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PHYSICS

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Contents

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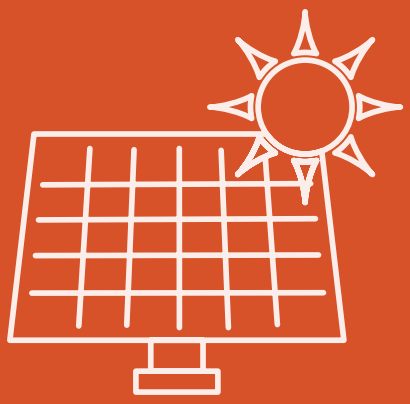
Physics in Technology

THEME 01



Conservation Principles

Wave, motion without material transfer

Field at rest and in motion

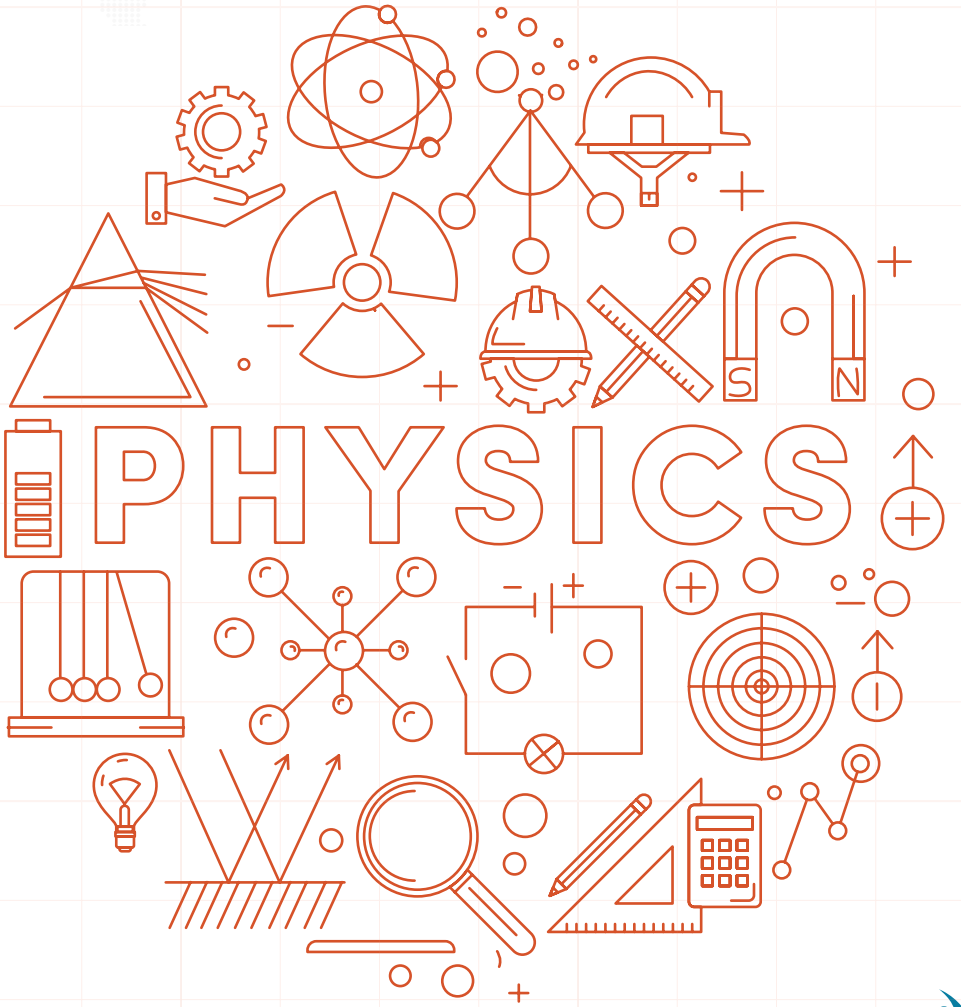
Energy quantization and duality of matter

Physics in Technology

ENERGY AND SOCIETY

PERFORMANCE OBJECTIVES

1. Identify the sources of energy in society
2. Distinguish between the renewable and non-renewable energy sources in the society
3. Identify the various ways energy is used
4. Explain the importance of energy in the development of society
5. Explain the impacts of energy on the environment
6. Identify energy sources that are environmentally friendly



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ENERGY

Energy is the capability to do work.

Energy is the lifeblood of modern-day society. Without it, life would almost be impossible.

Energy is a property of matter that can be converted to work, heat, light, or radiation

It can move things, do work, or produce heat.

TYPES

1. Potential energy is the energy possessed by a matter at rest. It is also called stored energy.
2. Kinetic energy is the energy possessed by a matter in motion. It is also called moving energy.

FORMS OF ENERGY

Mechanical Energy (Kinetic) - Energy a matter possesses by virtue of its motion

Mechanical Energy (Potential) - Energy a matter possesses by virtue of its position relative to a reference point examples are Pendulum, a spring

Others are

- Chemical Energy
- Thermal or Heat Energy
- Nuclear Energy
- Radiation Energy
- Hydropower Energy
- Wind Energy
- Tidal (Wave) Energy.

SOURCES OF ENERGY

Energy is stored and is available in different forms and sources.

RENEWABLE ENERGY SOURCES

When energy sources can be replenished over and over again, they are never depleted examples are

a. Solar - The energy from the sun, this sources produces different forms of energ such as heat, radiation, light, even sound but cannot be heard due to the vacuum space because sound cannot travel through a vacuum (i.e. a space without air)
b. Hydropower - The energy of moving water falling as a result of gravity
c. Wind - The energy of moving wind or dense air
d. Tidal (Wave) - The energy from wave movement of the ocean
e. Geothermal - The thermal energy from the earth crust
f. Biomass - The energy obtained from plants
g. Nuclear Fusion - The thermonuclear energy obtains as a result of fusing two or more light nuclei to form a heavy nucleus. These types of energy sources are usually converted to electricity or thermal.

NON-RENEWABLE ENERGY SOURCES

The energy sources that are used up and cannot be used again or that are produced in a short period of time, examples are

a. Fossil fuel - The chemical energy obtained from long decayed plants and animals eg. coal, petroleum, Natural Gas
b. Tar sand - A bituminous sands which has an unconventional petroleum deposit
c. Nuclear Fission - The energy obtain as a result of splitting up the nucleus of heavy radioactive elements.

These types of energy sources are usually converted into electricity, heat and mechanical. And we get most of our energy from non-renewable energy sources.

USES OF ENERGY

Energy uses are divided into 4 economic sectors such as Residential use, Commercial use, Industrial use and Transportation use

1. **For residential use** - for cooking, for heating and cooling our homes, for lighting
2. **For commercial use** - for lighting offices and to run gadgets in the offices
3. **For industrial use** - for running industrial machinery, for lighting etc.
4. **For transportation use** - for driving cars, for moving freight, aircraft, trains, etc.

ENERGY AND DEVELOPMENT

Energy is the raw material needed to fuel or power any country's economic growth. Advanced economies have the capacity to develop new sources of energy production to save costs to meet their needs, but many poorer countries lack the capacity. The advanced countries spend a lot on energy research for energy development, so now very fast trains are being used now which can use electricity. But developing countries like Nigeria are still struggling even to meet up with the energy needs of the people residing therein. Energy aids development.

ENERGY IMPACT IN SOCIETY

Energy has both positive and negative impacts on societies. Access to abundant, affordable, secure, safe, and clean energy is beneficial for humans.

But extraction, transportation, and use of energy can have negative consequences on the health, environment, and economics of a society. Some of the impacts are

1. Global warming this is caused as a result of the high carbon contents being released into the atmosphere which now accumulate and heating up the earth's atmosphere that is causing the temperature to rise above normal and also depleting the Ozone layers
2. Greenhouse effect is the process by which radiation from a planet's atmosphere warms the planet's surface to a temperature above what it would be.
3. Oil spillage is caused as a result of transporting crude oil on the sea, and it kills aquatic life.

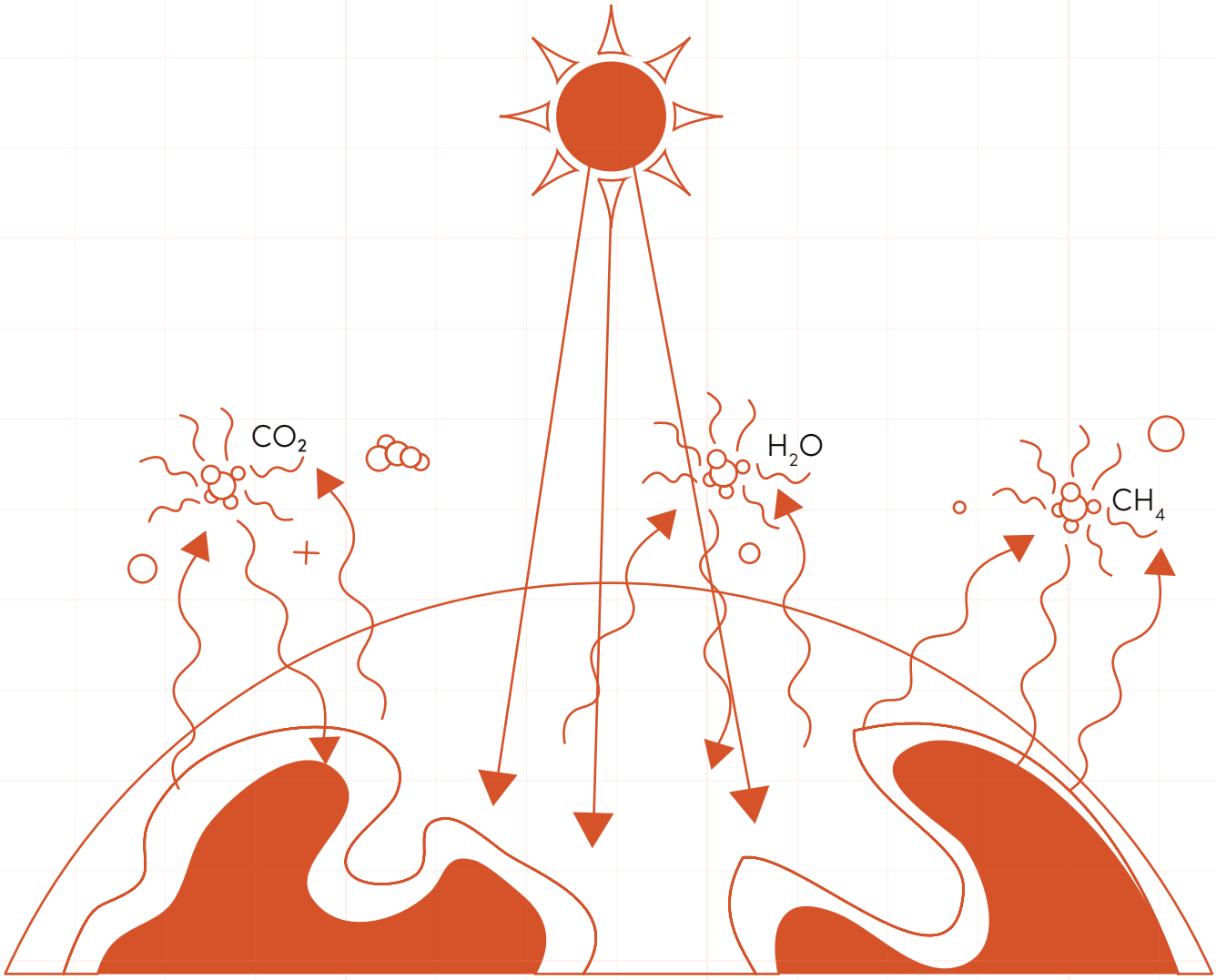
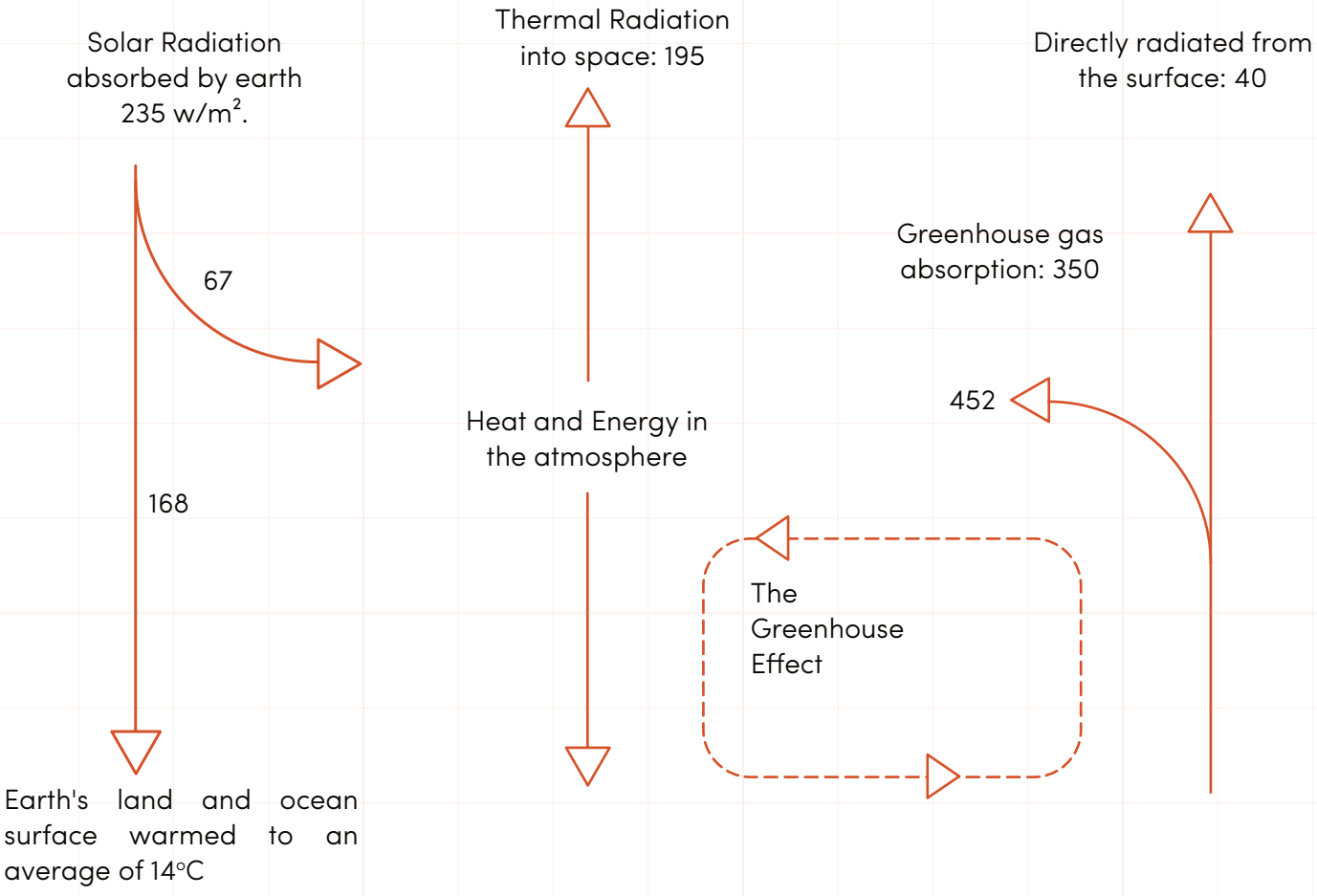


Fig. 1.1: Global Warming



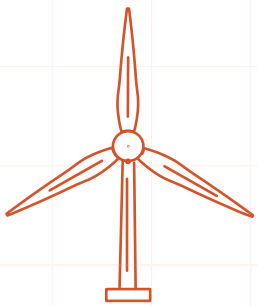
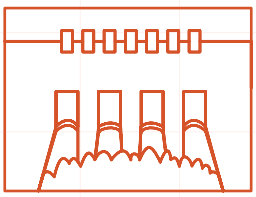
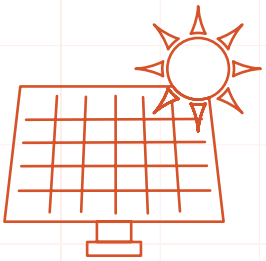
ENERGY CRISIS IN NIGERIA

The Nigerian energy supply crisis is the ongoing failure of the Nigerian government to provide adequate energy for its citizens to boost the economy. There is a high cost of fuel, no adequate supply of electricity for domestic and industrial use. We have all these in excess and abundant but no adequate technology and bad government policies to exploit them.

