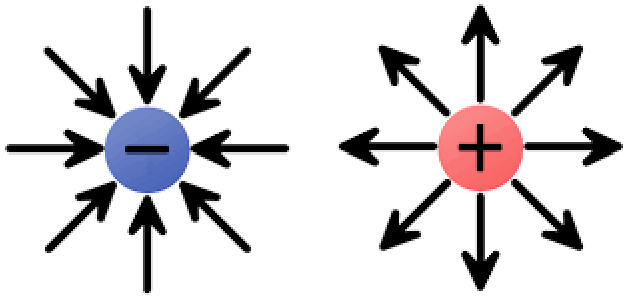
Protons, neutrons and electrons.

Protons	Neutrons	Electrons
Positive +	Neutral	Negative -



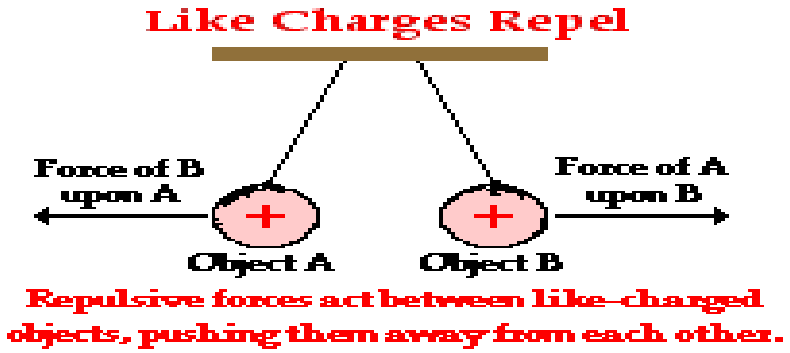
The flow of charges.

- Electrons :The subatomic particle which can move from one object to another.
- The object will be Negatively charged when we add electrons to the object.
- The object will be positively charged when we remove electrons from the object.

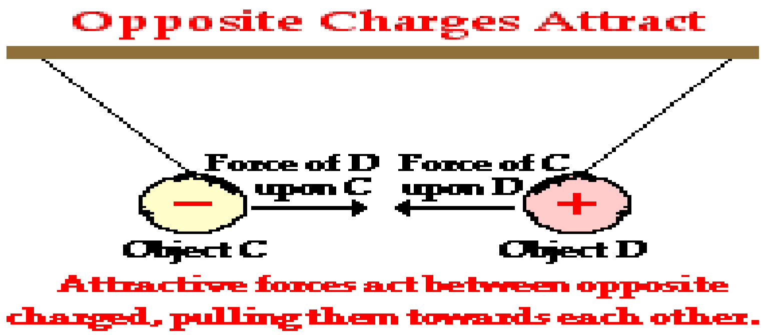


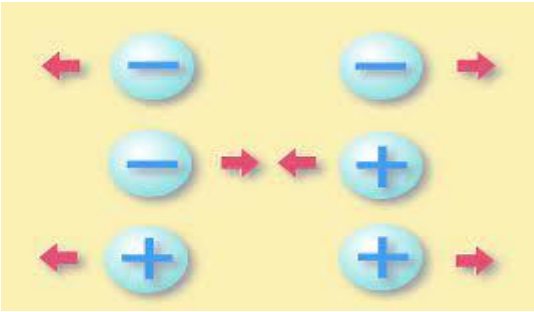
How charges interact?

- When two objects with same charge come into contact they will repel .



- When two objects with different charges come into contact they will attract.





How charges interact?

Coulomb's Law – Gives the electric force between two point charges.

$$F = k\frac{q_1 q_2}{r^2}$$

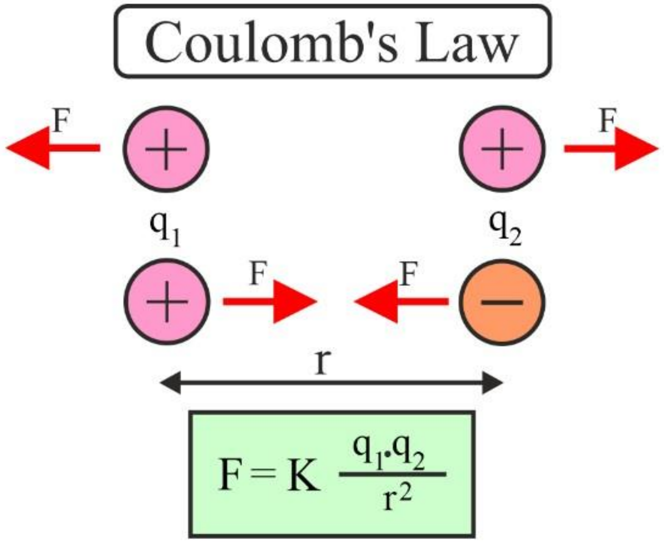
Inverse Square Law

k = Coulomb's Constant = $9.0\times10^9\ Nm^2/C^2$

q_1 = Point charge -1

q_2 = Point charge - 2

r = the distance between the two charges



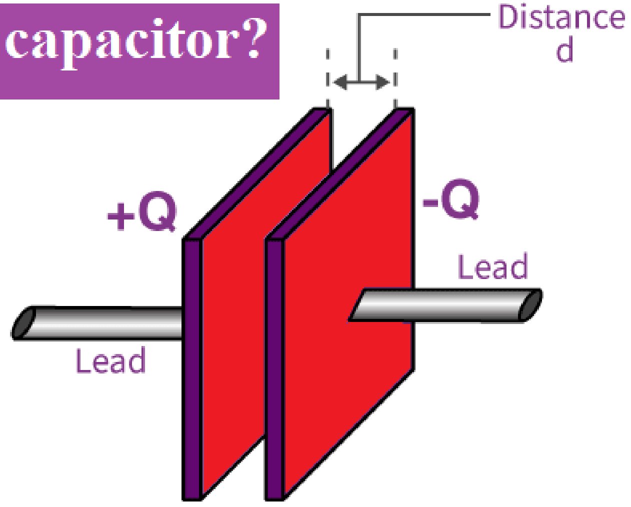
Definition.

- Electricity : a form of energy .
- Circuit: a continuous path through which electrons can flow.
- Current electricity: the study of charge that move
- Repulsion :is the movement away from each other.
- Attraction: is the movement towards each other.
- Static electricity : is the study of charges that do not move.

Capacitance.

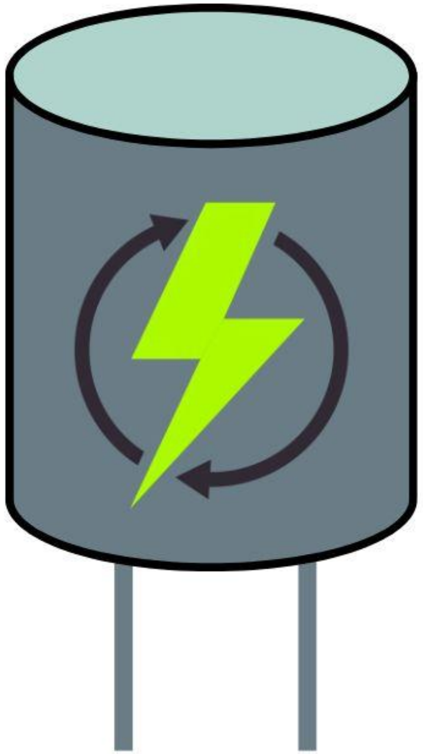
- Capacitor: electric device for storing charge.
- The symbol of charge (Q) , it measured in units called coulombs (C).
- The charge can be positive or negative .

