CHAPTER 7 ELECTRICITY AND MAGNETISM

Learning Outcomes:

1. To learn about electricity
2. To learn about electric current flow in a series circuit and a parallel circuit
3. To learn about magnetism

7.1 Electricity

Energy

1. Energy is the ability to do work. Every living thing need energy to carry out life processes such as movement, reproduction and growth. Energy enables plant to carry out photosynthesis by using the light energy from the sun.
2. A non-living thing (e.g. car) also needs energy. Car needs fuel energy to move.
3. The unit for energy is joule (J).
4. Energy cannot be created or destroyed. It can change from one form to another.

Heat energy (thermal energy)

- Energy that is stored in hot objects.
  - e.g. the sun, fire, geothermal sources

Chemical energy

- Energy that is stored in substances that can undergo a chemical change.
- e.g. food, dry cells, biomass fuel

Light energy

- Energy that can be radiated by a lit or shining object.

Sound energy

- Energy that is produced by vibrating objects; cannot travel through vacuum.
  - e.g. thunder, sirens

Kinetic energy

- Energy that is possessed by a moving object; depends on the mass and the speed.
  - e.g. wind, water current, waves

Electrical energy

- Energy produced from the flow of electrical charges.
  - e.g. generators, dynamos, dry cells

Nuclear energy (atomic energy)

- Energy stored in the nucleus of an atom.
  - e.g. atomic bombs, radioactive metals

Potential energy

- Energy that is stored in an object due to its position.
- Two types:
  (i) Gravitational potential energy
  e.g. a jumping athlete, the water retained in a dam
  (ii) Elastic potential energy
  e.g. a compressed spring, bent ruler

Table 7.1 Various form of energy

Sources of energy

1. Various natural sources of energy can be found on this earth. Energy is obtained from renewable energy sources and non-renewable energy sources.
    a. Water
        ≈ Water as a source of energy is used to turn the turbine that is connected to the generator until electrical energy is produced.
    b. Sun
        ≈ The energy from the sun is known as solar energy. Solar cells are used to convert solar energy into electrical energy.
    c. Biomass
        ≈ Energy obtained from animal and plant remains. It is used to produce gas fuel and liquid fuel.
    d. Geothermal
        ≈ Heat energy is obtained from the heat inside the Earth and it produces steam that can rotate the turbine to produce electricity.
    e. Wind
        ≈ Moving air is used to move the blades of the windmill to produce electricity.
    f. Waves
        ≈ It is used to move the turbine to generate electrical energy.
    g. Fossil fuel
        ≈ It is formed from the remains of dead plants and animals buried in the earth. The three forms of fossil fuel are coal, gas and petroleum.
    h. Radioactive substances
        ≈ It is used to produce nuclear energy.

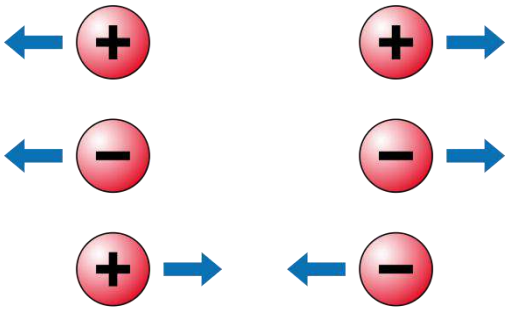
Electrostatic charges

1. Electrostatic is the study of electric charges that are not moving.
2. Electric charges are produced through friction when two different types of insulators are rubbed together. The phenomenon of producing charges by friction is called the triboelectric effect.
3. The electrons will separate from an object and transfer to the other object when rubbing. The object that loses electron is positively charged (+) whereas the object that gains electron is negatively charged (-).