ECO-FRIENDLY ENERGY

Renewable energy sources are eco-friendly energy unlike fossil fuels and others. Technologies that are being used in harnessing the Earth's renewable energy create no negative impact on the environment.

The energy includes but not limited to solar, wind, and hydropower etc.

Wind Power	Hydro-power	Bio Fuel	Solar Energy
			

SUMMARY

So far, we have learnt how to

1. Identify the sources of energy in society
2. Distinguish between the renewable and non-renewable energy sources in the society
3. Identify the various ways energy is used
4. Explain the importance of energy in the development of society
5. Explain the impacts of energy on the environment
6. Identify energy sources that are environmentally friendly

INTERACTIVE ASSESSMENT QUESTIONS

1. The major source of energy in Nigeria is

   A Hydro
   B Fossil fuel
   C Geothermal
   D Wind
   E Heat

2. Chemical energy is a

   A Geothermal
   B Hydro
   C Renewable
   D Non-renewable

3. Firewood is a

   A Nuclear energy
   B Chemical energy
   C Biomass energy
   D Heat energy

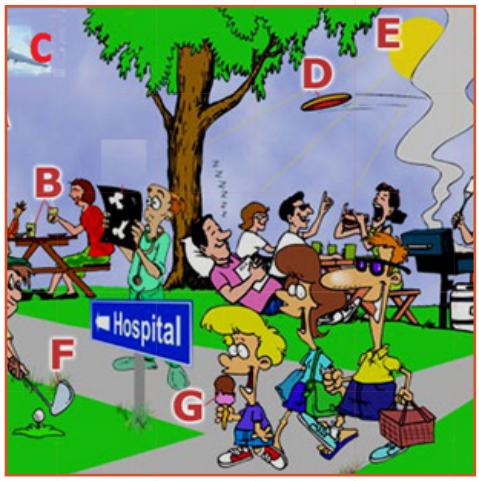
4. The energy obtain from the movement of the ocean is

   A Mechanical
   B Wind
   C Tidal
   D Breeze

5. The energy obtain from bituminous sand is

   A Coal sand
   B Crude sand
   C Sand tune
   D Tar sand

6. From A to G identify the forms of energy.



7. Sun produces sound energy. True or False

8. State the forms of energy you know

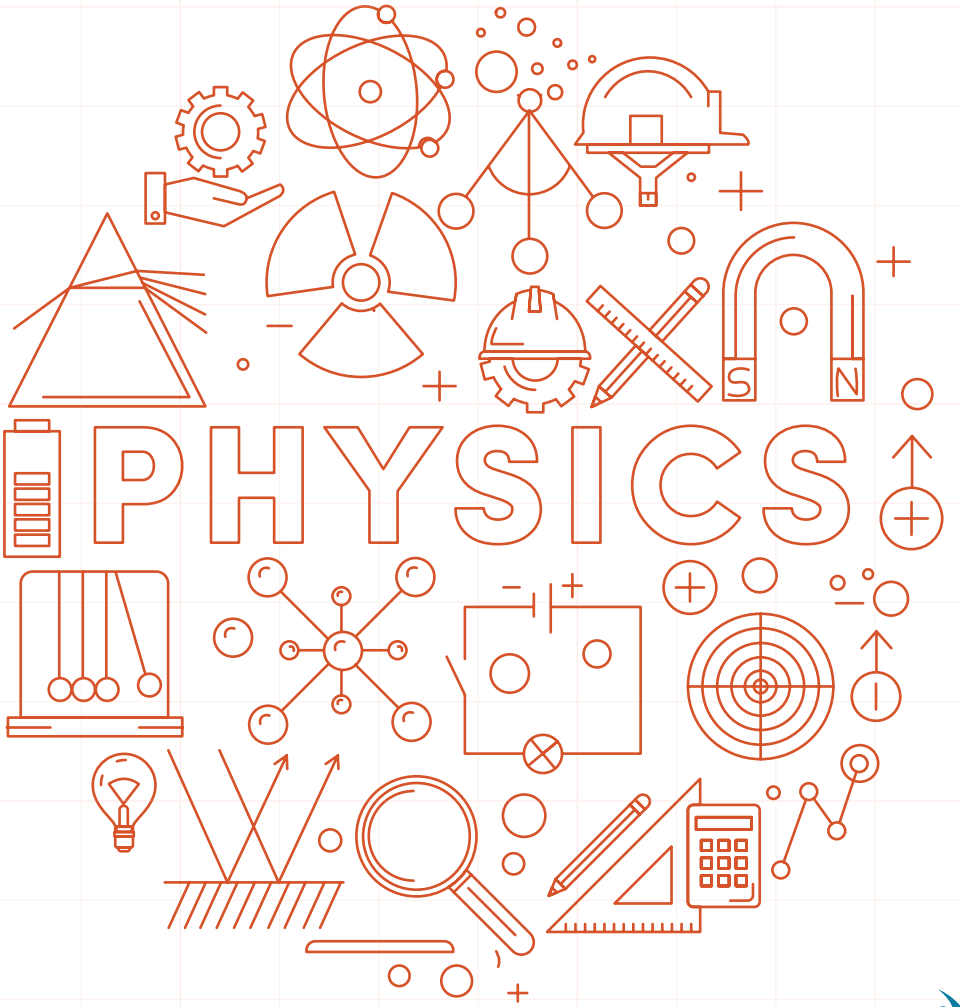
9. Identify 5 sources of energy you know and there uses

10. a. Explain briefly the energy crisis in Nigeria. b. Describe eco-friendly energy

ENERGY CONVERSION

PERFORMANCE OBJECTIVES

1. Identify different forms of energy
2. State how these forms can be converted from one to other
3. Use devices to convert one form to another



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ENERGY CONVERSION

Energy can neither be created nor destroyed but instead is converted to another form for proper usage.

1. Gasoline (Chemical) is put into a car engine and with the help of electrical energy from the battery to provide mechanical, heat, and sound energy.
2. Electricity is fed into TV and is converted to light, sound, heat at times
3. Electricity in the bulb is converted to light and heat energy
4. Bicycle dynamo converts mechanical energy to electrical energy
5. Solar panel converts solar energy to electrical energy
6. Electrical energy is fed into a fan to produce mechanical, wind, and sound energy
7. Foods as chemical energy in the body is converted to mechanical, heat energy by metabolic activities of the body.
8. Radiation falls on a black surface to produce heat energy
9. Electrical energy is fed into resistance wire to produce heat energy
10. Rubbing of hand mechanically to produce heat energy.
11. Sound energy is put into an ultrasound device to produce light energy.
12. Electrical energy is fed into an X-ray machine to produce radiation, light, and heat energy.

DEVICES FOR THE ENERGY CONVERSION

- Electric motor
- Dynamo
- Solar panel
- Black surface
- Thermocouple
- Resistance wires.
- Engine.

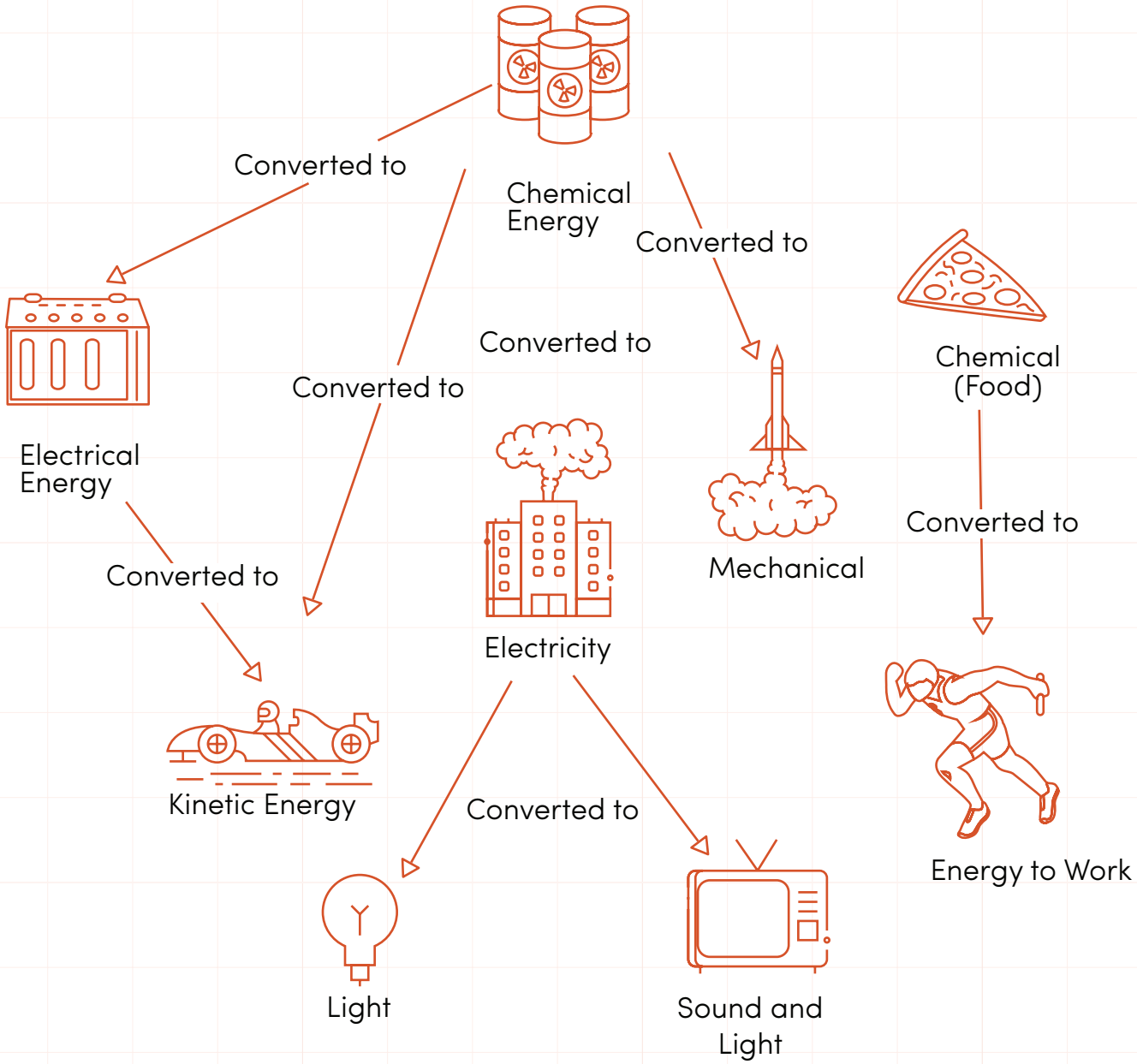


Fig. 1.2: Energy Conversion

SUMMARY

So far, we have learnt how to

1. Identify different forms of energy
2. State how these forms can be converted from one to other
3. Use devices to convert one form to another

INTERACTIVE ASSESSMENT QUESTIONS

1. Chemical energy is converted to mechanical energy in a solar panel: True or False
2. The cell converts heat energy to sound to light: True or False

THEME 02

Conservation Principles

Wave, motion without material transfer

Field at rest and in motion

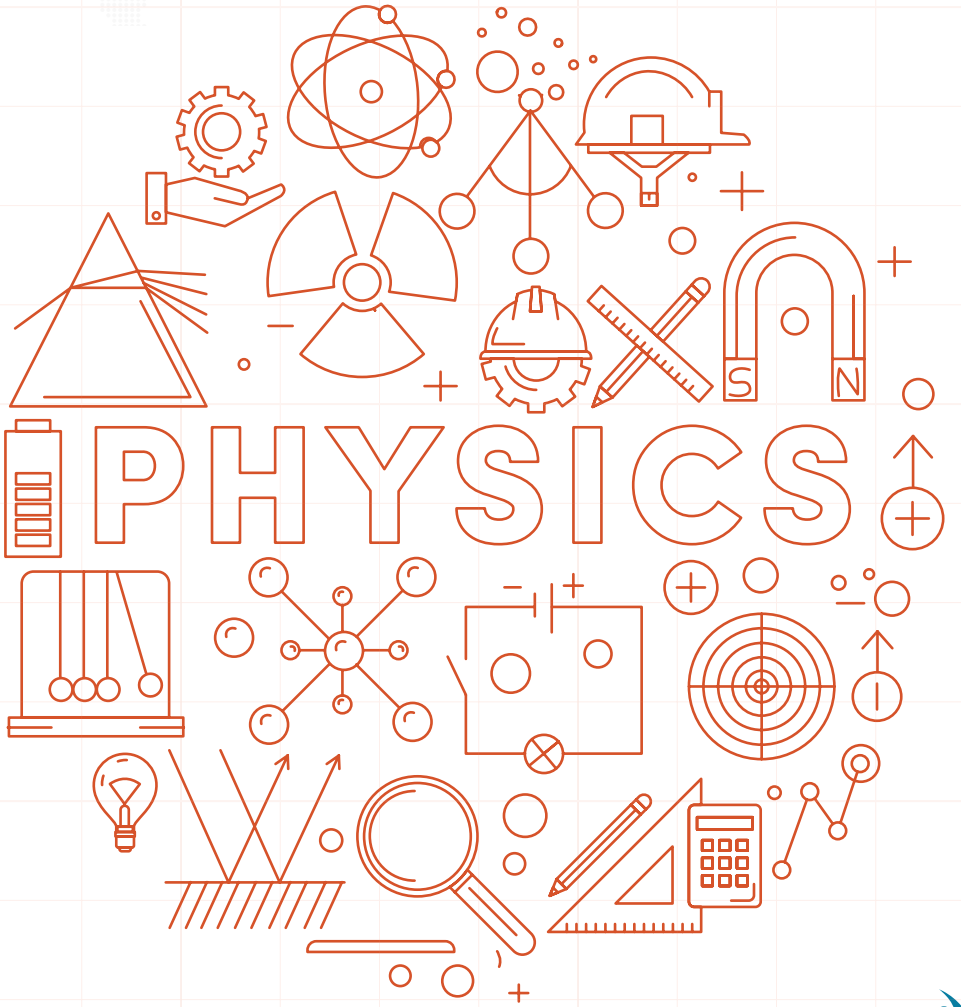
Energy quantization and duality of matter

Physics in Technology

PROPERTIES OF WAVES

PERFORMANCE OBJECTIVES

1. State and explain the properties of waves
2. Demonstrate diffraction of waves
3. Demonstrate interference of waves
4. Demonstrate polarization light waves



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PROPERTIES OF WAVES

Wave is a disturbance in a medium that carries energy without a net movement of particles.

