Electricity

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Electricity is a general term that encompasses a variety of phenomena resulting from the presence and flow of electric charge. These include many easily recognisable phenomena such as lightning and static electricity, but in addition, less familiar concepts such as the electromagnetic field and electromagnetic induction.
It is an important source of energy which is controllable and convenient for the uses in homes, hospitals, industries, etc.

Electric Circuit

The amount of charge flowing through a particular area in unit time is called electric current.
The SI unit of electric current is ampere and is denoted by 'A'. If 'Q' coulomb charge flows through a conductor in time 't', then

Electric Current = $\frac{\text{Charge}}{\text{Time}}$

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

Q = I x t

One ampere

When one coulomb charge flows through a conductor in 1 second, then the current flowing through it is called one ampere.

Electric charge

The charge contained in one electron is called electric charge. The charge contained in about 6x1018electrons is called one coulomb of electric charge.

There are two types of electric charges - positive charges and negative charges. The important property of charges is that 'like charges repel each other' while 'unlike charges attract each other'.
The charge on one electron is 1.6×10^{-19} coulomb.
Number of electrons in one coulomb of charge

1.6×10^{-19} coulomb = 1 electron

1 coulomb = $\frac{1}{1.6 \times 10^{-19}}$

= 0.625×10^{19} electrons

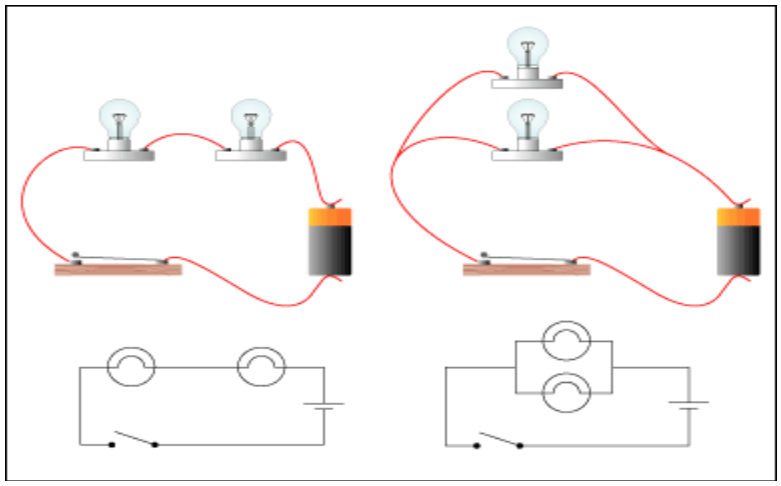
= 6.25×10^{18} electrons

Direction of current

The conventional direction of current is opposite to the direction of flow of electrons i.e. from positive electrode to the negative electrode. The direction of flow of electrons is from negative electrode to the positive electrode.

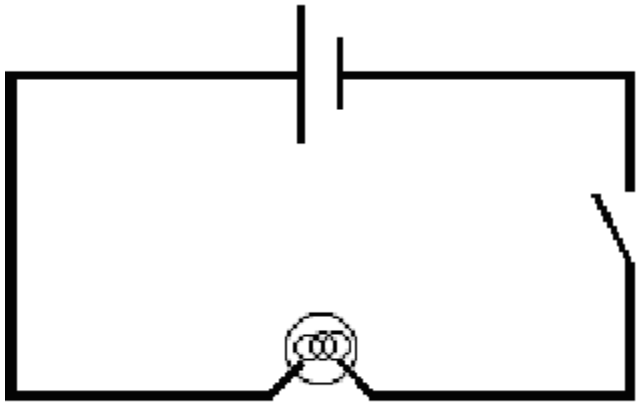
Electric circuit

The arrangement of source of electric power, resistances, switches, and other elements connected together by wires is called an electric circuit.