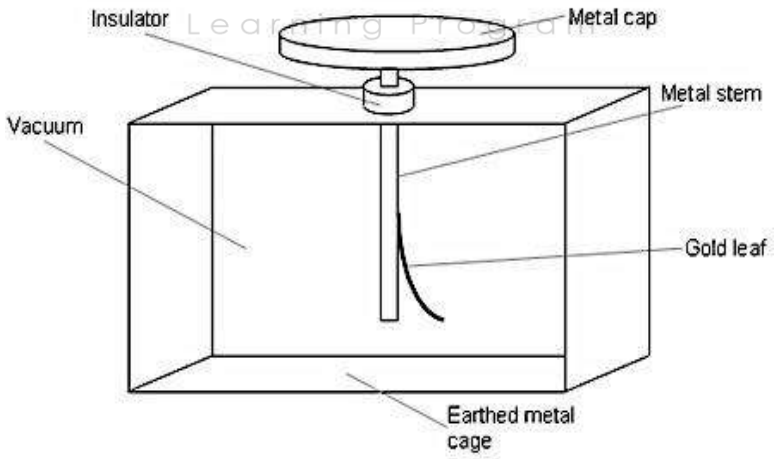
Positively charged objects	Negatively charged objects
Silk cloth	Hard rubber
Balloon	Nylon
Woollen cloth	Balloon, polythene
Acetate cellulose	Silk cloth, woollen cloth
Glass	Silk cloth

Table 7.1 Types of objects and types of charges produced when two objects are rubbed against each other

4. According to the Law of Charges,
   - Same charges repel or push each other away.
   - Different charges attract or pull on each other.



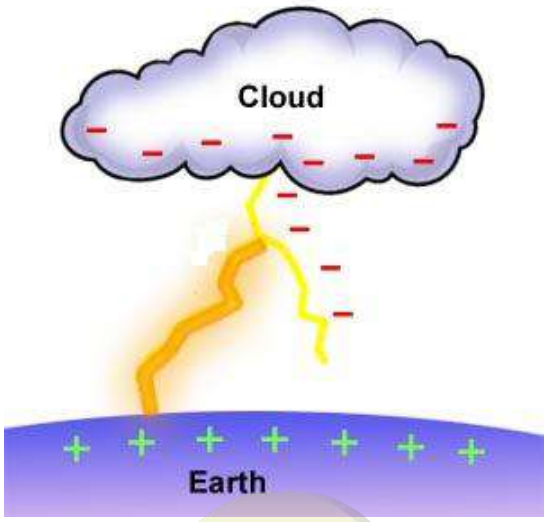
5. Hence, attraction and repulsion of objects produce a type of force known as the electrostatic force.
6. Examples of phenomena where materials attract one another after charged by friction:
   a. The hair is attracted to the comb after it is combed with a plastic comb.
   b. When we get out of the car, we will feel a mild electric shock when our hand touches the metal part of the car door.
7. An electroscope is a device that determines the presence, quantity and type of electrostatic charges. The electroscope that is commonly used is the one with the gold leaf.



   - When the rod with the positively or negatively charge is brought close to the metal cap of the electroscope, the gold leaf would diverge.
   - This is because the charged rod induces the charge on the metal cap, the metal stem and also the gold left. The same charges repel each other and cause the gold leaf to diverge.

- **Electrostatic in daily life**

e.g. Lightning



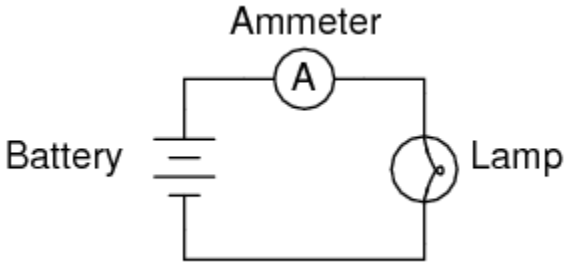
During a thunderstorm, clouds rub against rapid air flow and cause the bottom of the clouds to become negatively charged. The negative charges induce positive charges on the ground. Negative charges on the clouds move to the positively charged areas on the ground. Hence, the negative charge from the clouds to the ground is an electric discharge known as lightning.

- **Solving problems related to electrostatics**

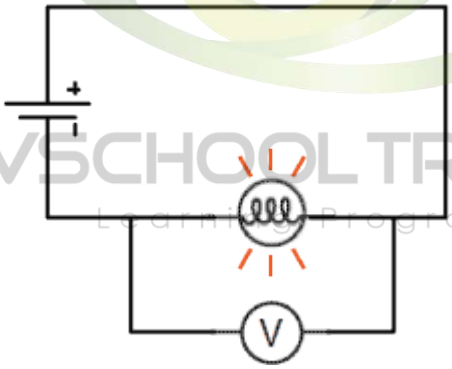
1. Lightning conductors fixed on buildings enable the electrons to flow to the Earth without causing any damage to the buildings.