Waves are usually

1. A transfer of energy
2. Involve a periodic repetitive movement
3. Do not result in a net movement of the medium or particles in the medium (mechanical waves)

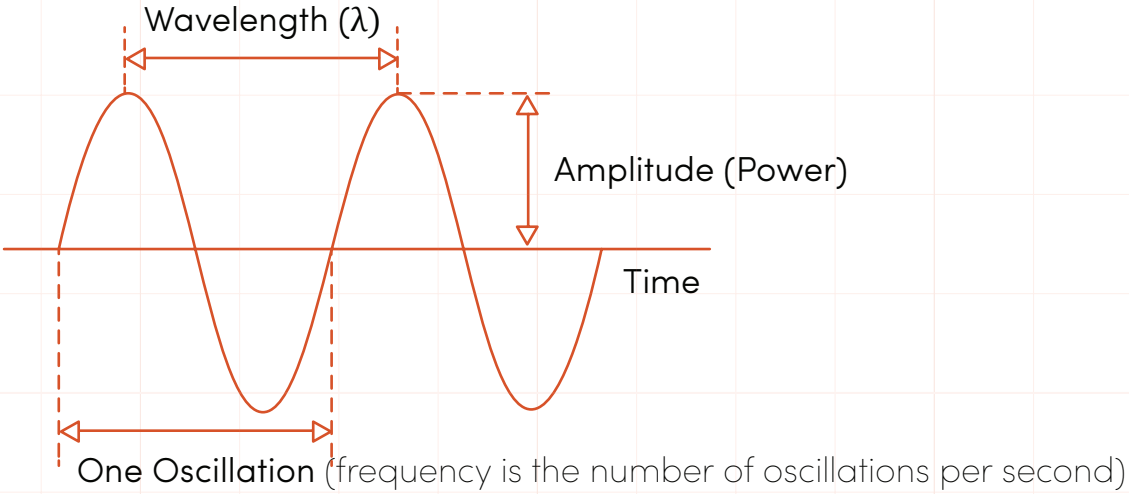


Fig. 2.1: Representation of Transverse waves

TYPES OF WAVES

1. **Transverse Wave** - Waves in which the medium moves at right angles to the direction of the wave. Examples are : water wave, light wave, S-wave earthquake, string or rope wave, torsion wave. The waves undergo successive crest and successive trough.
2. **Longitudinal waves** - The particles movement of the medium is the same or parallel as the direction of the movement of the wave.

Examples are: sound wave, P-type earthquake wave, compression wave.

The waves undergo compression (*the point where the particles are too closed together)* *and rarefaction (the point where the particles are too spread apart*).

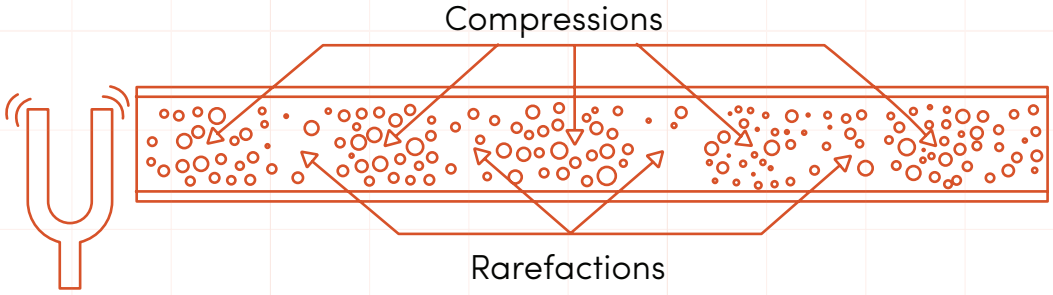


Fig. 2.2: Wave produced by a turning fork (Longitudinal)

CLASSES OF WAVES

1. Mechanical Waves are the waves that need medium to propagate
   Examples are: sound wave, water wave, string wave
2. Electromagnetic Waves are the waves that do not require medium to propagate
   Examples are radio wave , light wave
3. Matter Waves - the wave that is also termed De Broglie wave because they depict a similar wave nature of all matters that form atoms and their frequencies are relied on the kinetic energy.

PROPERTIES OF WAVES

Waves exhibit 5 properties by transverse but only 4 by longitudinal

1. Reflection:-It involves a changing in the direction of waves when they bounce off a barrier

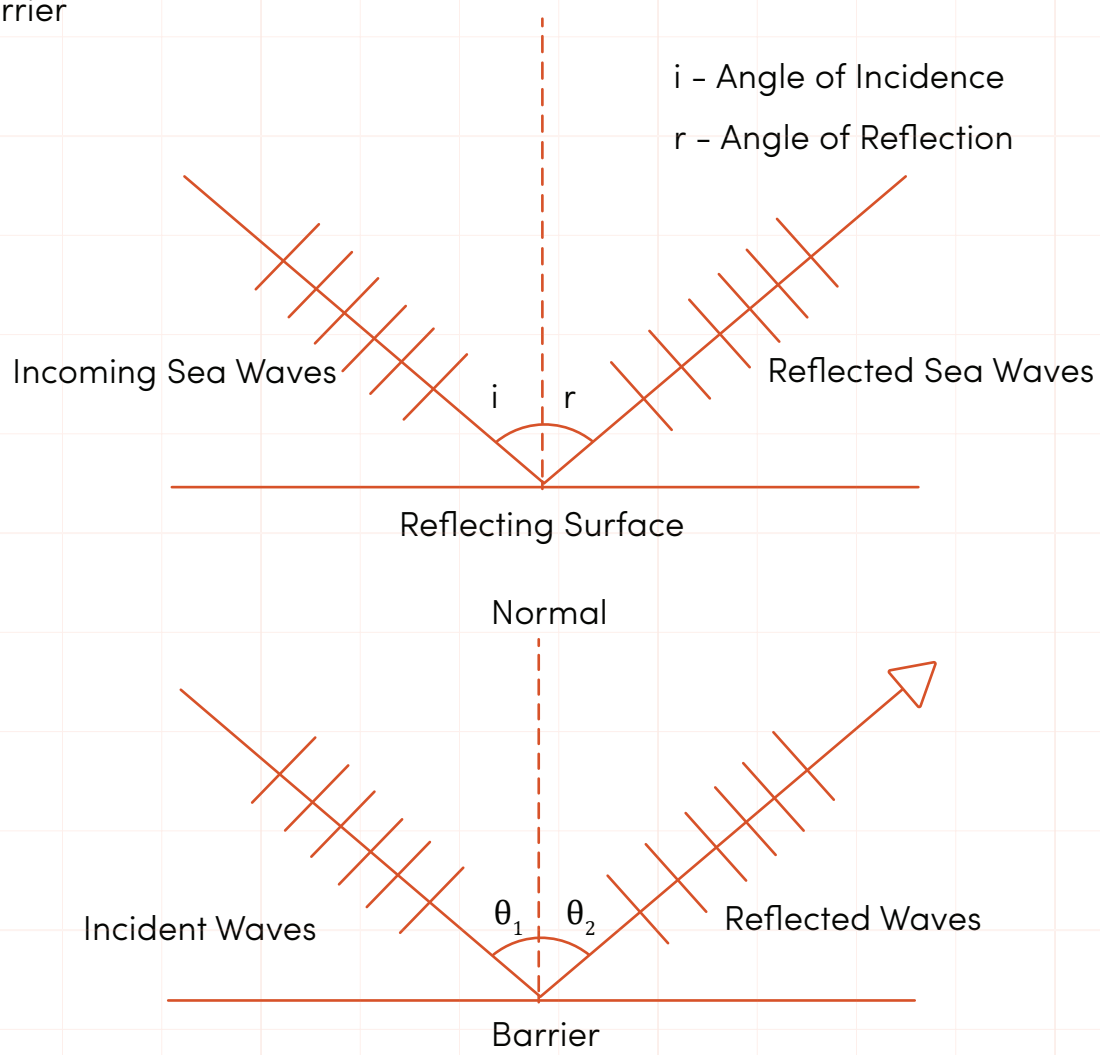


Fig. 2.3: Reflection of waves at a plain surface

2. Refraction: - The bending of the direction of the wave or the change in speed and wavelength of the wave when passing from one medium to another of different densities.

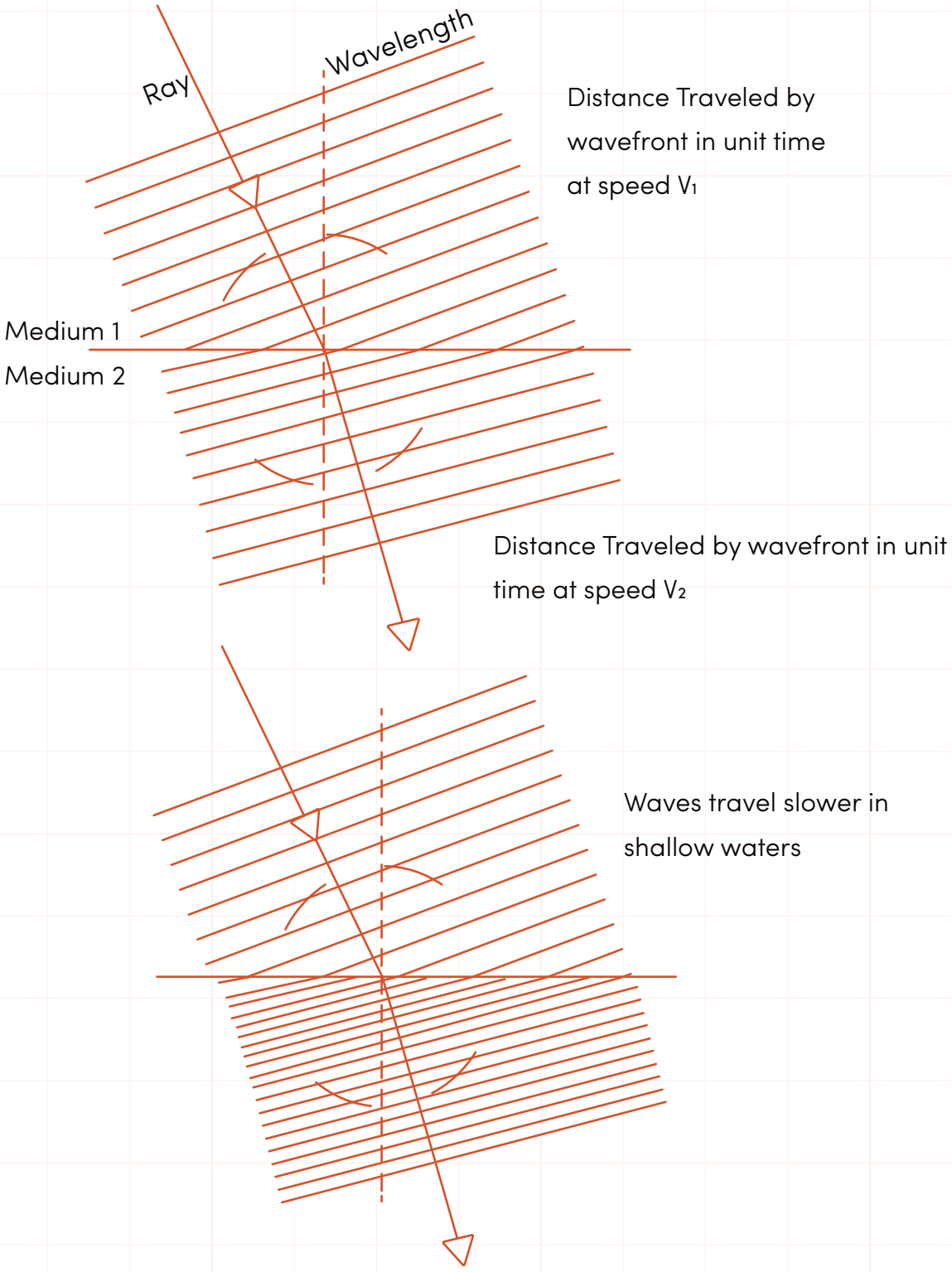


Fig. 2.4: Reflection of waves at a plain bounding

3. Diffraction :- The bending of wave around obstacles and openings, which spread out as they pass through the apertures or around the objects

Fig. 2.5a: Diffraction of waves through a small opening

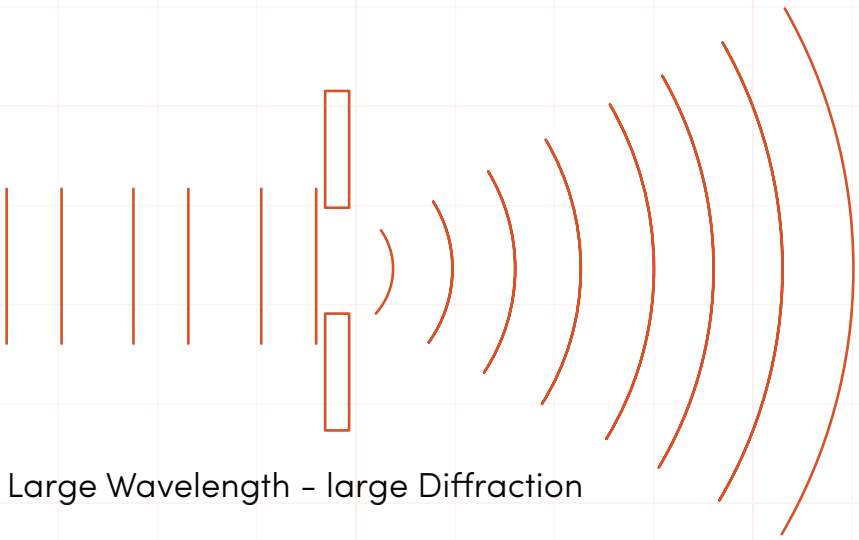


Fig. 2.5a: Diffraction of waves through a large opening

Waves diffract more when passing through small openings and diffract less when passing through wide openings.

Formula $d\sin\theta = n\lambda$

Where d = distance between slits

θ = diffraction angle

n = order number for the maximum

λ = wavelength.