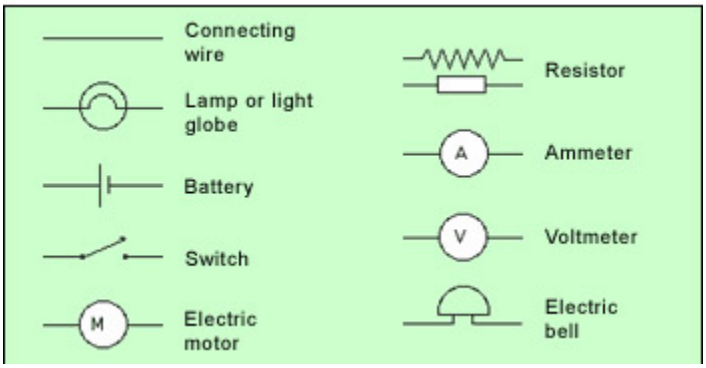


Circuit diagrams

The diagram which represents the different components connected in a circuit by using their symbols is called a circuit diagram.



Symbols used in Circuit diagrams



Electric potential

The work done in moving a unit positive charge from infinity to a given point is called electric potential.

Potential difference

The amount of work done in moving a unit positive charge from one point to another point is called potential difference. Its SI unit is volt. It is represented by 'V'.

Potential difference = work done / charge (V = W/Q)

One volt

If one joule work is done in moving one coulomb of electric charge from one point to the other, then the potential difference between the points is called one volt.

Ammeter

The device which is used to measure the electric current in the circuit is called ammeter. It is always connected in series in a circuit through which current is to be measured.

Voltmeter

The device which is used to measure the potential difference across the ends of a resistor is called voltmeter. It is represented by eV. It is always connected in parallel across the resistor.

Ammeter

Ammeter has low resistance so that it may not change the value of current in the circuit.

Voltmeter has high resistance so that it may take the very less (negligible) current from the circuit.

How can we get the continuous flow of electric current?

We can get the continuous flow of electric current by maintaining the potential difference between the two ends of the conductor using a cell or a battery.

Ammeter	Voltmeter
It is used to measure the electric current in the circuit.	It is connected in series with the resistance.
It has very low resistance.	It is used to measure the potential difference across the resistance.
It is connected in the parallel to the resistance.	It has very high resistance.

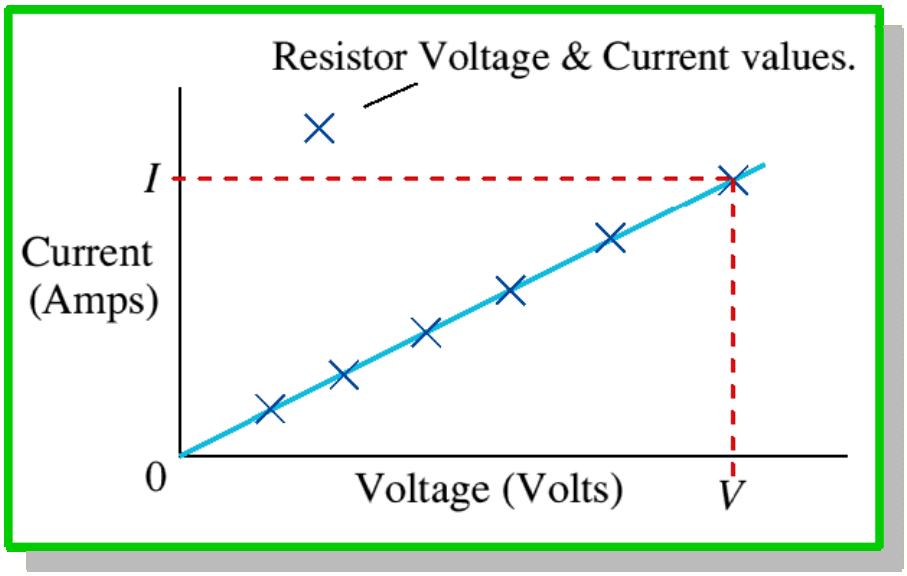
Ohm's law

Ohm's law (Important condition for Ohm's Law is that the temperature must remain constant) According to Ohm's Law -'At constant temperature, the current flowing through the conductor is directly proportional to the potential difference across its ends'. If the current flowing through the conductor is 'I' and the potential difference across its ends is 'V', then

or $V = IR \quad I = V/R$ (R is constant)

R is called the resistance Its SI unit is ohm (Ω).
Resistance is the property of a conductor that resists the flow of charge passing through it.