What is capacitor?



Parallel Plate Capacitor

Capacitance.



CAPACITANCE

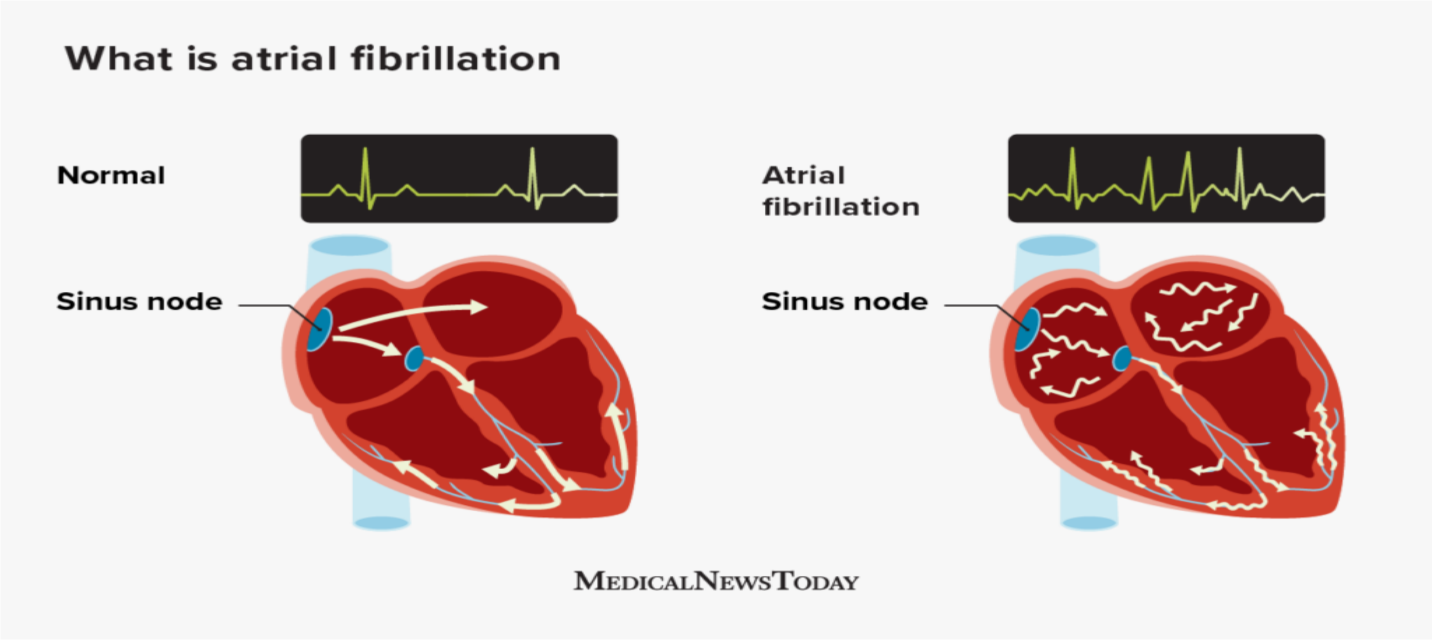
CAPACITANCE IS A FUNDAMENTAL ELECTRICAL PROPERTY THAT MEASURES THE ABILITY OF A CAPACITOR TO STORE ELECTRICAL CHARGE. IT IS DENOTED BY THE SYMBOL "C" AND IS MEASURED IN UNITS CALLED FARADS (F).

The medical use of capacitors

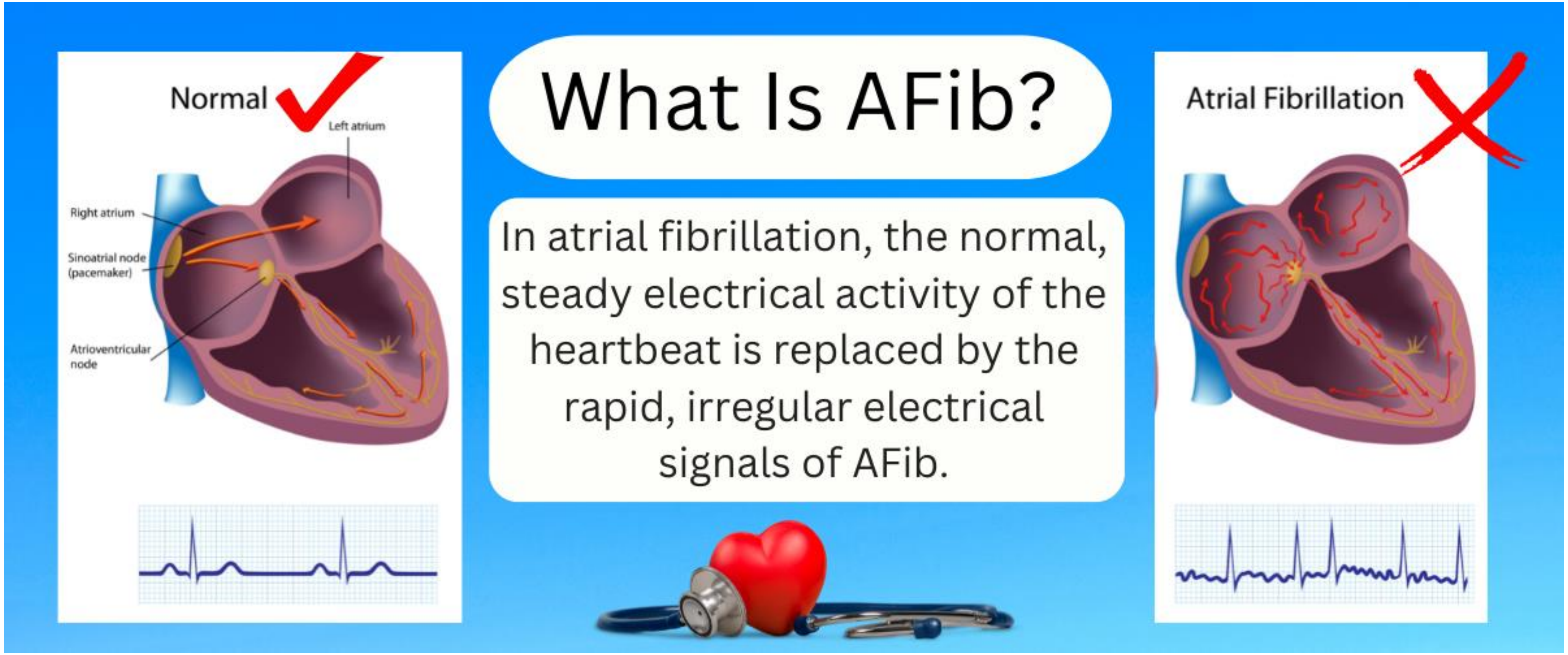
- A defibrillator machine is a medical device that uses a single very large capacitor
- This machine gives a patient an electric shock across his heart.
- The shock stops the heart beating erratically (fibrillation)

What is fibrillation?