1. Interference:- The process in which two waves superpose to form a resultant wave of lower, same or greater amplitude

It forms constructive interference and destructive interference

These are the 4 main properties of waves by longitudinal and transverse waves, but transverse can also undergo polarization

2. Polarization:- This is the property applying to only transverse waves, in which the waves vibration occur in a single plane

The process of changing unpolarized wave into polarized wave is called POLARIZATION

It is only longitudinal wave that cannot be polarized.

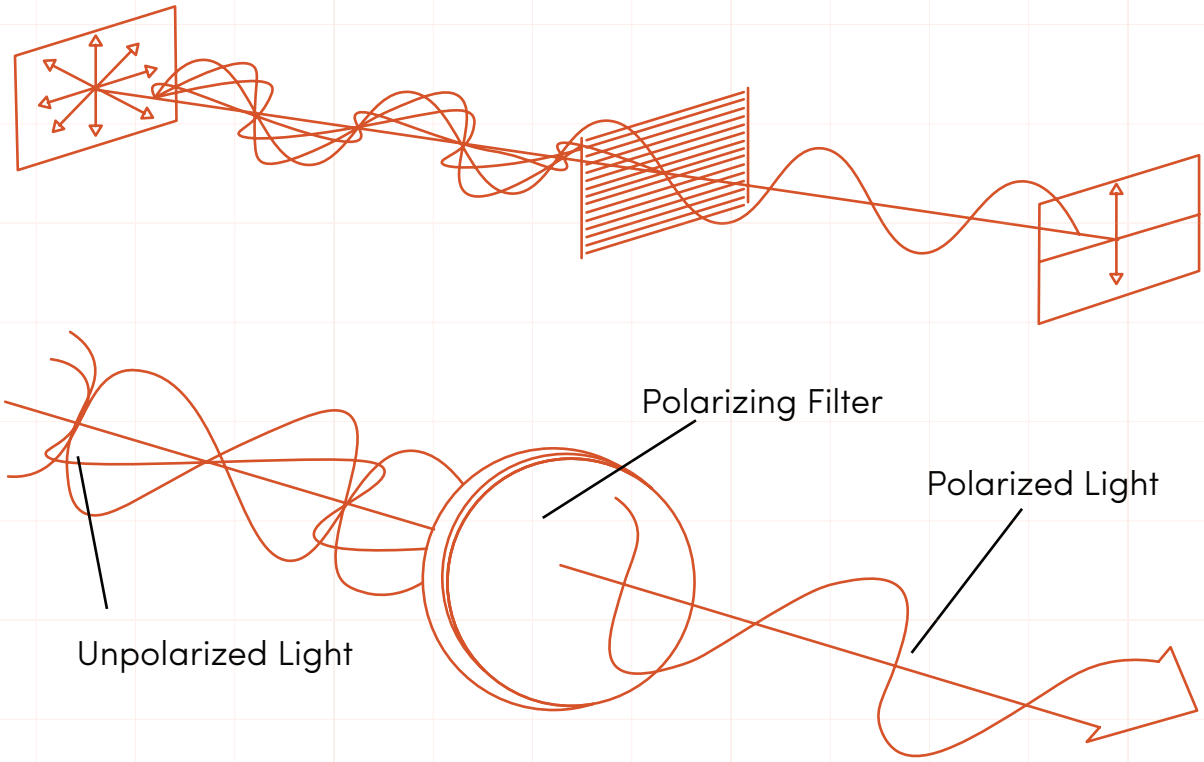


Fig. 2.6: Polarization of light by using a polarizing filter

TYPES OF POLARIZATION

There are 3 types

1. Linear Polarization:- The electric field of light is limited to a single plane along the direction of propagation

2. Circular Polarization:-When the amplitude are equal and the phase difference is 900, it forms circular motion.

3. Elliptical Polarization: - The amplitude and the phase difference of the linear components are not equal.

METHODS OF POLARIZATION OF WAVES

1. Mechanical method
2. Selective absorption method
3. Polarization by transmission
4. Polarization by reflection at 570 incident angle
5. Polarization by scattering
6. Polarization by refraction

APPLICATIONS OF POLARIZATION

1. It is used in sun glasses to reduce the glare
2. Polaroid filters are used in plastic industries for performing stress analysis tests
3. 3D movies are produced with the help of polarization
4. It is used to differentiate longitudinal and transverse waves
5. It is used in infrared spectroscopy
6. It is used in seismology to study earthquake
7. Chirality of organic compounds are tested using polarization techniques.

SUMMARY

So far, we have learnt how to

1. State and explain the properties of waves
2. Demonstrate diffraction of waves
3. Demonstrate interference of waves
4. Demonstrate polarization light waves

INTERACTIVE ASSESSMENT QUESTIONS

1. The chirality of organic compound are tested by
   - A Refraction
   - B Interference
   - C Polarization
   - D Reflection
   - E Diffraction

2. The bouncing off of wave when contacting a barrier is
   - A Polarization
   - B Refraction
   - C Diffraction
   - D Reflection

3. The spreading of wave through openings is
   - A Polarization
   - B Refraction
   - C Diffraction
   - D Interference

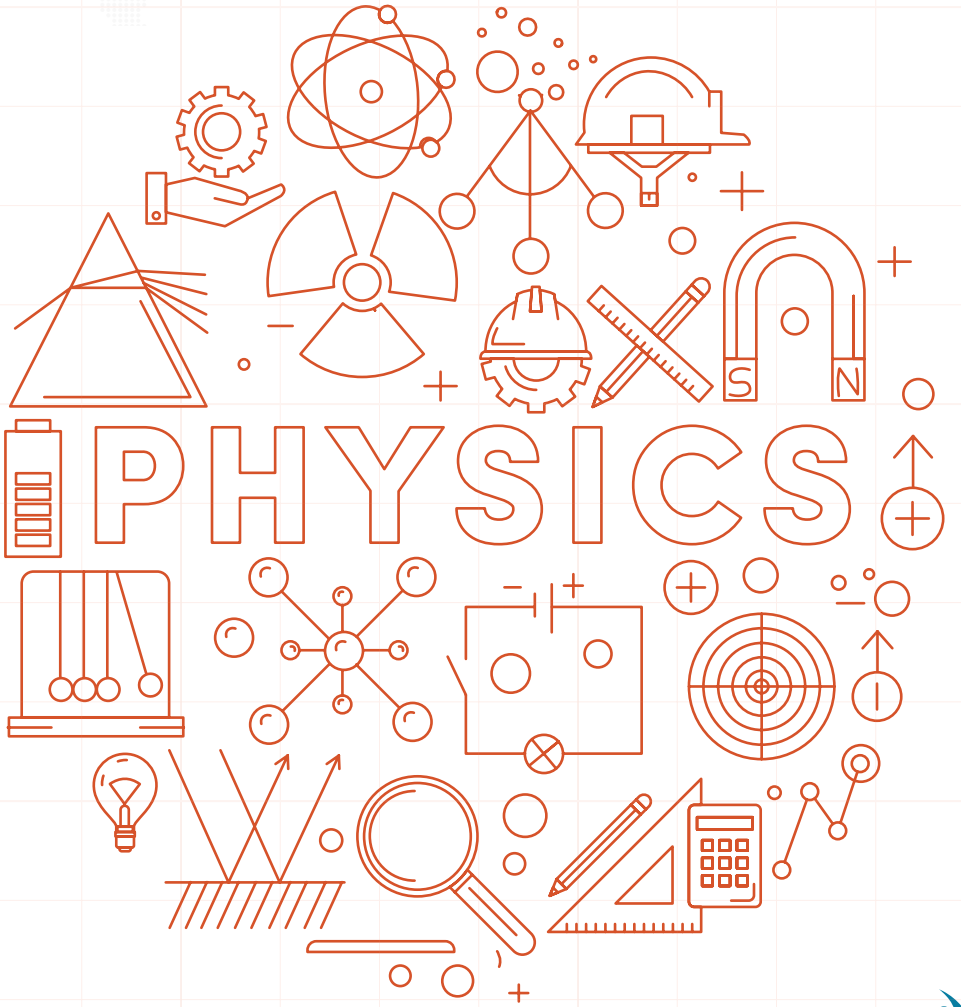
4. The wave that cannot be polarized is
   - A Reflection
   - B Transverse
   - C Longitudinal
   - D Longitudinal

5. The wave that travel with the speed of light is
   - A Mechanical
   - B Sound
   - C Electromagnetic
   - D Water wave.

ELECTROMAGNETIC WAVES

PERFORMANCE OBJECTIVES

1. Distinguish between electromagnetic waves and mechanical waves
2. List the types of radiation
3. State uses of electromagnetic waves
4. Use the formula to solve real problems.



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INTRODUCTION

THE ELECTROMAGNETIC WAVES

1. The wave formed as a result of the vibration of electric field and magnetic field when they are perpendicular to each other.

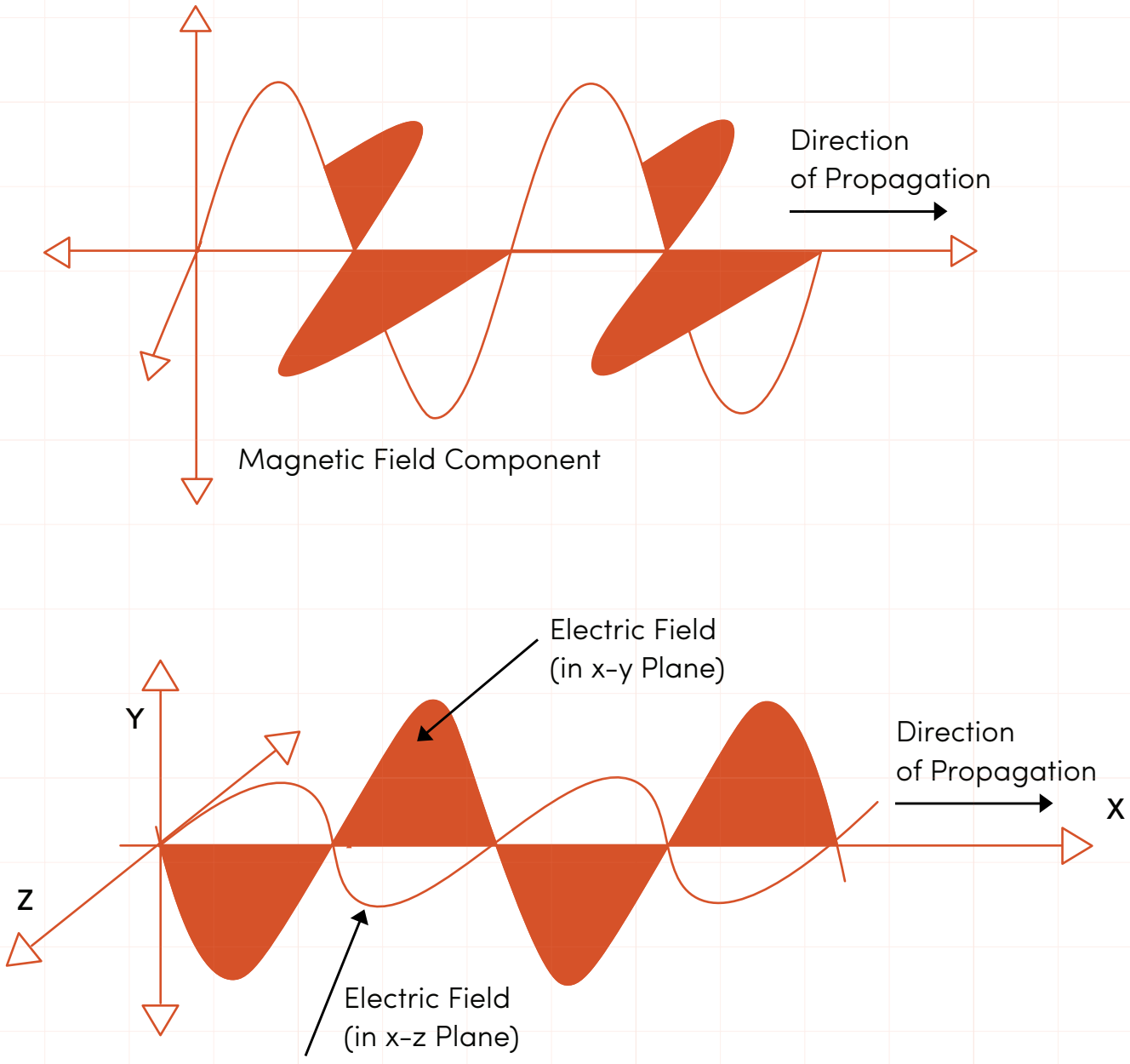


Fig. 2.7: Interactions between Electrons and Magnetic Field

Difference between Mechanical Waves and Electromagnetic Waves.

1. Mechanical waves are those that need medium in order to propagate while Electromagnetic Waves are those that do not require medium to propagate
2. Mechanical Waves cannot travel with the speed of light while Electromagnetic Waves do.
3. Mechanical Waves can be longitudinal or transverse but an Electromagnetic Waves are always transverse.

ELECTROMAGNETIC SPECTRUM

1. The electromagnetic spectrum is the range of all types of electromagnetic radiation.
2. Radiation is the energy that travel and spread out as it goes – the visible light which comes from bulb and the radio signals from a radio station are two types of electromagnetic radiations.
3. The other types of radiation are microwave, infrared, ultraviolet light, X-rays and gamma rays.
4. The radiation with the longest wavelength has the weakest frequency while the one with the shortest wavelength has the strongest frequency
5. The image below shows where you find each position of the electromagnetic spectrum.