2. Electrostatic charges can be produced on the body of the petrol tanker when there is friction between the tank and the air on a hot day. The charges that gather can produce sparks of fire that can cause a fire. Hence, metal chains are fixed at the back of the petrol tanker to enable the charges to flow to the earth.
3. The fabrics of our clothing are made of wool, animal fur, nylon etc. These materials produce charges when they are in contact by friction, especially in dry conditions. Hence, it's better to wear clothes made of cotton and to avoid wearing clothes made of wool and synthetic fabrics.

- **Electric current**
  1. Electric current is the rate of electrical charges that pass through a point in a conductor. Electricity is a form of energy that is produced by electric current.
  2. The S.I. unit for current is Ampere, A. The device that measures current is ammeter. An ammeter is connected in series with the electrical components.



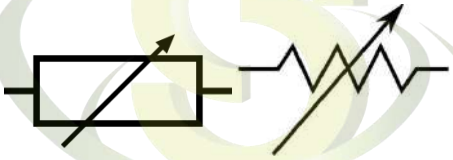
- **Voltage**
  1. Voltage is the electric potential difference between two points in a circuit. It is the force that moves charges (electrons) from one point to another through a conductor.
  2. The S.I. unit for voltage is volt (V). The device that measures voltage is voltmeter. A voltmeter is connected in parallel with the electrical components.



- **Resistance**
  1. Resistance is the ability of a conductor to resist the flow of electric current through it. When the resistance in a circuit becomes higher, the current flow in the circuit becomes smaller.
  2. The S.I. unit is ohm (Ω).
  3. The resistance of a conductor depends on:
     a. Type of material: Different material has different levels of resistance.
     b. Length of conductor: The longer the conductor, the higher its resistance.
     c. Diameter: The smaller the diameter, the higher its resistance.
     d. Temperature: The higher the temperature, the higher the resistance.

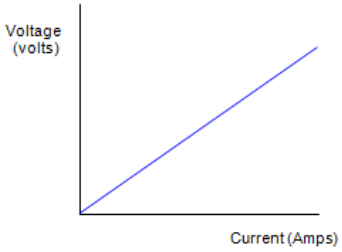
4. There are two types of resistors:
    a. Fixed resistor – has permanent resistance that cannot be changed.

b. Variable resistor (Rheostat) – has resistance that can be changed.

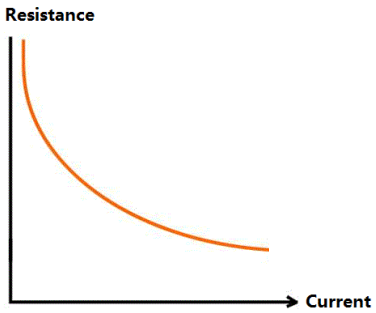


- **The relationship between current, voltage and resistance**

1. When the resistance in the circuit changes, the quantity of the current and voltage also change. Same goes to total amount of voltage; the quantity of the current and the resistance in the circuit also varies.
2. The higher the voltage, the greater the current.



3. The larger the resistance, the smaller the current.

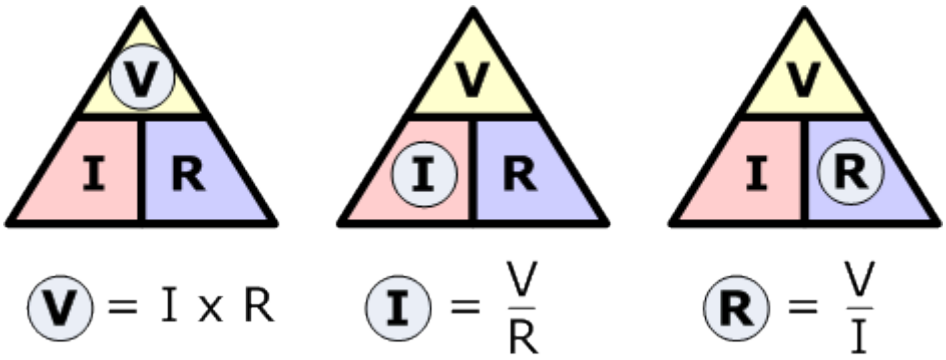


- **Ohm's law**

1. Ohm's law states that current flow in a circuit is directly proportional to the voltage across both ends of the conductor with the condition that the temperature and the physical conditions are constant.
2. Ohm's law can be stated as:

$$V = IR$$

It is used to calculate the value of current, voltage and resistance in the circuit.