- Atrial fibrillation (also called AFib or AF) is an irregular heartbeat (arrhythmia) that can lead to blood clots, stroke, heart failure and other heart-related complications.



What is fibrillation?

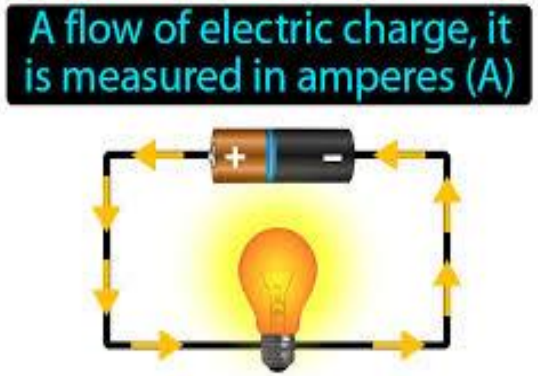


Defibrillation

- Defibrillation: is the process in which an electronic device sends an electric shock to the heart to stop an extremely rapid, irregular heartbeat and restore the normal heart rhythm.
- Defibrillators can also restore the heart's beating if the heart suddenly stops.
- Defibrillators help to stop fibrillation.

Electric current .

- Electric current : is a flow of charged particles.
- Symbol : I
- The SI unit of electric current is ampere (A)
- Formula : $I = \frac{q}{t}$= Coulomb / sec=C/s= 1 amp
- Where q is the charge , t is the time



Example 1

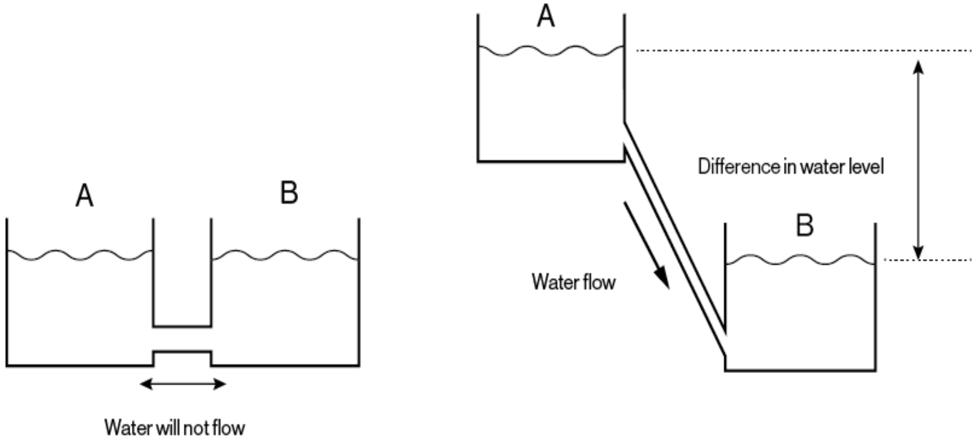
- if a current of 80mA exists in a metal wire , how many electrons flow past a given cross-section of the wire in 10 minutes ?

Potential difference (Voltage)

- When a point charge q moves from point A to point B, it moves through a potential difference
- The potential difference is the change in electric potential energy per unit charge.
- Voltage describes the “pressure” that pushes electricity. The amount of voltage is indicated by a unit known as the volt (V), and higher voltages cause more electricity to flow to an electronic device. However, electronic devices are designed to operate at specific voltages; excessive voltage can damage their circuitry.

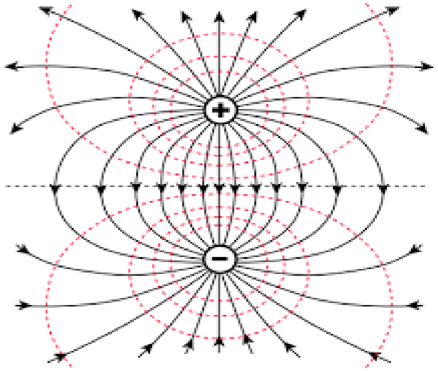
Potential difference (Voltage)

- Electricity flows as a current. You can imagine it as a flow of water, like in a river. The water in rivers flows from mountains upstream to the ocean downstream. In other words, water flows from places with a high water height to places with a low water height. Electricity acts similarly: the concept of water height is analogous to electric potential, and electricity flows from places with high electric potential to places with low electric potential.



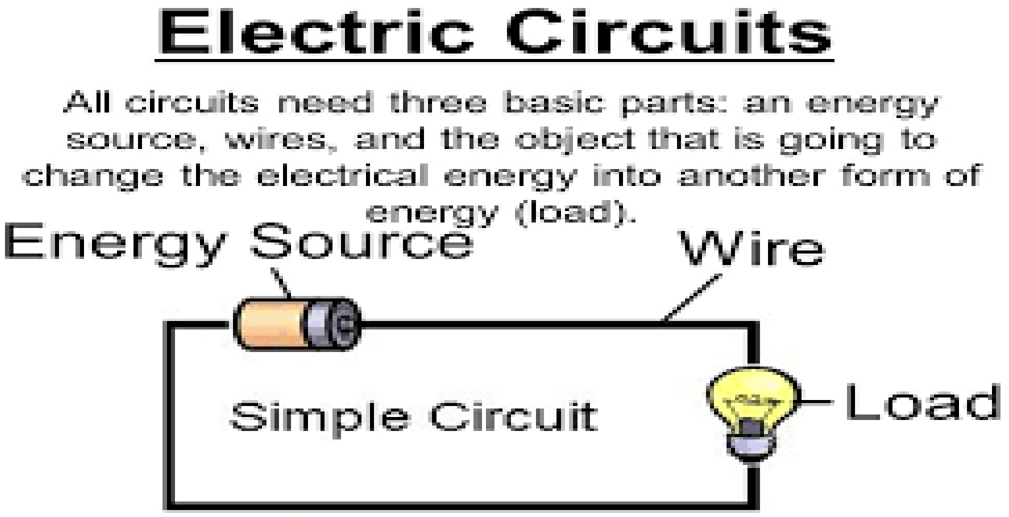
Potential difference (Voltage)

- Formula : $V = \frac{W}{Q}$=joules/coulomb =volts
- Batteries
- Outlets
- EKG : records the electrical signal from the heart to check for different heart conditions
- Equipotential lines: points at same potential.