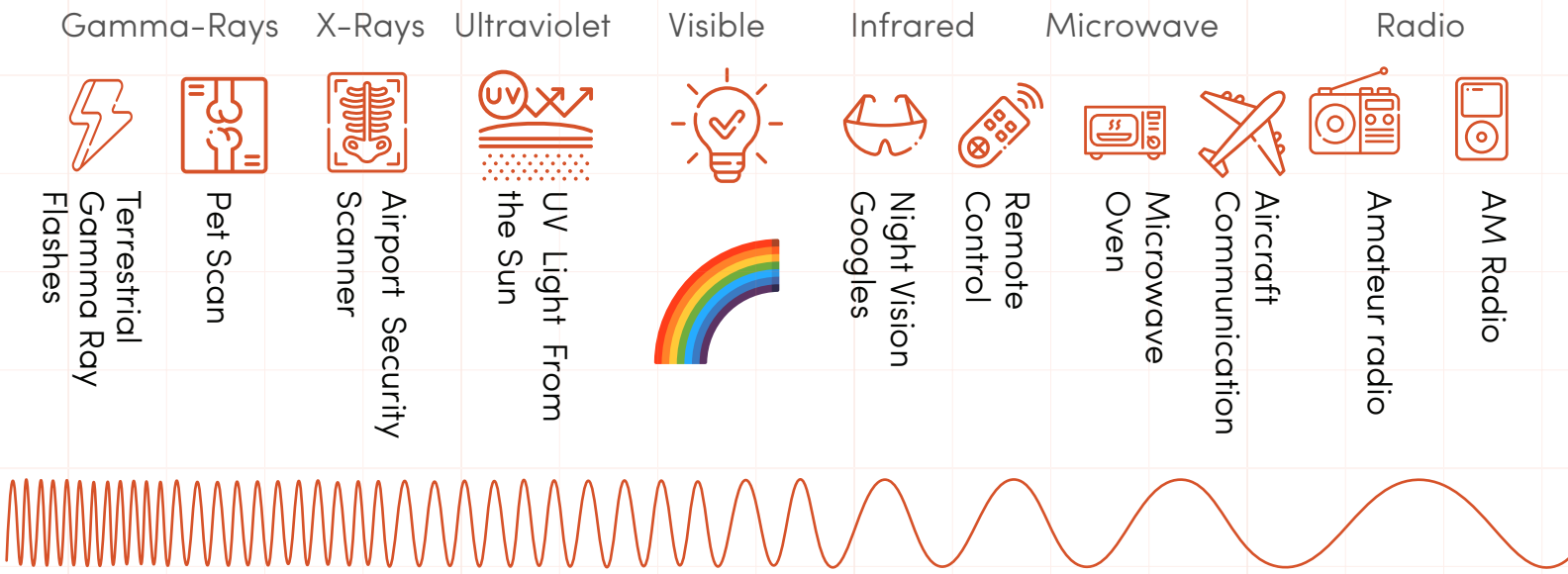


Fig. 2.8: The Electromagnetic Spectrum and its sources

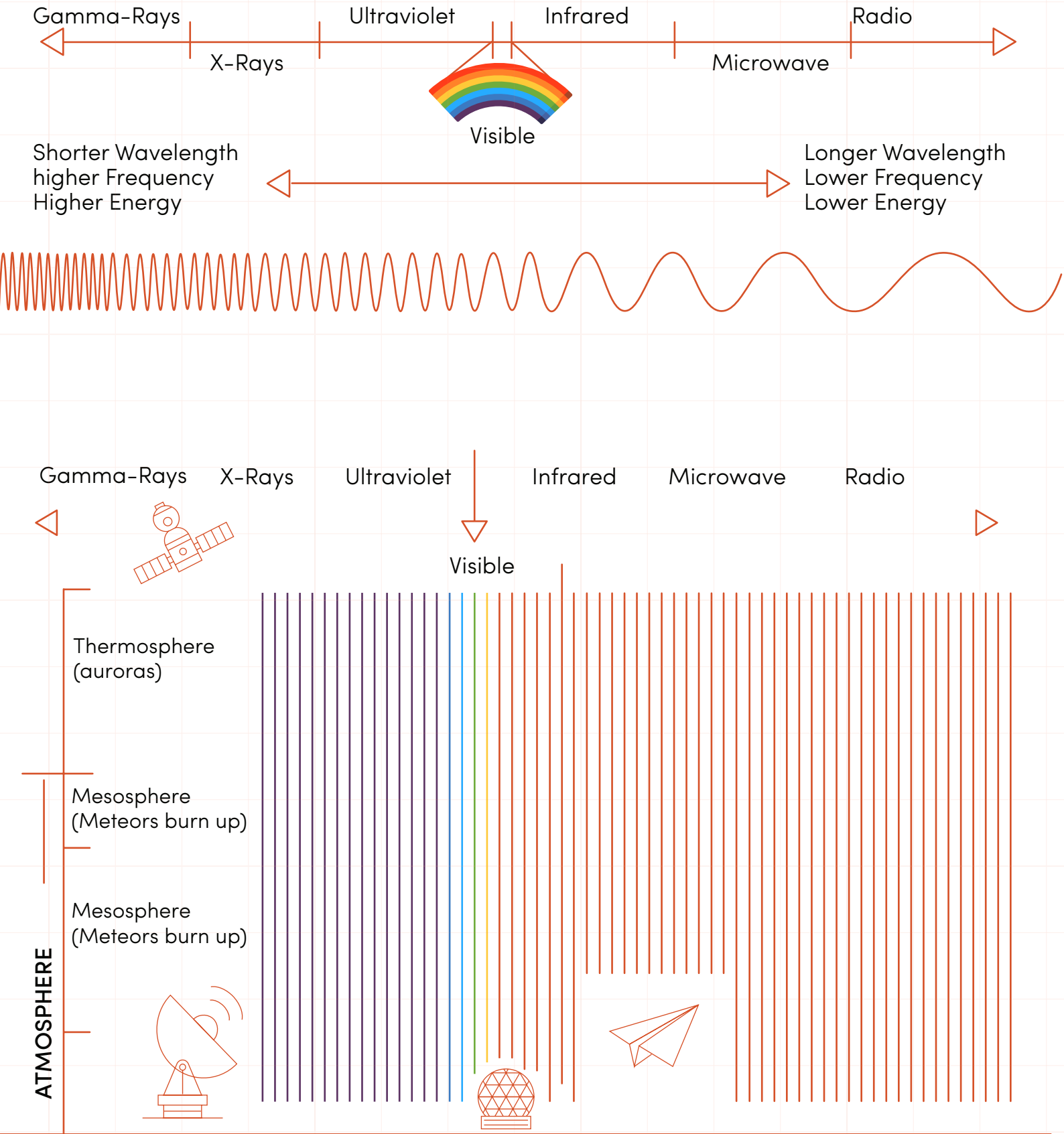


Fig. 2.9: The order of the Electro Magnetic Spectrum

USES OF ELECTROMAGNETIC WAVES

1. **Radio:** Radio signals emitted by radio stations, radio waves are also emitted by gases and stars in space.
2. **Microwave:** Microwave radiation cook food in few minutes. It is also used by astronomers to learn about the structure of nearby galaxies.
3. **Infrared:** Night vision goggles the infrared light emitted by skin and objects with heat. In space, infrared light is used for mapping the dust between stars.
4. **Visible:** Eyes detect visible light. Light bulbs, fire flies and stars all emit visible light.
5. **Ultraviolet:** Ultraviolet radiation is emitted by the sun and that is the reason skin tans and burns. Hot objects in space also emit UV radiation.
6. **X-ray:** Dentist uses X-rays imaging for teeth, and airport security uses it to see through bags. Hot gases in the Universe also emit X-rays.
7. **Gamma ray:** Doctor uses gamma-ray imaging to see the inside of the human body. The biggest producer of gamma-ray is the Universe.

The Formula of Electromagnetic Wave

$$f = \frac{c}{\lambda}$$

Where f = frequency

c = the speed of light 3×10^8m/s

λ = wavelength

Activity: A radio station has a frequency of 1000,000Hz, find the wavelength of the station

Solution

Using

$$f = \frac{c}{\lambda} \qquad \text{Then, } 1000000 = \frac{3 \times 10^8}{\lambda}$$

$$\lambda = \frac{3 \times 10^8}{1000000} = 300\text{m}$$

SUMMARY

So far, we have learnt how to

1. Distinguish between electromagnetic waves and mechanical waves
2. List the types of radiation
3. State uses of electromagnetic waves
4. Use the formula to solve real problems.

INTERACTIVE ASSESSMENT QUESTIONS

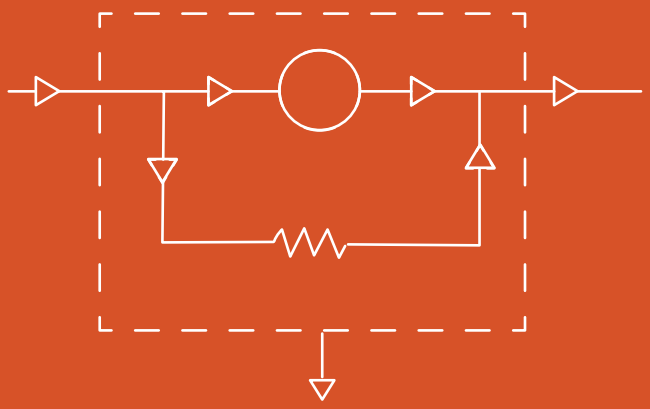
1. Microwave is a type of radiation. True or False

2. Radio wave has the highest frequency in the electromagnetic spectrum. True or False

3. X-ray is the strongest radiation. True or False

4. Electromagnetic radiations can be used to sterilize medical equipment. True or False

5. Human eyes cannot detect visible light radiation . True or False



THEME 03

Conservation Principles

Wave, motion without material transfer

Field at rest and in motion

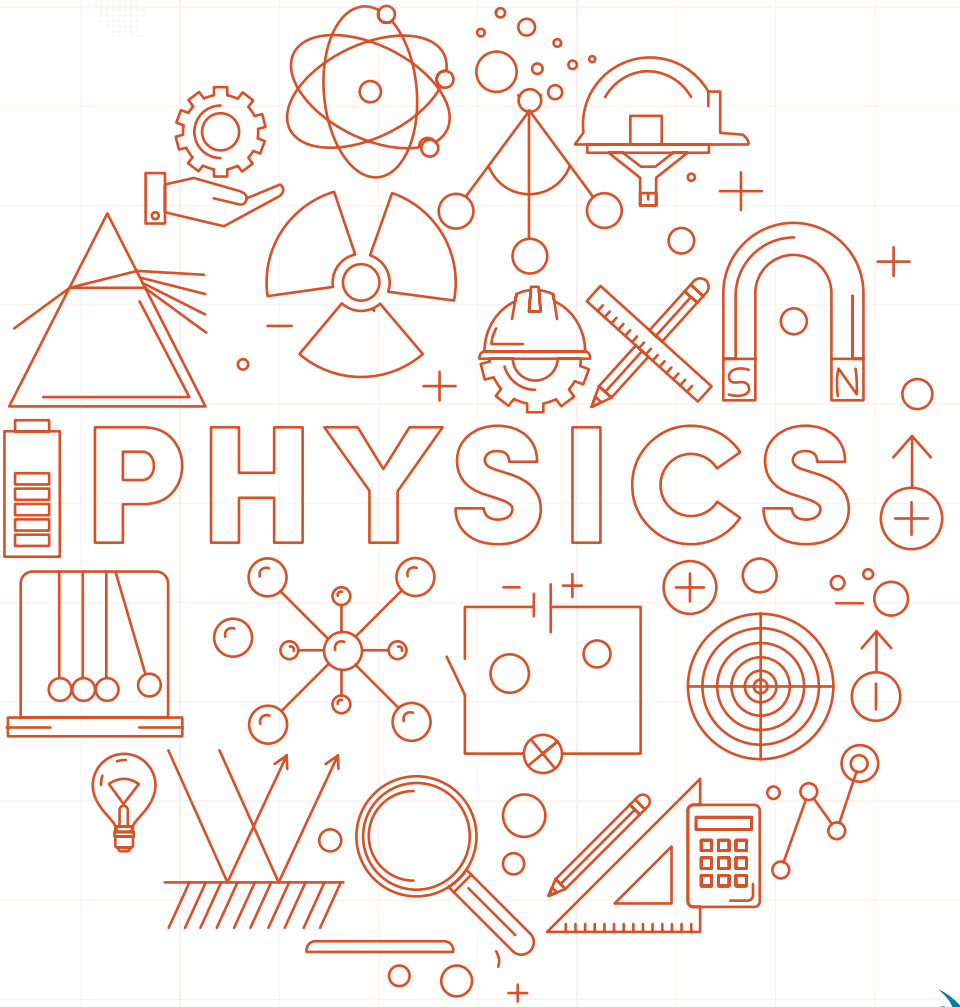
Energy quantization and duality of matter

Physics in Technology

GRAVITATIONAL FIELD

PERFORMANCE OBJECTIVES

1. Calculate gravitational force between two masses
2. Calculate gravitational force between two planets
3. Explain “G” and show “g” is the force per unit mass on the surface of the earth
4. Relates Kepler’s laws to the motion of the solar system
5. Distinguish between natural and artificial satellite
6. Explain the concept of escape velocity and how satellites are launched



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INTRODUCTION

GRAVITATIONAL FIELD

Gravitational field is a region or space around the mass of an object where gravitational force could be felt or experienced.

GRAVITATIONAL FORCE

Is the force of attraction between two bodies M1 and M2 is directly proportional to the product of their masses M1 and M2 and inversely proportional to the square of the distance d between them.

This force acts along the line joining their center and it's called Newton's law of Universal gravitation.

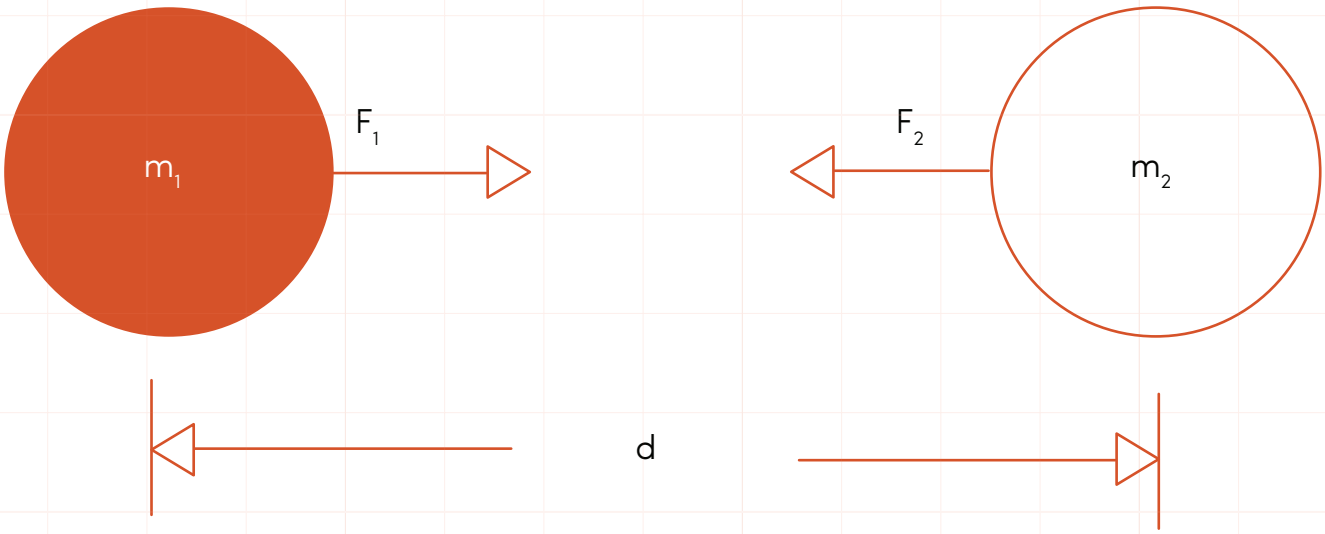


Fig. 3.1: Gravitational attraction between two bodies.

$$F_1 = F_2 = F = G\frac{m_1 m_2}{d^2}$$

$$f \alpha = \frac{M_1 m_2}{d^2}$$

$$f = \frac{GM_1 m_2}{d^2}$$

Where **F** = Gravitational force of attraction in Newton

- M_1 = mass of first body
- M_2 = mass of second body
- D = distance between the two bodies
- G = Gravitational constant **G** = 6.67×10^{-11} Nm^2kg^{-2}.