7.2 Flow of electric current through a series circuit and a parallel circuit

1. The electrical components can be represented with electrical symbols in a circuit.

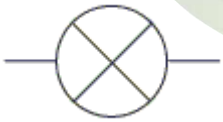
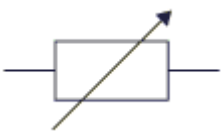
	Switch
	Dry cell
	Bulb
	Voltmeter
	Ammeter
	Resistor
	Variable resistor/ Rheostat

Table 7.2 Symbols of electrical components

2. Simple electrical circuits can be set-up as a parallel or a series circuit.

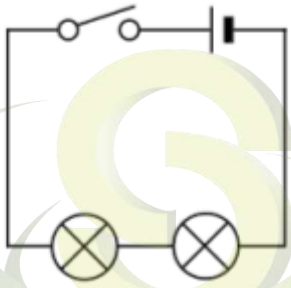
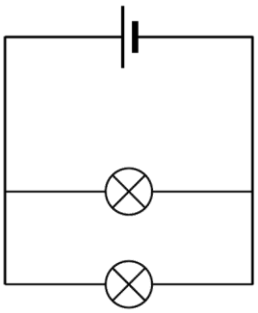
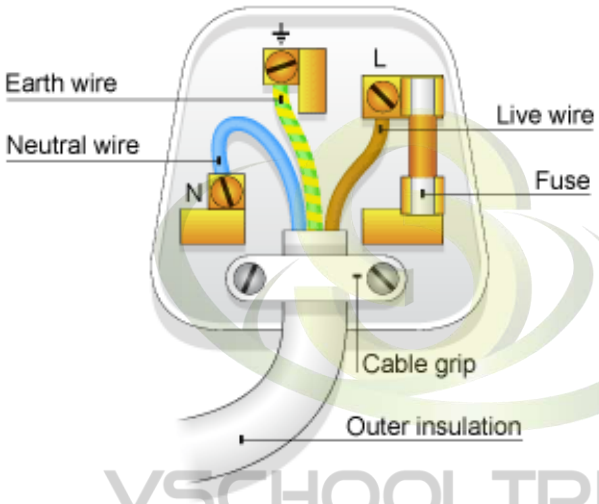
Type of circuit	Series circuit	Parallel circuit
Circuit diagram	 All the electrical components are connected in one path.	 The electrical components are connected from one end to the other end with more than one path.
Current (I)	$I = I_1 = I_2$	$I = I_1 + I_2$
Voltage (V)	$V = V_1 + V_2$	$V = V_1 = V_2$
Resistance (R)	$R = R_1 + R_2$	$1/R = 1/R_1 + 1/R_2$
Advantages	➢ All components are controlled using one switch. ➢ The current that flows through each electrical component is the same and not affected by resistance. ➢ An increase in voltage (dry cells) increases the voltage that flow through the circuit.	➢ Each component can be controlled individually. ➢ The increase in the number of components does not jeopardize the function of the other components. ➢ The voltage is the same across each component.
Disadvantages	➢ If one component spoils, the other components do no function. ➢ When the electrical components increase, the resistance increase causes the current flow to decrease. ➢ Each electrical component cannot be controlled with individual switches.	➢ The cell power used decreases if many components are connected in the circuit. ➢ Uses too many wires.

Table 7.3 Comparison between series and parallel circuit

- **Electrical wiring in homes**
  1. Electricity that is supplied to our homes is called the main. The electrical wiring at home is connected in parallel in order to ensure lights get full voltage from its main power supply.
  2. The main voltage for residential homes in Malaysia is 240V.
- **3-pin plug**