Part of circuits

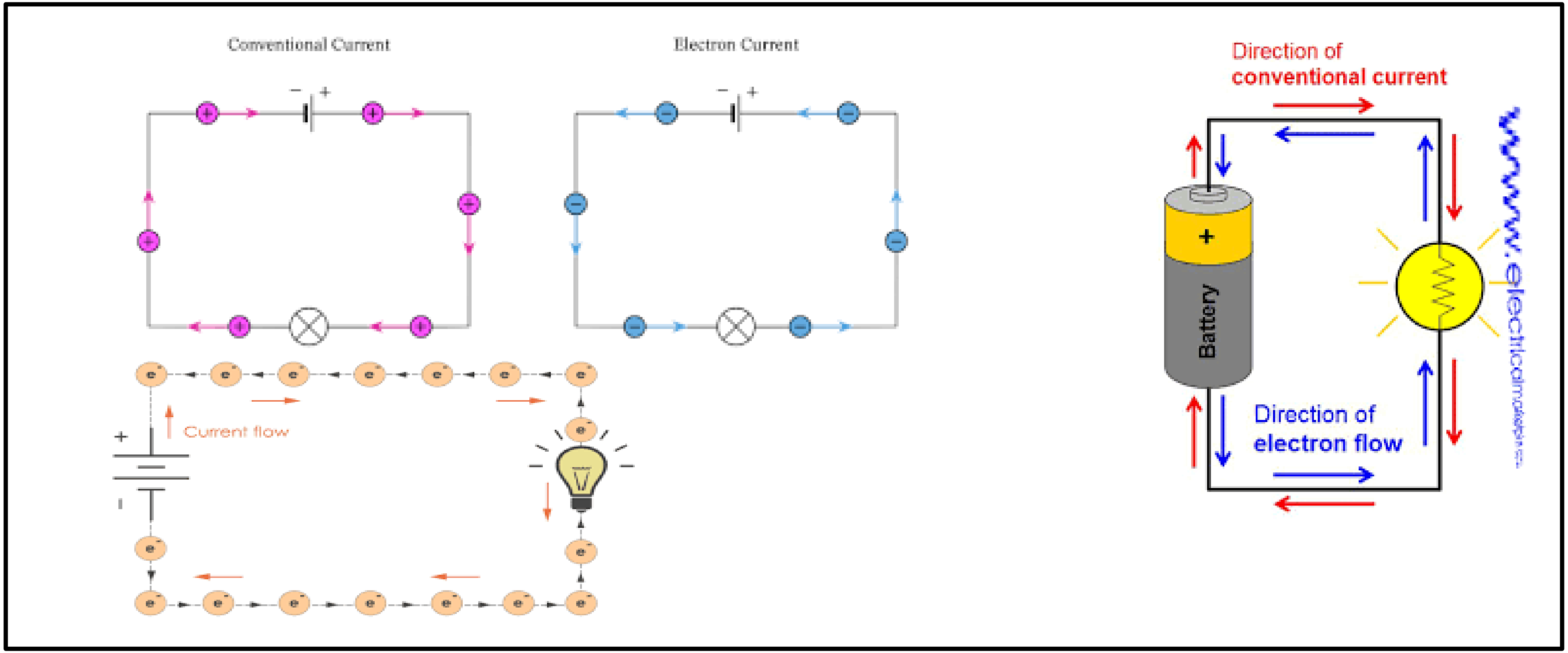
- Energy Source :circuit needs an energy source to push a charge through the circuit.
- Load : a device in a circuit that operates using electrical energy.



Power

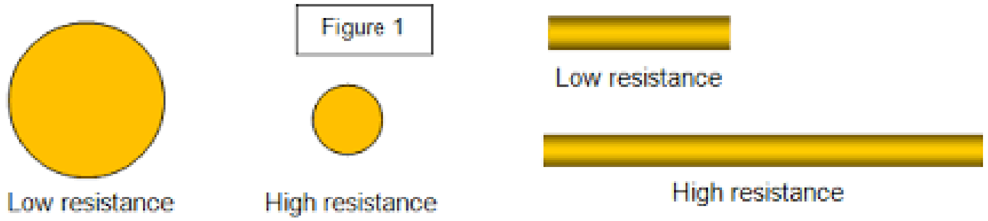
- Power : Electric power is the rate at which electrical energy is transferred by an electric circuit.
- Symbol: P
- Formula :P=$\frac{W}{t} = \frac{joule}{Second} = watt\ (W)$
- $P = IV$
- The SI unit of the power is watt

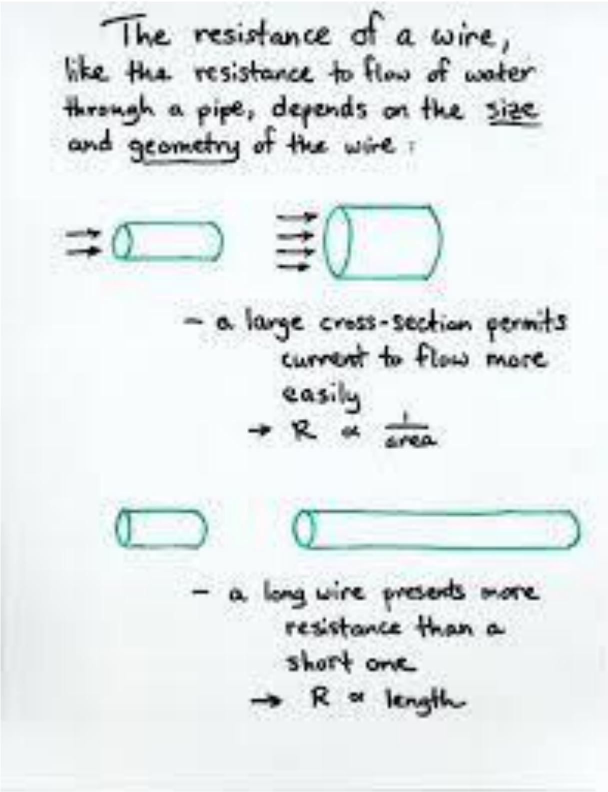
Conventional current direction and electrons flow direction



Electrical resistance

- Resistance is a measure of the opposition to current flow in an electrical circuit.
- Resistance is measured in ohms Ω.
- The symbol of resistance (R) .

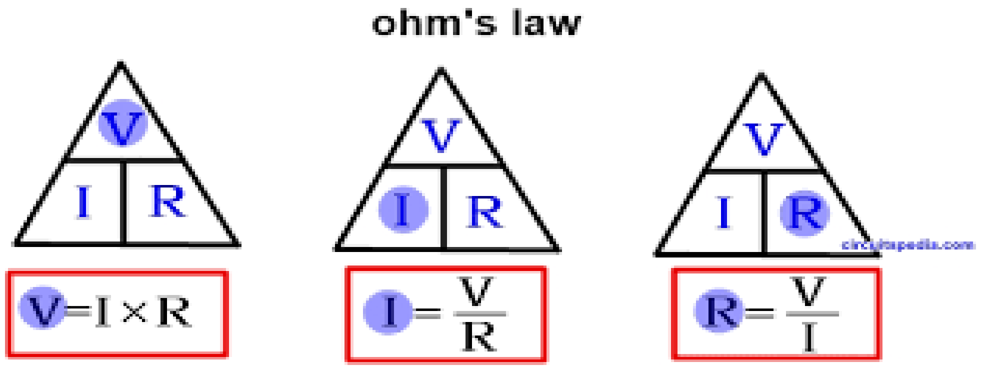


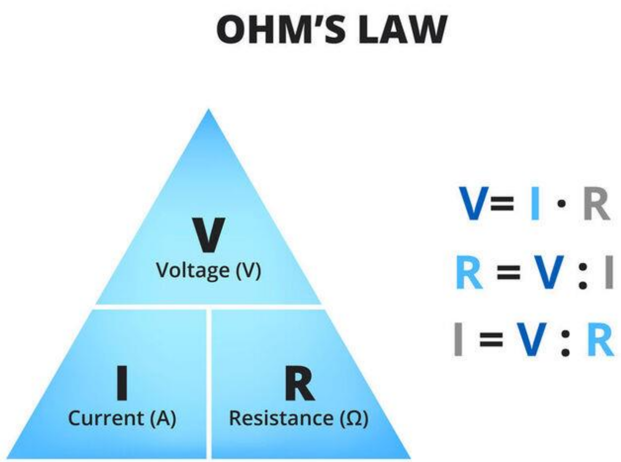


- Long wire has a higher resistance.
- The ratio of voltage to current is called resistance
- $R=\frac{V}{I}$