1. **Activity:** Two balls of masses 50kg and 45kg respectively have a distance of 1m between them, calculate the force of attraction between the two balls. (**G**=6.67×10^{-11} Nm^2kg^{-2})

Solution.

$$f \alpha = \frac{M_1 m_2}{d^2}$$

$$f = \frac{6.67 \times 10^{-11} \times 50 \times 45}{1^2} = 3.01 \times 10^{-7} \text{ N}$$

ACCELERATION DUE TO GRAVITY g AND GRAVITATIONAL FIELD

The acceleration due to gravity g is also known as the force per unit mass m of a body.

$$f = \frac{GM_e m}{d^2_e} = mg$$

M_e = mass of the earth

d_e= distance of the earth to the body m

$$f = \frac{GM_e m}{d^2} = mg$$

$$\therefore g = \frac{GM_e}{d^2}$$

GRAVITATIONAL POTENTIAL

The work done in taking a unit mass from infinity to the point.

$$V = -\frac{GM_e}{d^2}$$

The negative sign indicates that the potential decreases when an object is moving from infinity towards the earth.

Activity: Find the gravitational potential on the surface of the earth with mass 6.00 x 10^{24}kg and radius 6 x 10^{5}m.

Solution:

$$V = -\frac{GM_e}{d^2} = -\frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{6 \times 10^{5}} = 6.6x10^{8}jkg^{-1}$$

KEPLER'S

Kepler's laws of planetary motion explain the orbit of bodies around the sun,

The laws are:

1. The radius vector between the planets and the Sun sweep equal areas in equal time.
2. The ratio of the square of the period of revolution to the cube of the average distance from the Sun
3. Planetary orbits are elliptical with the sun at a focus.

These explained better how planetary bodies orbiting the Sun.

NATURAL AND ARTIFICIAL SATELLITES

Satellite is a body of mass that moves round another body.

There are two types

1. NATURAL SATELLITES: The celestial bodies that orbit the planets, examples are the moons of the planetary bodies. The moons are the natural satellites.
2. ARTIFICIAL SATELLITES: The man-made objects orbiting the earth and other planets such as sputnik, space telescopes.

LAUNCHING OF SATELLITES

Only artificial satellites can be launched, and they are launched with the aid of rockets, it is first carried to a certain height above the earth, then launched in a direction parallel to the earth's surface with powerful launching of rocket to beat the earth gravity.

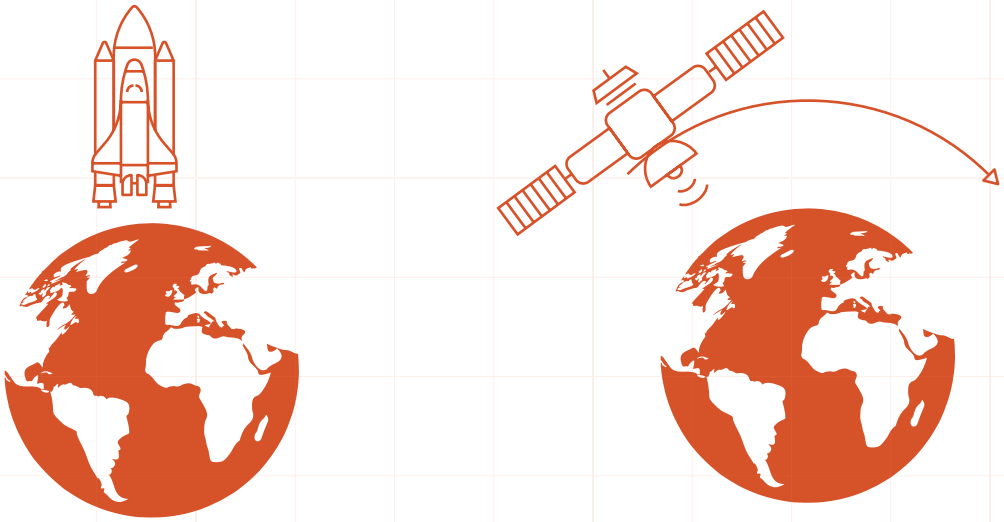


Fig. 3.2: Launching of Satellites

ESCAPE VELOCITY

The minimum velocity needed by a body to escape or leave the gravitational field of any planetary bodies.

Work done = force x distance = Kinetic energy

$$W = \frac{GM_e m}{d^2} \times d = \frac{1}{2} mv_e^2 = \frac{GM_e m}{d} = \frac{mv}{2^2}$$

$$v^2 = \frac{2GM}{d} \quad \text{and} \quad M = \frac{gd^2}{G}$$

$$\text{Substitute} \quad V^2 = \frac{2G}{d} \times \frac{2d^2}{G} = 2gd$$

Where d = r = R radius of the earth

$$\therefore v = \sqrt{2gR}$$

R = 6400km radius of the earth

SUMMARY

So far, we have learnt how to

1. Calculate gravitational force between two masses
2. Calculate gravitational force between two planets
3. Explain "G" and show "g" is the force per unit mass on the surface of the earth
4. Relates Kepler's laws to the motion of the solar system
5. Distinguish between natural and artificial satellite
6. Explain the concept of escape velocity and how satellites are launched

INTERACTIVE ASSESSMENT QUESTIONS

1. Satellite is by

   A Moving
   B Orbiting
   C Energy
   D Mass
   E Skipping

2. Field is a

   A Force of attraction
   B Gravity
   C Space where force is experienced
   D Constant

3. "g" varies in all planets. True or False

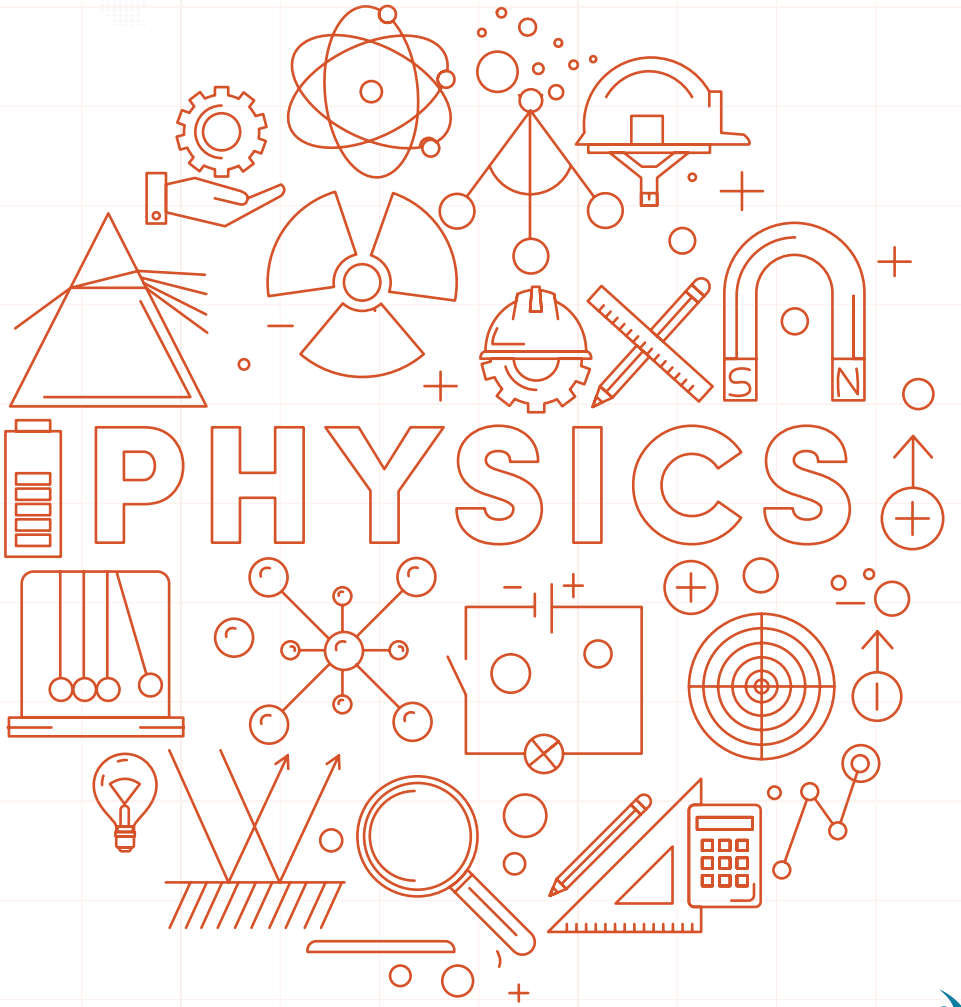
4. Natural satellites are

5. Aeroplanes can escape from the gravitational field of the earth

ELECTRIC FIELD

PERFORMANCE OBJECTIVES

1. Identify all the component parts of simple cells
2. Identify the series and parallel connections of cells and resistors
3. State galvanometer conversion and the conditions for balance Wheatstone bridge
4. Explain the basic principle of potentiometer
5. Explain the conditions which liquid and gases conduct electricity and its applications
6. State electric force between charges
7. State the electric field intensity, capacitance and its connections
8. State energy stored in capacitor.



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ELECTRIC FIELD

Production of charges

Charges are produced by cells, dynamo and others

Components of cells are :

1. **The electrodes:** positive and negative metal rods or plates placed in the cells for easy connection and flow of charges.

   The positive electrodes are carbon rod (graphite), copper rods, brass

   The negative electrodes are zinc rods

2. **Electrolytes:** the chemical solution that dissociates which can allow the flow of charges, examples are dilute acids, bases.

CONNECTION OF CELLS AND RESISTORS

There are only two connections of cells

1. Series connection: The linear connection of cells

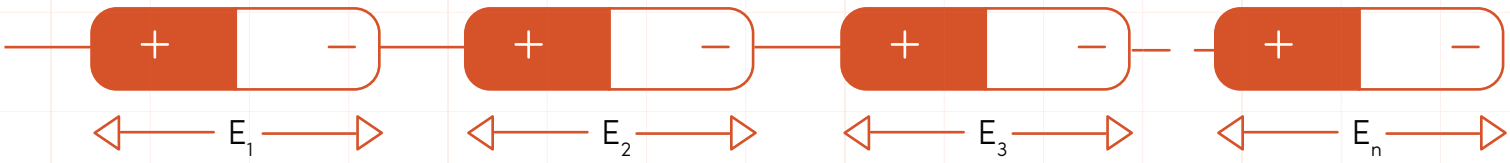


Fig. 3.3: Arrangement of cells in series

The total resistance value is:

$E = E_1 + E_2 + E_3 + ... + E_n$

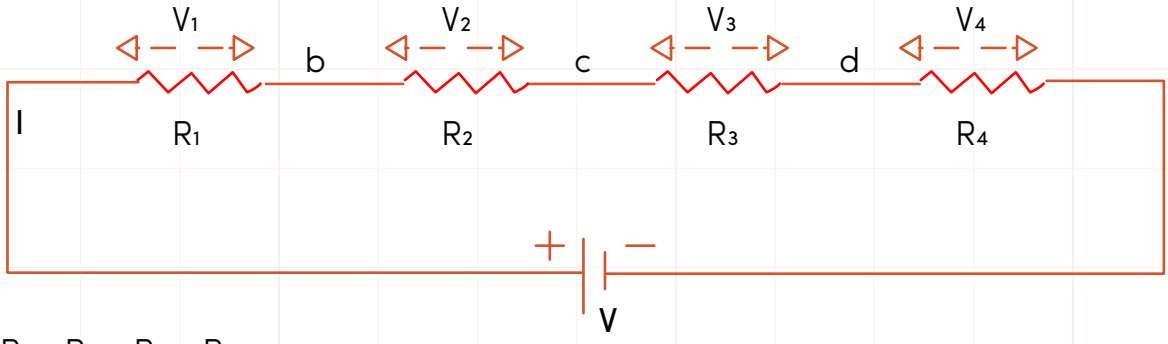
2. Parallel connection:- The non-linear connection of cells

$E = E_1 + E_2 + E_3 + ... + E_n$

For cells in series connection increase the voltage of the cell while the parallel connection does nothing and the value will not change

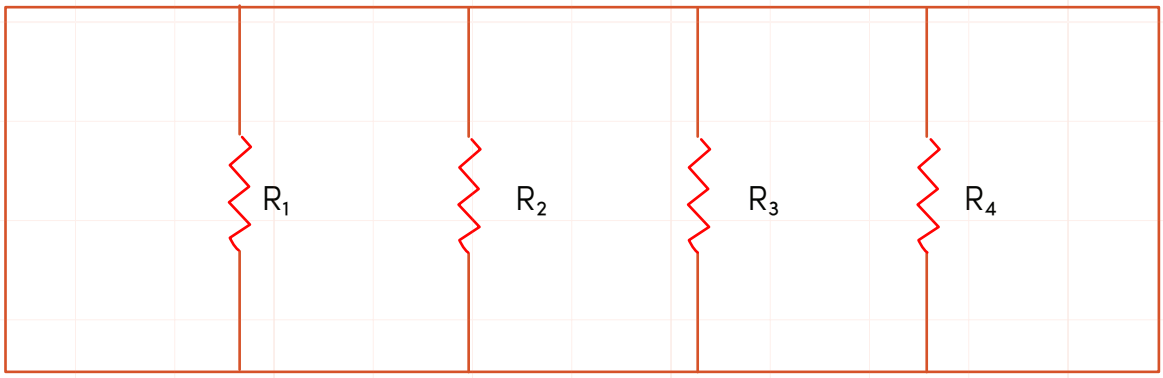
Resistor connection

1. Series connection: The linear connection of resistors



$R_T = R_1 + R_2 + R_3 + R_4$

2. Parallel connection: The non-linear connection of resistors



$R_T = R_1 + R_2 + R_3 + R_4$

3. Parallel connection: The non-linear connection of resistors

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}$$

Galvanometer conversion

To ammeter:-It is connected in parallel to the standard resistor in parallel called shunt