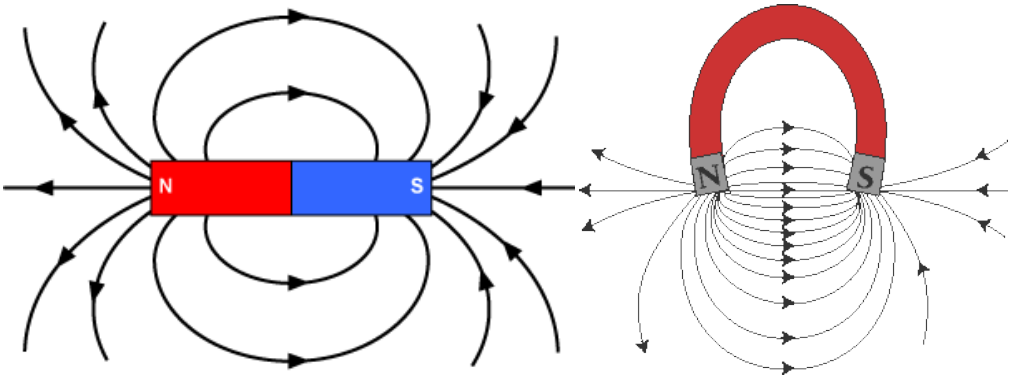
1. We connect plugs to socket outlets to use electrical appliances. 3-pin plugs are commonly used in medium to high voltage electrical appliances, such as televisions, computers and refrigerators.
    a. Fuse – Ensures there is no excessive current flow to appliances and users.
    b. Live wire (L) – Brown in colour; it carries current from the mains to appliances.
    c. Neutral wire (N) – Blue in colour; it carries current away from appliances.
    d. Earth wire (E) – Yellow and green in colour; it flows leaked current to the ground.



2. The international code is used to identify the different types of wires in a plug.

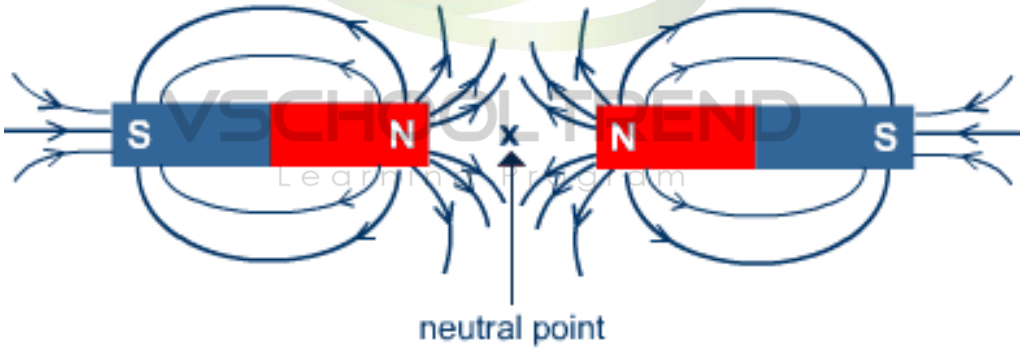
7.3 Magnetism

1. Magnets are substances that can produce a magnetic field and attract materials like nickel, iron and cobalt.
2. Weak magnets exist naturally as mineral in rocks called magnetite or lodestone. The man-made magnets are stronger and they contain metallic alloys.
3. Characteristics of a magnet:
    - Has a North Pole (N) and a South Pole (S)
    - Has a magnetic field
    - Produce a magnetic force which is a push or a pull that is produced when magnetic poles are brought closer.
    - Same poles repel while opposite poles attract each other
4. A magnetic field is a region surrounding a magnet where magnetic forces can be detected. It has a particular pattern and direction.



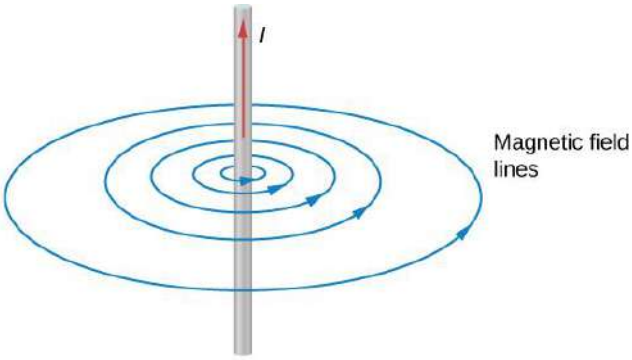
- The magnetic field lines show the shape of magnetic field.
- The direction of the magnetic field lines is from the north pole (N) to the south pole (S).
- The stronger the magnetic pole, the closer the magnetic field lines.
- The magnetic field lines do not cross one another.