Ohm`s law

- ohm`s law :a law stating that electric current is proportional to voltage and inversely proportional to resistance.
- $V = IR$

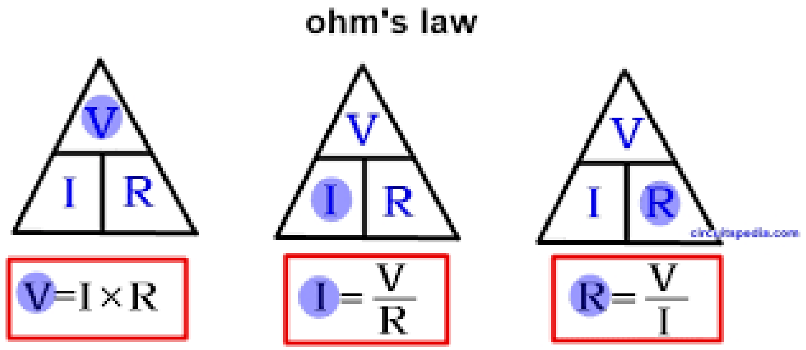


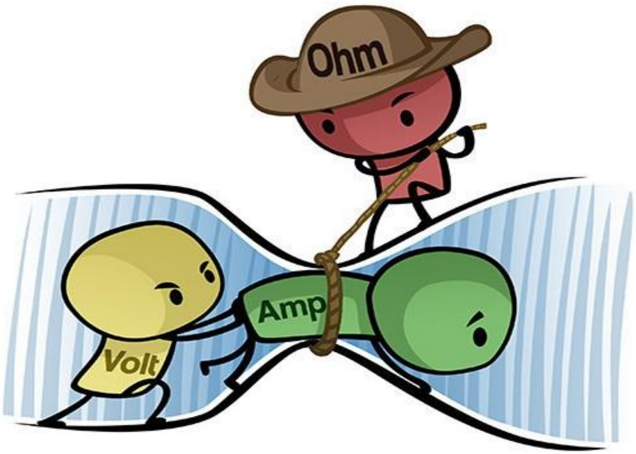


Ohm`s law

- Example 2:

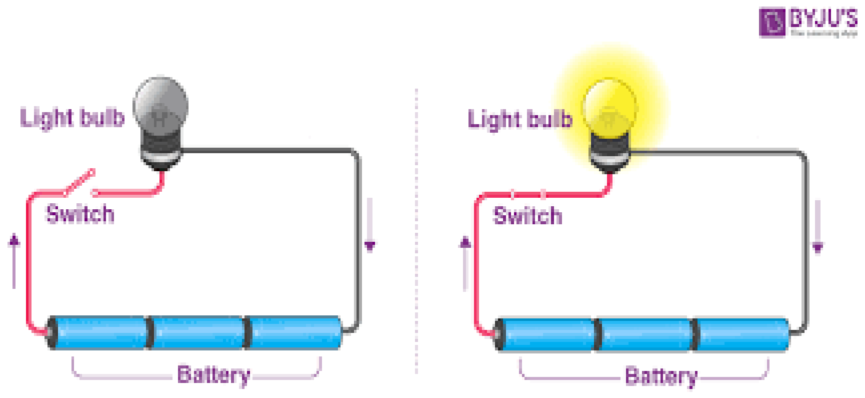
calculate the current if the voltage v=24 volts and R=8Ω?





electric circuits

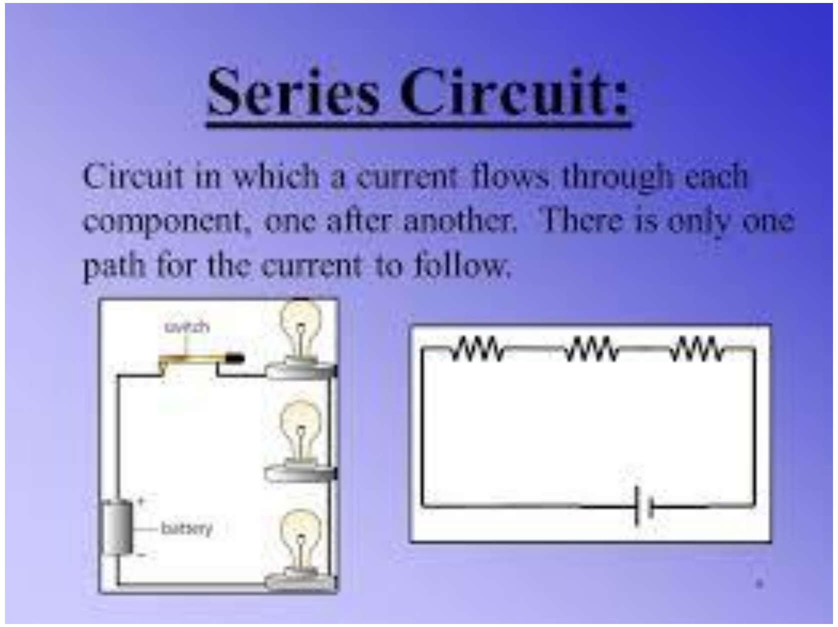
- Electric circuits: path for transmitting electric current .



- We will study two types of electric circuits , Series and parallel circuits.

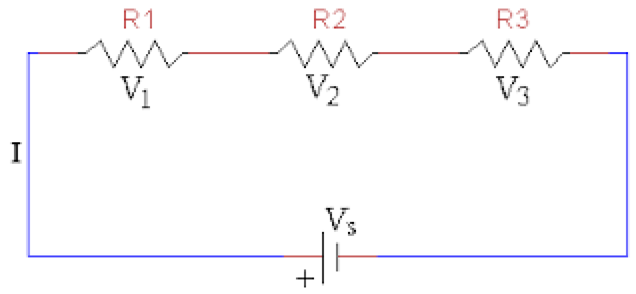
Series Circuits

- A series circuit is defined as the circuit in which a number of resistances are connected one after the other.
- In a series circuit, the flow of current follows a single path.