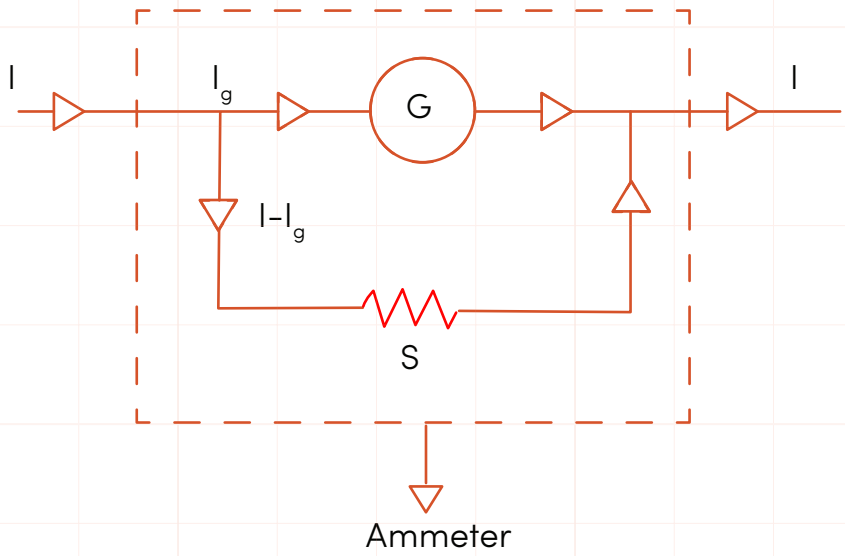


Fig. 3.4: Conversion of galvanometer to ammeter

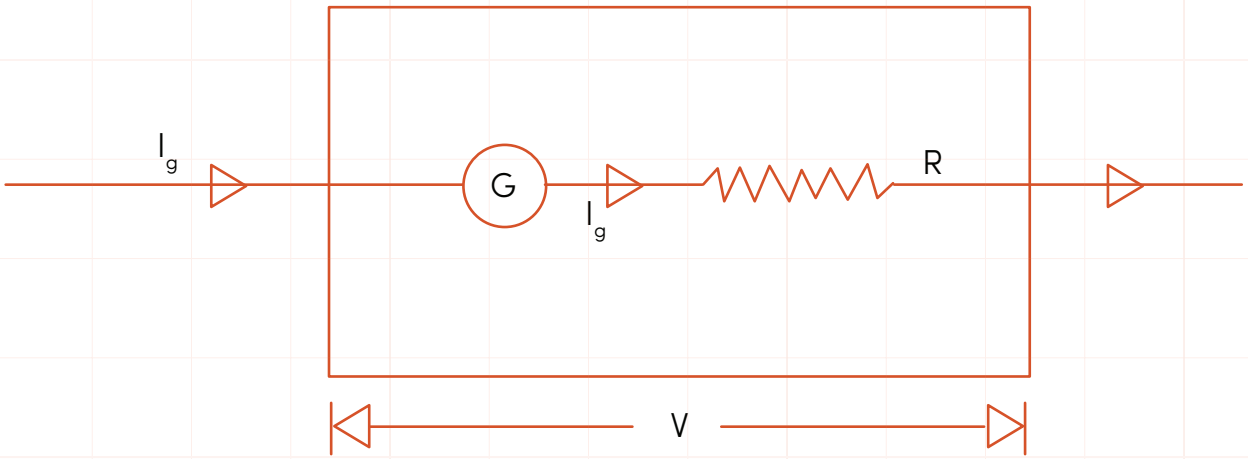


Fig. 3.5: Conversion of galvanometer to voltmeter

$I_g = I_m$

$V = IR$

$V_g = I_g R_g$

$V_m = I_m R_m$

$V = V_g + V_m = I_g R_g + I_m R_m = IgR_g + I_g R_m = I_g(R_g + R_m)$

Activity:

A galvanometer which has 200Ω gives a full scale deflection for a current of 10mA. Calculate the values of the resistance to convert the galvanometer to,

(a) An ammeter reading up to 10A

(b) A voltmeter reading up to 5V.

SOLUTION

(a) For shunt

I=10A, I_g= 10mA = 10x10 - 3A

$I_s = I - I_g = 10 - 0.01 = 9.99A$

$R_s = I_g R_g / Is = 0.01 \times 200 / 9.99 = 0.2\Omega$

(b) For multiplier

$V = I_g(R_g + R_m)$

$Rm = V - I_g R_g / I_g$

$= 5 - 0.01 \times 200 / 0.01 = 300\Omega$

RESISTIVITY AND CONDUCTIVITY

Resistivity: the resistance of unit length of a material of unit cross-sectional area

$\rho = RA/L$

Where ρ = resistivity of the wire

R = resistance of the wire

A = cross sectional area of the wire

L = length of the wire

CONDUCTIVITY σ

Conductivity of the wire is the reciprocal of the resistivity of the wire

$\sigma = 1/\rho$

POTENTIOMETER

It is a device for measuring an accurate value of potential difference or to compare the emf of the cells.

It consists of a resistance wire of about 1m placed on metre-rule, a cell and variable resistor are connected across it to maintain constant flow of current through the resistance wire.

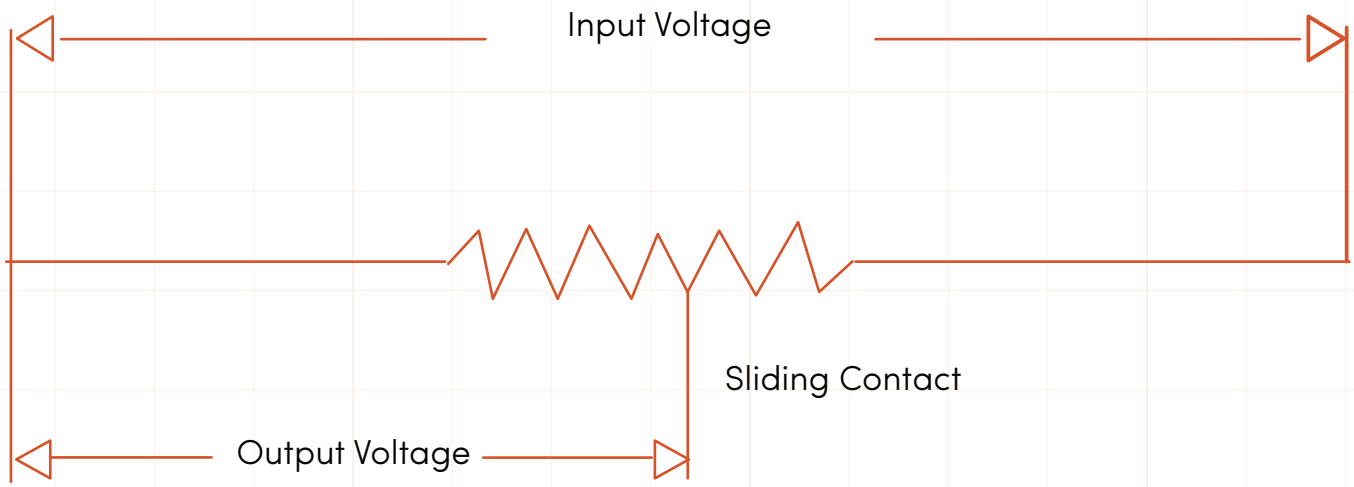


Fig. 3.6: The potentiometer

WORKING PRINCIPLE

When there is steady flow through it wire, there will be steady p.d drop throughout the wire.

In that case V is directly to I

$V \alpha I$

$V \alpha L$

Advantage of potentiometer over Voltmeter

1. It does not give reading errors
2. It measures emf to a very high degree of accuracy
3. It can measure in an open circuit.

WHEATSTONE BRIDGE

An instrument that consists of four standard resistors arranged as shown below, with a galvanometer at the centre.

It is used to measure the unknown resistance

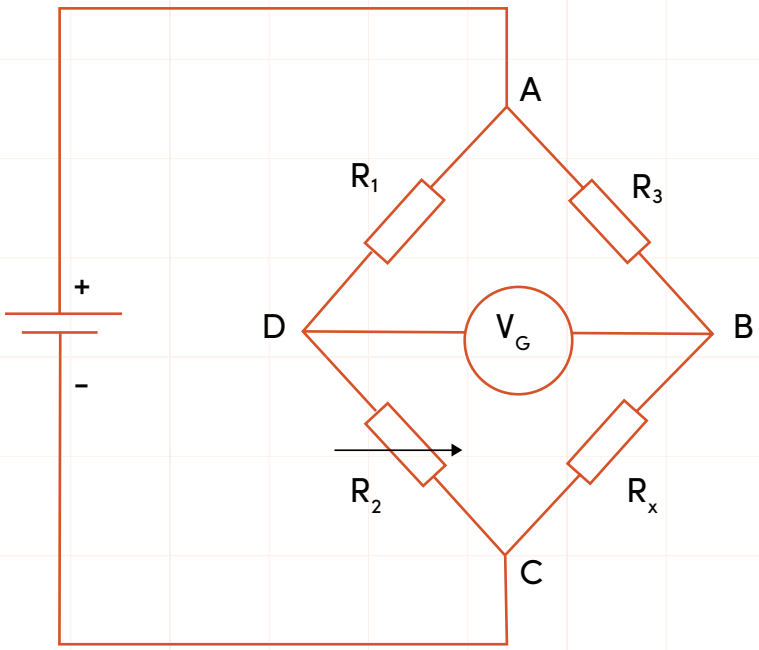


Fig. 3.7: Wheatstone Bridge

$$\frac{R_1}{R_2} = \frac{R_3}{R_X}$$

METRE BRIDGE

Is a practical connection of wheatstone bridge which is used to find unknown resistance

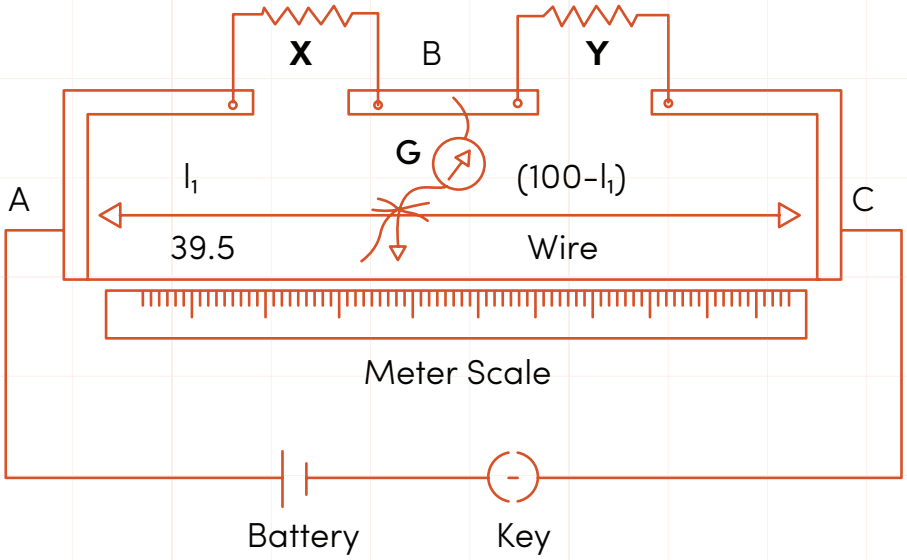


Fig. 3.8: Meter Bridge

$$\frac{R_x}{R} = \frac{x}{100 - x}$$

OHM's LAW

Ohm's law stated that the current flowing in the conducting material is proportional to the potential difference across its ends when the temperature and other factors are constant.

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

CONDITION WHICH LIQUID AND GASES CONDUCT ELECTRICITY

Electrolysis: Is defined as the chemical decomposition of a liquid due to the flow of charges

Electrolyte: The chemical or liquid in molten form that can allow the flow of charges e.g. diluted acids and bases

Electrodes: The conducting plates or rods inserted in the electrolytes for the flow of charges.

Volt-ammeter A device for studying the flow of charges in an electrolyte.

FARADAY LAWS OF ELECTROLYSIS

1. States that the mass m of a substance deposited during electrolysis is proportional to the quantity of charges passing through the electrolyte

$$M \alpha Q$$

$$M = ZQ$$

Where Q=It, Therefore M= ZIt

M=mass of the substance, I=current, t=time and Z=electrochemical equivalent g/c

In a situation where density of substance is given

Mass = density x volume

2. The second law states that when same current passes through different electrolyte for the same time, the masses deposited are proportional to their chemical equivalent

$$\frac{\text{Mass of A}}{\text{Mass of B}} = \frac{\text{De-electrochemical equivalent of A}}{\text{De-electrochemical equivalent of B}}$$

APPLICATION OF ELECTROLYSIS

It can be used for

1. Electroplating
2. Calibration of ammeter

CONDUCTION OF ELECTRICITY THROUGH GASES

Gases can conduct electricity at very low pressure and very high voltage, in this process cathode ray tube, fluorescent lamps can be produced.

ELECTRIC FIELD

Electric field is a space where electric force could be felt.

ELETRIC FORCE:-The force of attraction or repulsion between two points charges q_1 and q_2 is proportional to the product of their charges and inversely proportional to the square of the distance between the two charges

Fig. 3.9: The force between two charges q_1 and q_2

$$F_e \alpha \frac{kq_1q_2}{d^2} \qquad F = \frac{kq_1q_2}{d^2}$$

Where K= constant = $1/4\varpi\varepsilon 0 = 9 \times 10^9 Nm^2/c^2$

ELECTRIC FIELD INTENSITY

Is the force experienced by a unit positive charge at a point?

$$F = \frac{F}{q} = \frac{kq}{d^2}$$

The unit is N/C.

ELECTRIC POTENTIAL

Is the work done by an electric field in bringing a unit positive charge from infinity to that point.

$$V = \frac{kq}{d} = \frac{q}{4\ \varpi\varepsilon 0\ d}$$

The unit is volt.

CAPACITOR AND CAPACITANCE

A **capacitor** is a device for storing charges.

Capacitance (**C**), is the ratio of charges **q** stored by the capacitor to the potential difference **V** between the plates

$$c = \frac{k}{v}$$

It is measured in farad.