5. Point X is an empty space that does not have any magnetic field, which is known as neutral point.

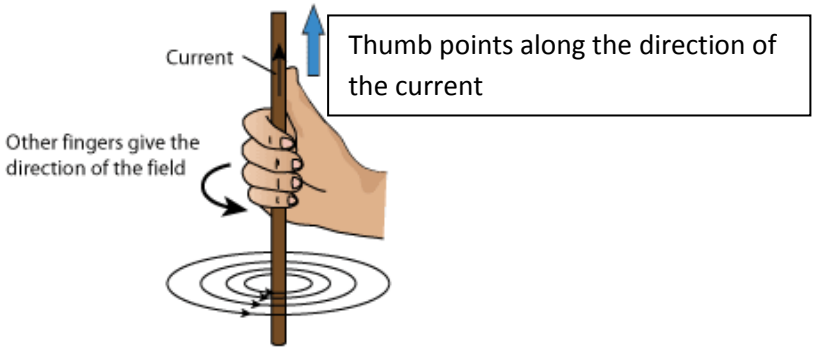


Electromagnet

1. An electromagnet is a material with temporary magnetic effect when the current flows through the conductor.
2. When the current flows through the conductor, a magnetic field is produced around it. When the current is stopped, the magnetic field disappears.
3. A straight conductor produces a circular magnetic field pattern.

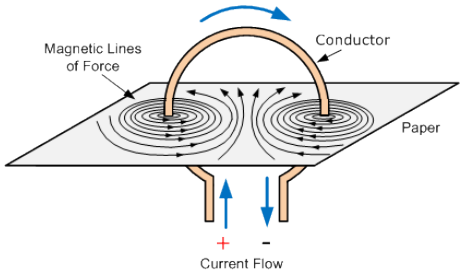


- Direction of the magnetic field depends on the direction of current (I) that flow through the conductor.
- The lines in the magnetic field are closer when nearer to wire because a strong magnetic field is produced there. The strength of the magnet decreases when far from the conductor.
- The Right-Hand Grip Rule is used to determine the direction of the magnetic field.



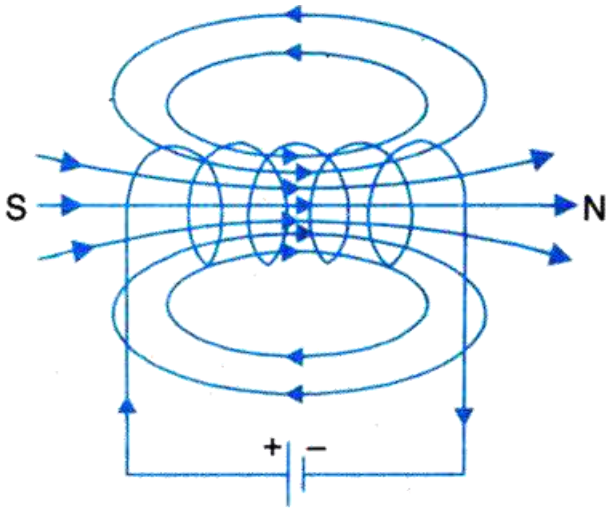
Right Hand Grip Rule

4. The coiled wire creates a different pattern of magnetic field from a straight conductor.



- The magnetic field line at the centre of the coil is almost a straight line.
- The field lines are in opposite directions and can be determined by using the right-hand grip rule.

5. The current-carrying solenoid creates a different pattern of magnetic field from a straight conductor and the coiled wire.



- The poles for the solenoid can be determined by looking at the current at the ends of the solenoid.
- The current that flows in an anti-clockwise direction points to the north pole; the current that flows in a clockwise direction points to the south pole.

6. The strength of an electromagnet increases when the current increases and/or the number of turns of wire increases.

Uses of magnets in everyday life

1. Compass

- The compass uses magnets to assist its pointer needle to show the poles of the earth correctly.
- When a compass is placed near a stronger magnet, the needle of the compass will be deflected.

2. Electric motor and dynamo

- A motor is a device that converts electrical energy into kinetic energy.
- A dynamo is a device that converts kinetic energy into electrical energy.
- Magnets are used in motors and dynamos.

3. Electric bell

- When the switch is pressed, the circuit becomes complete. The iron becomes an electromagnet, pulling the iron armature and the hammer towards it. The movement of the hammer rings the bell and breaks the circuit. When the circuit is broken, the iron core loses its magnetic field and hence, the iron armature returns to its original position. The process is repeated until the switch is pressed again.