Series Circuits

- What is the formula for resistance in series ?
- $R_{eq}=R_1+R_2+R_3$



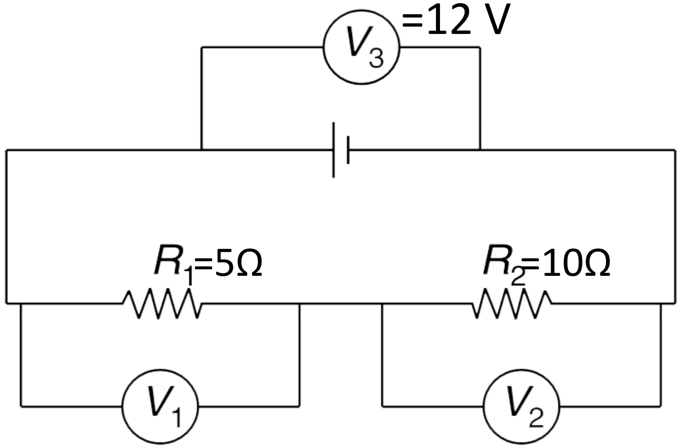
- The current in a series circuit goes through every component in the circuit. Therefore, all of the components in a series connection carry the same current. A series circuit has only one path through which its current can flow.
- The voltages In a series circuit, the sum of the voltages across components is equal to the supply voltage.

Series Circuits

- ## Example 3 :

In the circuit shown in the figure, two resistors R_1 and R_2 have been connected in series

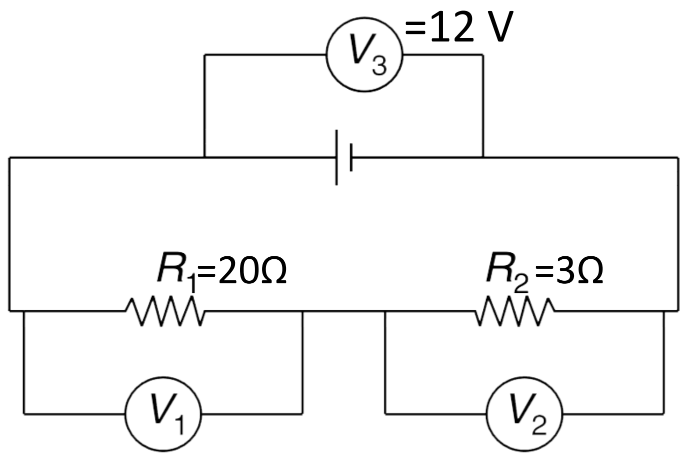
Find : R_{eq}, I , V_1, V_2, ?



Series Circuits

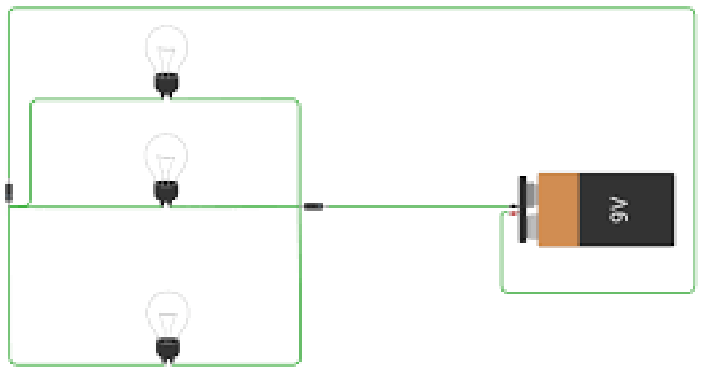
- Example 4 :

In the circuit shown in the figure, which resistor will take more voltage



Parallel circuits

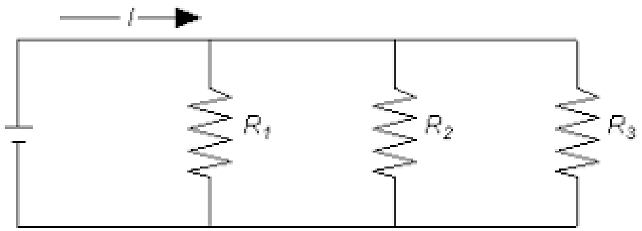
- Parallel circuit, an electrical path that branches so that the current divides and only part of it flows through any branch.



Parallel circuits

- What is the formula for the resistance in parallel ?

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)^{-1}$$



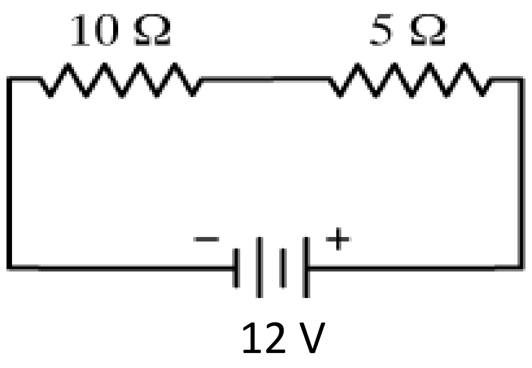
- The current in a parallel circuit splits into different branches then combines again before it goes back into the supply.
- Voltage is the same across each component of the parallel circuit.

Parallel circuits

- Example 5 :

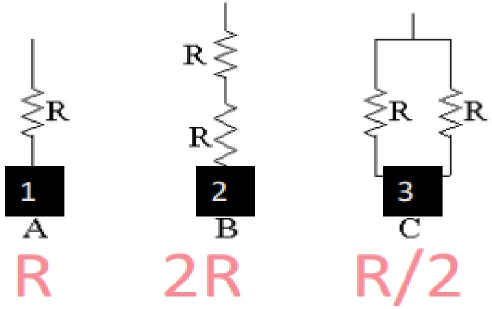
In the circuit shown in the figure, two resistors R_1andR_2 have been connected in parallel ?

Find:$R_{eq}, V_1,V_2,I_{1,}I_2,I_{eq}$



Preflight

Preflight



Which configuration has the smallest resistance?