Diagram of Ohm’s law with current and Voltage at constant temperature .



Factors affecting the resistance of a conductor

The resistance of a conductor -

- Is directly proportional to the length of the conductor
- Is inversely proportional to the area of cross-section (or thickness)
- Is directly proportional to the temperature
- Depends upon the nature of the material of the conductor

One ohm

When the potential difference across the ends of a conductor is 1 volt and the current passing through it is 1 ampere, then the resistance of the conductor is 1 ohm.

Therefore, 1 ohm = 1 volt / 1 ampere

How is current affected in Ohm's Law ?

The current flowing through a conductor is

- Is directly proportional to the potential difference.
- Is inversely proportional to the resistance.

Variable resistance

The component which is used to regulate the current without changing the potential difference is called the variable resistance. It is represented by

Rheostat

The device which is used to change the resistance in the circuit is called rheostat. The resistance in the circuit diagram is denoted by Rh.

Resistance

The ratio of the potential difference across the ends of a conductor to the current flowing through it is called the resistance. It is denoted by 'R' and denoted in circuit diagram by. Its SI unit is ohm (Ω).

Resistor

Resistor is an object having resistance of desired value while resistance is the property due to which it opposes electric current.

The current flowing through different components is different because the different components retard the motion of electrons by different amount of resistances.

Good conductor, Insulator

The component that offers a very low resistance is called a good conductor. The component that offers higher resistance is called a poor conductor. An insulator of same size offers a very-very high resistance.

Resistivity

The ratio of the product of the resistance and the area of cross-section to the length of conductor is called resistivity of substance. Its SI unit is ohm^{-m} (Ωm).

Factors affecting on Resistance

- Resistance of a conductor is directly proportional to its length($R \propto l$)
- Resistance of a conductor is inversely proportional to the area of cross-section ($R \propto 1/A$)
- (rho) is called the resistivity or the specific resistance of a material.
- (rho) is called the resistivity or the specific resistance of a material.

Factors affecting resistivity

- The resistivity of a substance depends only on the nature of material.
- It also depends on the temperature and does not depend on length and thickness of conductor.

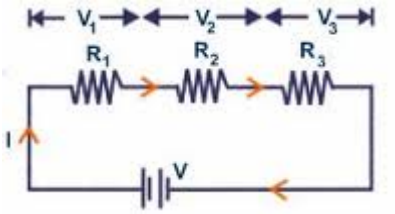
Combination of resistances

Resistances in series

when the resistances are joined end to end, they are said to connected in series. If the resistances R_1, R_2, R_3,. are connected in series, their resultant resistance $R = R_1 + R_2 + R_3 + .$

Derivation

Let the resistances R_1, R_2, and R_3 be connected in series. The current flowing through the circuit is I and the potential difference across the resistances is V , then according to Ohm's law, the potential difference across the resistors R_1, R_2 and R_3 is



$V_1 = IR_1$, $V_2 = IR_2$ and $V_3 = IR_3$.