1

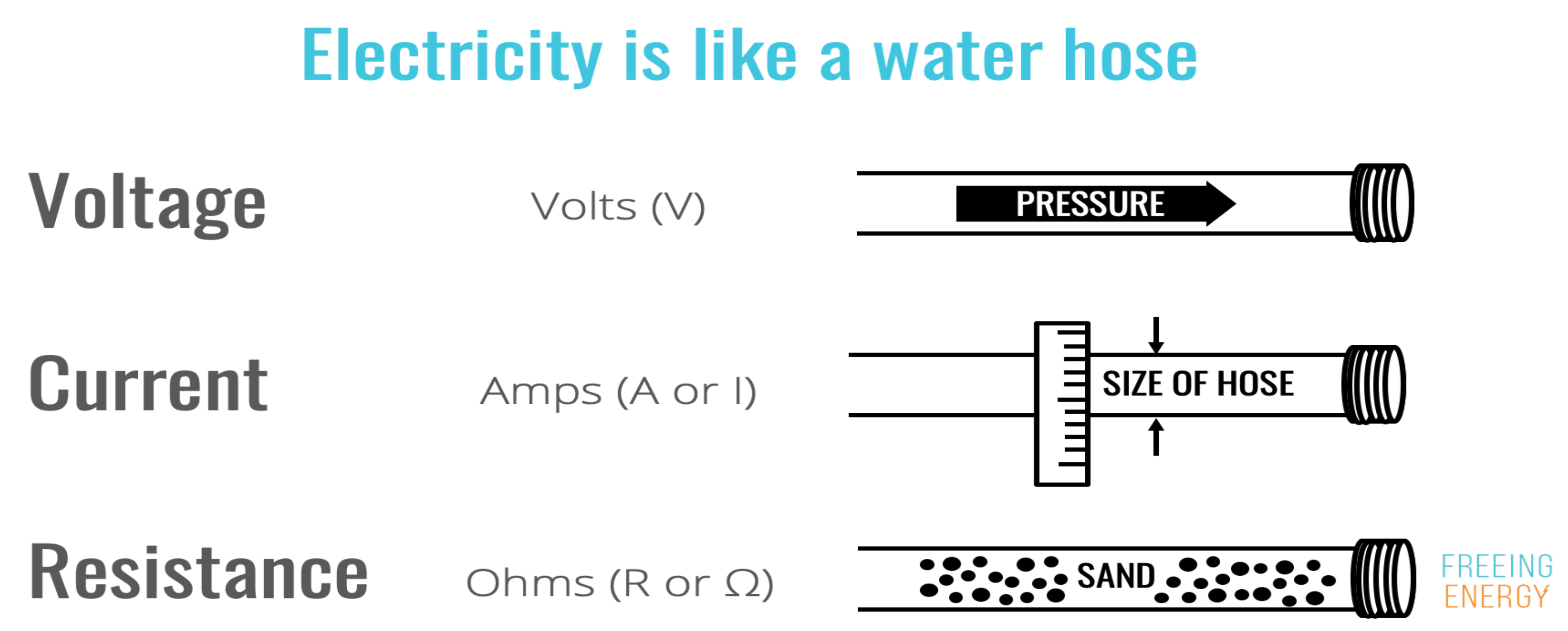
2

3

Which configuration has the largest resistance?

2

summary

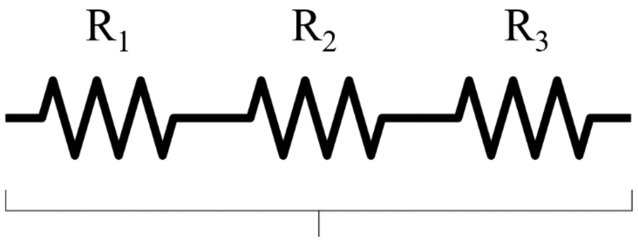

Electricity is like a water hose
Voltage
Volts (V)
PRESSURE
Current
Amps (A or I)
SIZE OF HOSE
Resistance
Ohms (R or Ω)
SAND
FREEING
ENERGY

summary

•

Series Resistors

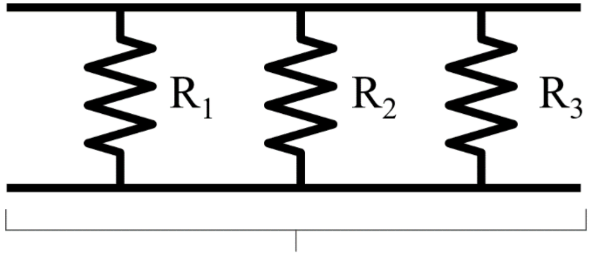
Current is the same across each resistor. Voltage is divided.



$$R_{Equivalent} = R_1 + R_2 + \ldots + R_{N-1} + R_N$$

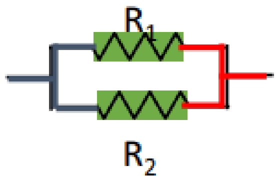
Parallel Resistors

Voltage is the same across each resistor. Current is divided.



$$R_{Equivalent} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_{N-1}} + \frac{1}{R_N}}$$

summary

	Series	Parallel
		
Wiring	Each resistor on the same wire.	Each resistor on a different wire.
Voltage	Different for each resistor. $V_{total} = V_1 + V_2$	Same for each resistor. $V_{total} = V_1 = V_2$
Current	Same for each resistor $I_{total} = I_1 = I_2$	Different for each resistor $I_{total} = I_1 + I_2$
Resistance	Increases $R_{eq} = R_1 + R_2$	Decreases $1/R_{eq} = 1/R_1 + 1/R_2$

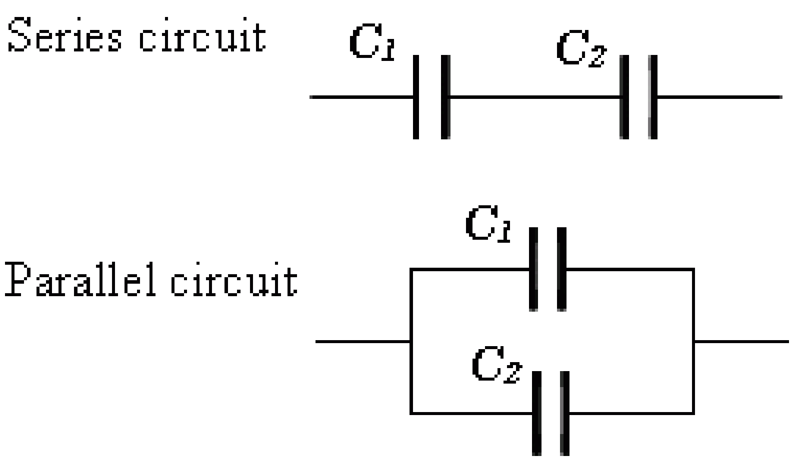
Example 6

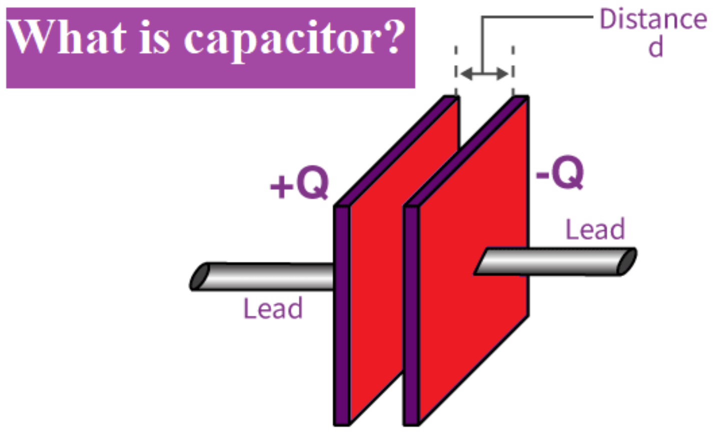
- Find power P? , if resistance R= 50Ω

V=220 v ?

Capacitors

- A capacitor is a two-terminal electrical device that can store energy in the form of an electric charge.
- Capacitors may be connected in series or in parallel to obtain a resultant value which may be either the sum of the individual values (in parallel) or a value less than that of the smallest capacitance (in series).





Parallel Plate Capacitor

Capacitors

- How can we calculate the equivalent value in capacitors?

Series Capacitances

$$C_{total} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots \frac{1}{C_n}}$$

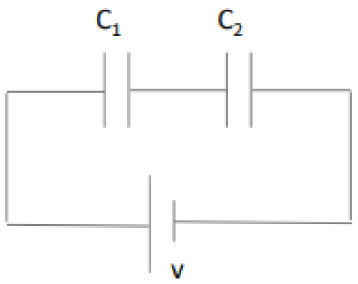
Parallel Capacitances

$$C_{total} = C_1 + C_2 + \ldots C_n$$

Capacitor in series

-

Capacitors in Series:

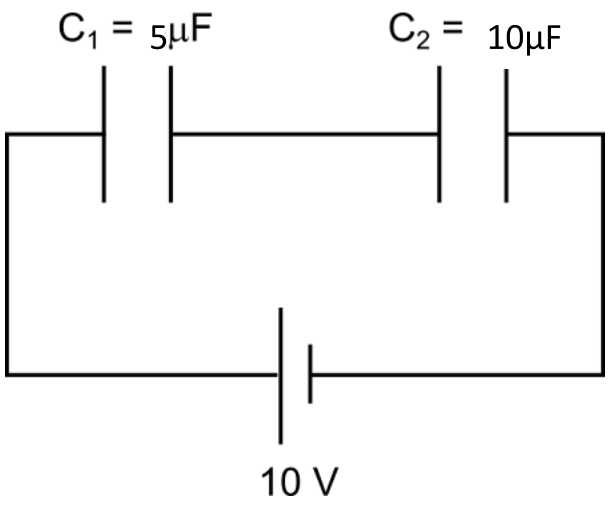


For capacitors in series the charge on the plates is the same.

$$C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)^{-1}$$

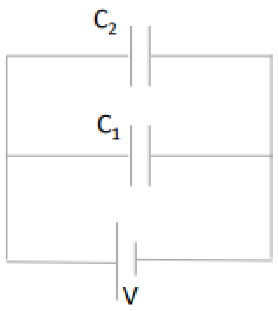
Capacitor in series

- Example 7:
- What is the total capacitance for the circuit presented below ?



Capacitor in parallel

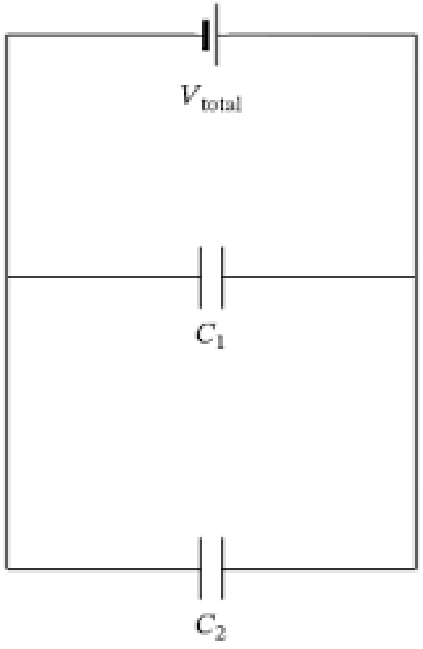
Capacitors in Parallel:



$$C_{eq} = C_1 + C_2.$$

Capacitor in parallel

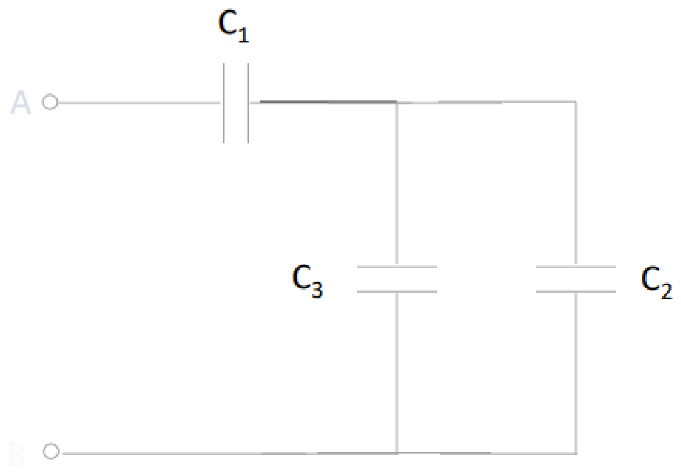
- Example 8:
- What is the total capacitance for the circuit presented below ?
- if $C_1 = 20\mu F, C_2 = 50\mu F$



combination circuit

- A combination circuit is one that has a "combination" of series and parallel paths for the electricity to flow. Its properties are a combination of the two.

Example: Find the value of a single capacitor that replaces the three in the circuit below if
$C_1 = C_2 = C_3 = 12\ \mu F$.



C_2 and C_3 are in parallel

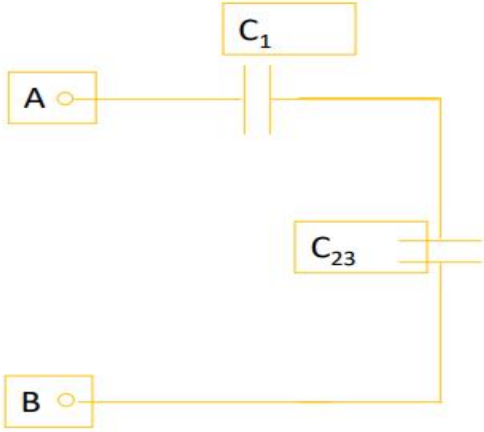
$$C_{23} = C_2 + C_3$$

$$C_{23} = C_2 + C_3$$
$$= 24\ \mu F$$

combination circuit

Example continued:

The circuit can be redrawn:



The remaining two capacitors are in series. $C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \right)^{-1}$

C_{123}

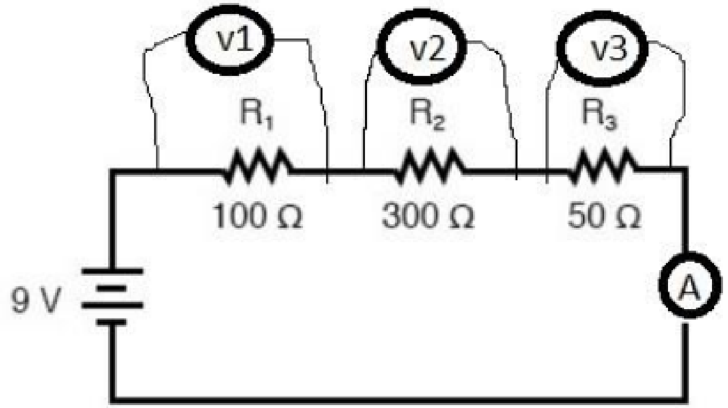
Is the final, equivalent circuit.

Question 1

Calculate the total resistance of the given circuit

ANSWER

$R_{eq} = 450\Omega$

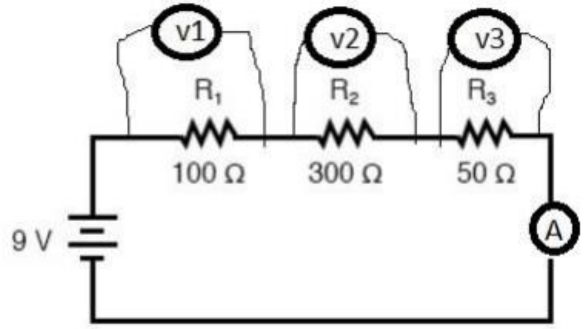


Question 2

Calculate the total current (I) generated by the battery in the circuit given below.

ANS

I = 0.02A



Question 3

Calculate **power dissipated (P)** in across an electric machine which draws **current R= 44 Ω** and connected to main supply **v = 220 V.**

Ans

$$P = V*I$$

AND I = V/R

1100 W.

Question 4

1.

In the circuit given below which of the resistors would draw maximum potential drop(V)?

2. Where you would connect the voltmeter to measure the total voltage?