Since, the total potential difference in the circuit remains same

$$V = V_1 + V_2 + V_3$$

$$\Rightarrow \quad IR = I R_1 + I R_2 + I R_3$$

$$\Rightarrow \quad R = R_1 + R_2 + R_3$$

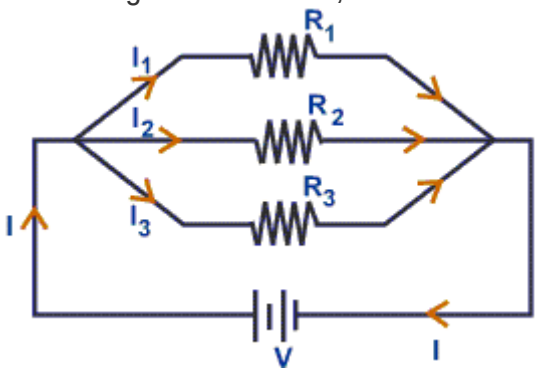
Resistances in Parallel

When one end of all the resistances is connected at one point and the other end is connected at another single point, then the resistances are said to be connected in parallel. If the resistances R_1, R_2 ,R_3. are connected in parallel, their resultant resistance

$1/R = 1/R_1 + 1/R_2 + 1/R_3 + .$

Derivation

Let the resistances R_1, R_2, and R_3 be connected in parallel. The potential difference across the resistances is V and the current flowing through the circuit is I. Then according to Ohm's law, the current through the resistors



R_1, R_2 and R_3 is $I_1 = V/R_1$, $I_2 = V/R_2$ and $I_3 = V/R_3$.

Since, the sum of current through each resistance in parallel is equal to the total current in the circuit.

$I = I_1 + I_2 + I_3$

$\Rightarrow V/R = V/R_1 + V/R_2 + V/R_3$

$\Rightarrow 1/R = 1/R_1 + 1/R_2 + 1/R_3$

The sum of the potential differences across the ends of the resistances connected in series is equal to the total potential difference in the circuit.

The current passing through the resistances connected in series remains same. The sum of current through each resistance in parallel is equal to the total current in the circuit.

The potential difference across the resistances connected in parallel remains same.

Disadvantages of series circuit in domestic wiring

- In series circuit all the electrical objects have only one switch and cannot turned off separately.
- If one gadget stops working due to some defect, then all the gadgets stop working.
- All the gadgets do not work at the same potential difference (voltage).
- The resultant resistance of the circuit becomes too high and the current becomes too low.

Advantages of parallel circuit

- Each gadget has its own switch and can be switched off separately without affecting others.
- If one gadget stops working due to some defect, then all the gadgets keep working normally.
- All the gadgets work at the same potential difference (voltage).
- The resultant resistance of the circuit becomes less and the current becomes high.

Heating effect of electric current (Joule's Law of heating)

The heat produced in a resistor is directly proportional to the square of the current flowing through it.

Heat produced in a resistor is $H = I^2 Rt$

Fuse wire

The wire of short length which is used in series with an electrical appliance to make it safe is called electric fuse. They are made of metal like Al, Cu or alloy of lead and tin of suitable melting point.

Working of a fuse

When current larger than the specified value flows through the circuit, the temperature of the fuse wire increases. Due to this it melts and breaks the circuit.

Characteristics of a fuse wire

- A fuse wire should have short length, high resistance and low melting point.
- Heating effect is useful in electric iron, electric heater, geyser, toaster, etc.
- The filament of the bulb is made of tungsten because its melting point is very high.
- The inactive gases filled in bulbs are nitrogen and argon.
- The three important effects of electric current are heating effect, magnetic effect and chemical effect.
- 5A fuse wire is used for low power appliances like mixer, bulbs, tubes, fans, etc.

- 15A fuse wire is used for high power appliances like AC, electric heaters, geysers, ovens, etc.

Electric power

The electric work done in unit time is called electric power. It is represented by P. Its SI unit is watt (W) which is also known as joule per second.

Electric power = electric work done / time

i.e. $P = W/t$

One watt

When one joule of electrical energy is consumed by an appliance in one second, the power of the appliance is called one watt.

Relation between kWh and Joule 1 kWh = 1000Wh =1000 x 3600Ws = 3.6×10^6 joule.

Commercial unit of electricity

The commercial unit of electricity is called kilowatt-hour (kWh). It is commonly known as unit. 1kWh is the energy consumed by an appliance when 1 kilowatt power is used per second.

Electricity consumed = Power x Time

$E = P.t$