Capacitance of parallel plates is :

$$c = \frac{\varepsilon A}{d} = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

A = Area of plates

d = Pistance between plates

ε = Permittivity of material

ε_0= Permittivity of free space

ε_r= Relative permittivity of material

CONNECTION OF CAPACITORS

Series connection: The linear or chain arrangement of capacitors

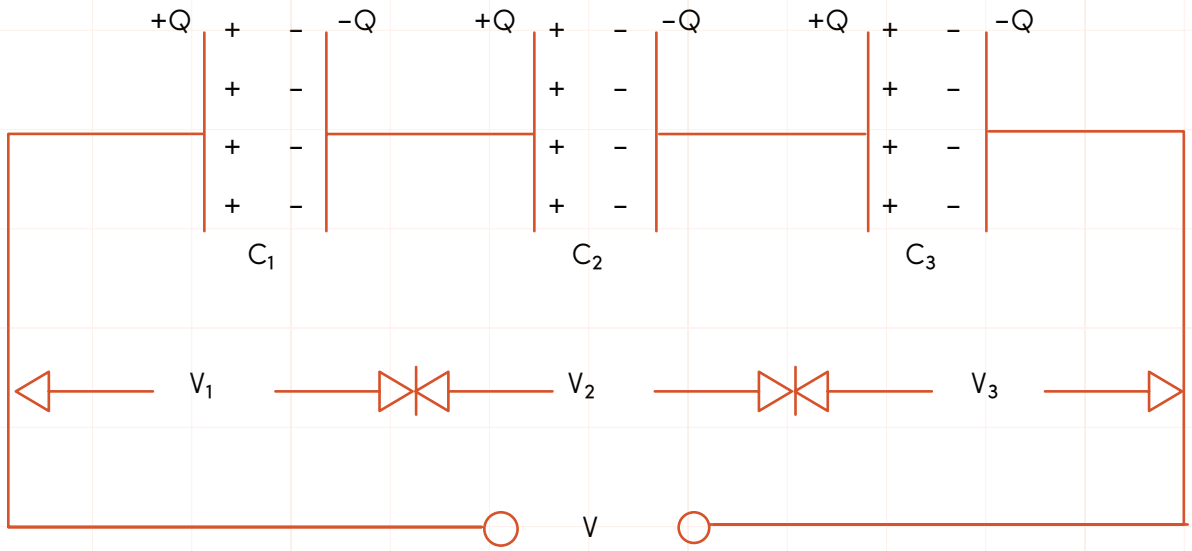


Fig. 3.10a: The arrangement of capacitors in series

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

Parallel connection: Non-linear arrangement of capacitors

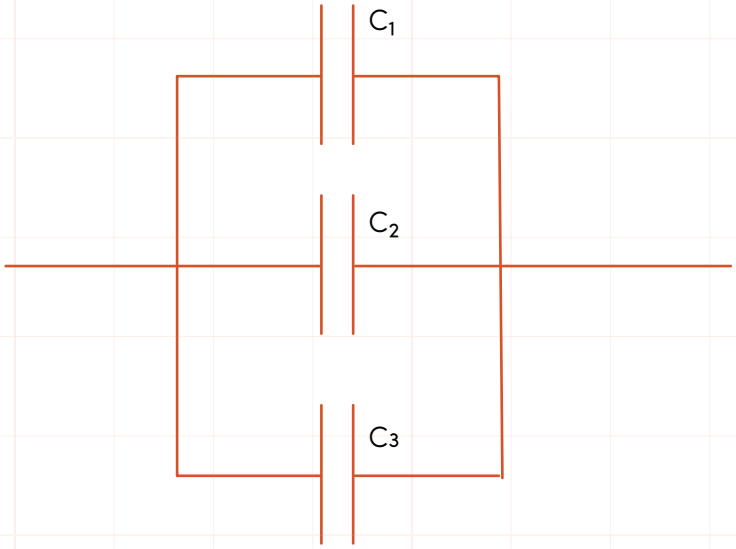


Fig. 3.10b: The arrangement of capacitors in parallel

ENERGY STORED IN A CAPACITOR

Energy stored is the work done in charging the capacitor

$$W = \frac{qV}{2} + \frac{CV^2}{2} + \frac{q^2}{2C}$$

Where W= work done, q= quantity of charge, C=capacitance value and V=voltage

USES OF CAPACITORS

Capacitors are used for:

1. For spark plug
2. For tuning circuit in radio
3. For engine ignition system.

The factors which the capacitance of a parallel plates capacitor depend

1. The area of the plates
2. The distance between the plates
3. The nature of the dielectric material
4. The quantity of charge on the plates.

SUMMARY

So far, we have learnt how to

1. Identify all the component parts of simple cells
2. Identify the series and parallel connections of cells and resistors
3. State galvanometer conversion and the conditions for balance Wheatstone bridge
4. Explain the basic principle of potentiometer
5. Explain the conditions which liquid and gases conduct electricity and its applications
6. State electric force between charges
7. State the electric field intensity, capacitance and its connections
8. State energy stored in capacitor.

INTERACTIVE ASSESSMENT QUESTIONS

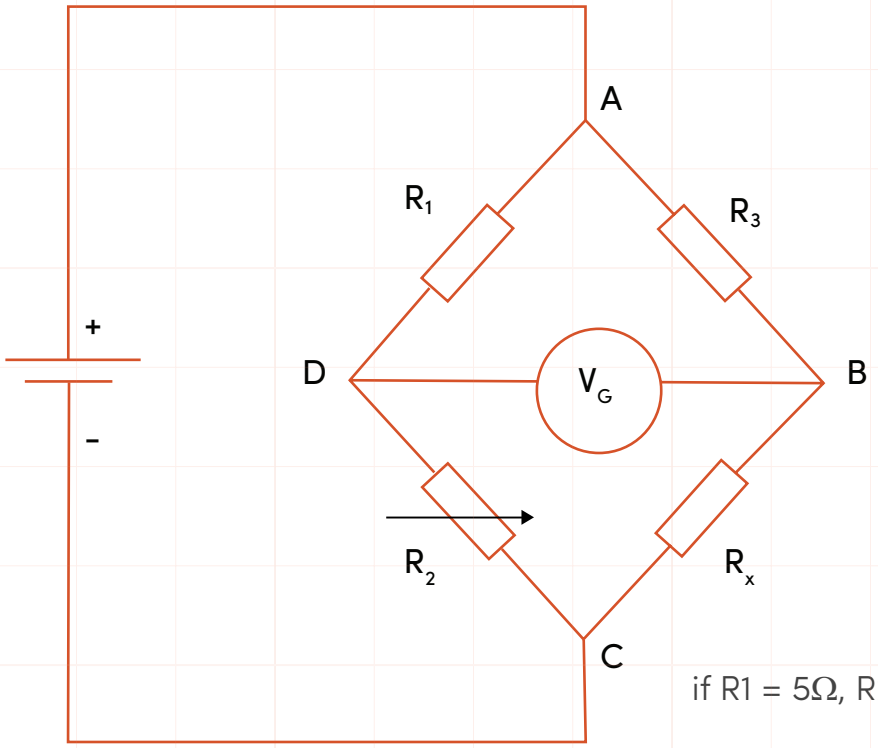
1. Which of the following is not a components of cells

   A Dilute acid
   B Diamond
   C Ammonium chloride
   D Graphite
   E Zinc rod

2. A galvanometer which has 200Ω gives a full scale deflection for a current of 10mA. Calculate the values of the resistance to convert the galvanometer to an ammeter reading up to 10A

   A 2Ω
   B 20Ω
   C 0.2Ω
   D 200Ω
   E 0.02Ω

3. Using the diagram below to solve the question



if R1 = 5Ω, R2 = 10Ω and R3 = 16Ω

A 30Ω
B 35Ω
C 42Ω
D 32Ω
E 20Ω

4. The conditions in which gases conduct electricity are

A High current and high voltage
B Low current and low voltage
C High current and low voltage
D Low current and high voltage
E Low current and high resistance

5. State the electric force between charges

6. State electric field intensity and electric potential

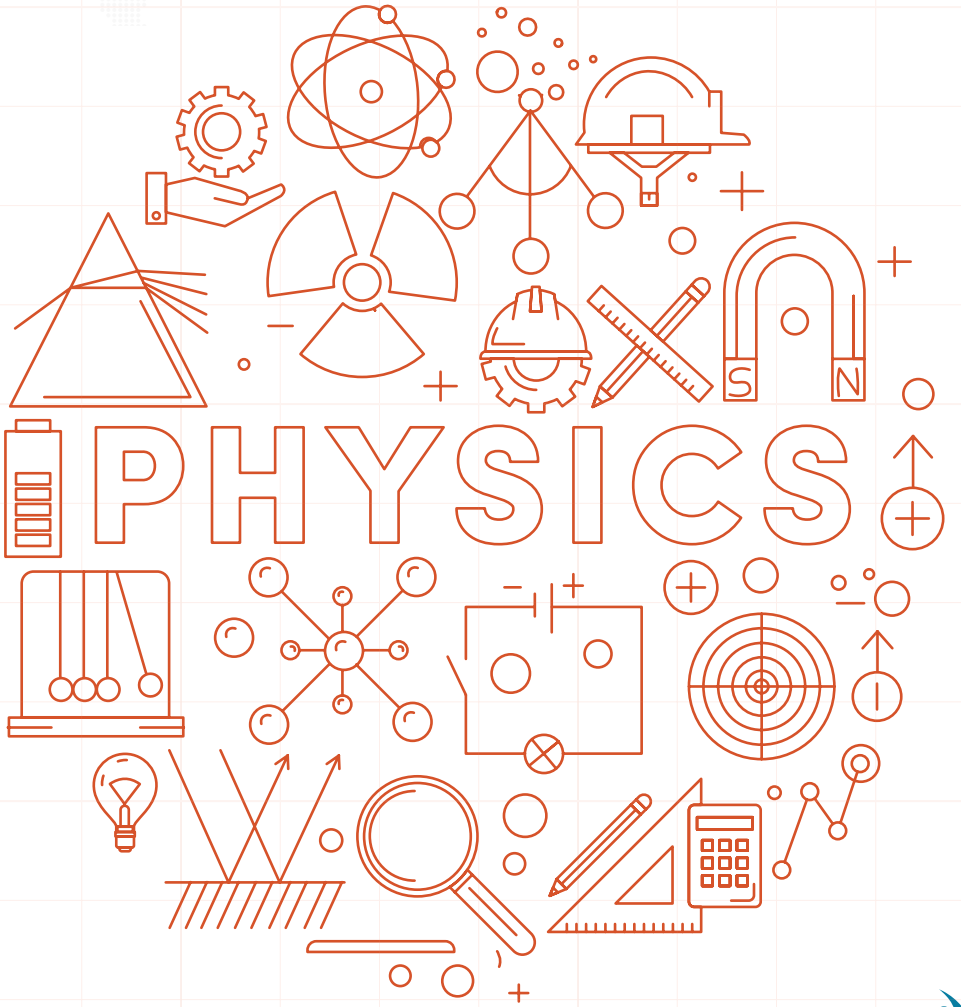
7. On which of the following factors does the capacitance of a parallel plate's capacitor depend?
   (i) The area of the plates
   (ii) The distance between the plates
   (iii) The nature of the dielectric constant between the plates
   (iv) The amount of charge on the plates

   A (i) and (ii) only
   B (i), (ii) and (iii) only
   C (i), (iii) and (iv) only
   D (ii) and (iii) only
   E (i), (ii), (iii) and (iv) only

MAGNETIC FIELD

PERFORMANCE OBJECTIVES

1. Plot magnetic field.
2. Make a magnet from a soft iron bar.
3. Make an electromagnet.
4. Describe the working principle of electric bell and ear piece.
5. Locate the earth's magnetic north-south direction.
6. Explain the magnetic force on a moving charge.
7. State the relation between magnetic force and motion of a charge in a magnetic field.



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MAGNETIC FIELD

Magnetic field is a region or space where magnetic force is experienced or felt.

Magnetic line of force

The imaginary lines running from North pole to South pole of a bar magnet

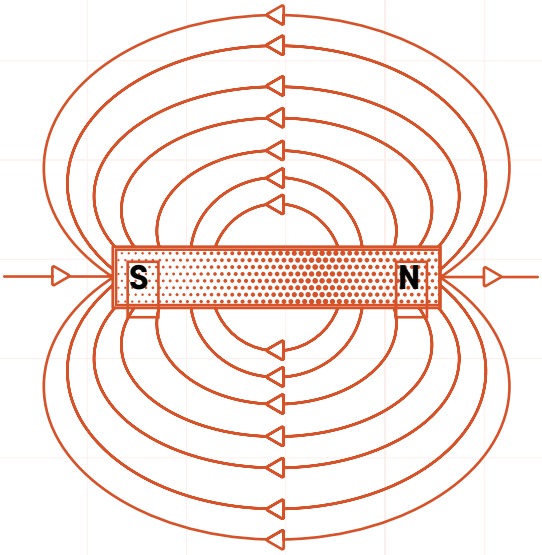


Fig. 3.11: Magnetic lines of forces

LAWS OF MAGNET

1. Like poles repel
2. Unlike poles attract

Magnetic field around a conductor

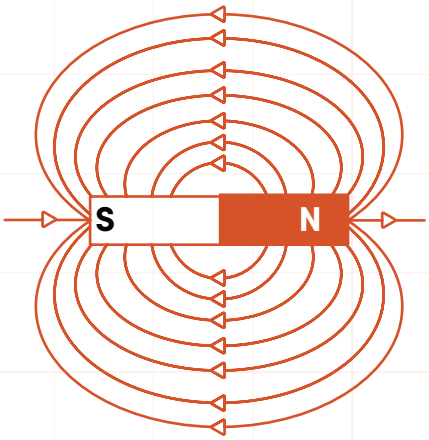


Fig. 3.12a: Bar Magnet

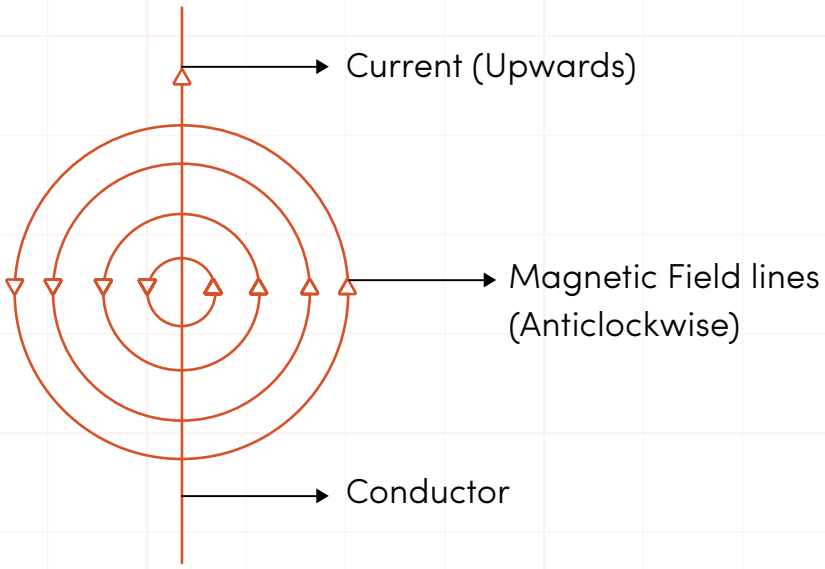


Fig. 3.12b: Straight Conductor

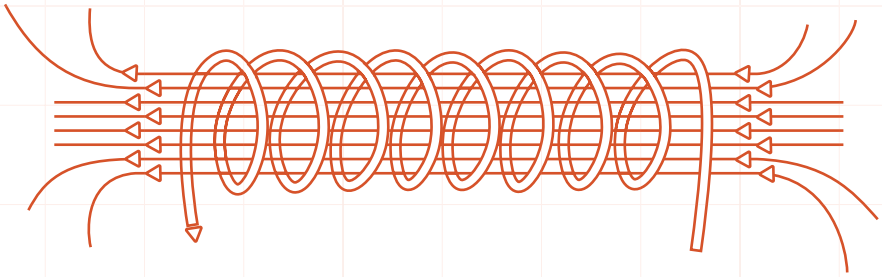


Fig. 3.12c: Solenoid

MAKING OF MAGNET

Magnet can be made by the following processes

1. **Contact:** When a soft iron bar or steel is placed or touched a magnet in an inclined position and dragged

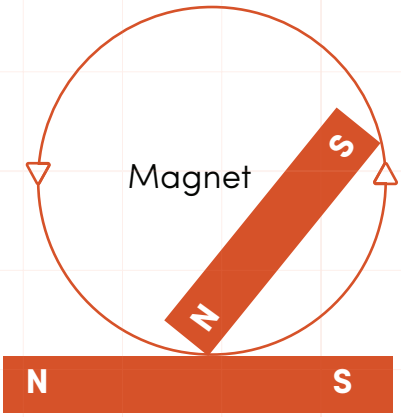


Fig. 3.13: Magnetization by Contact method

2. **Electrical method:** When a soft iron rod is passed through a solenoid coil connected to electrical source,it becomes a magnet.

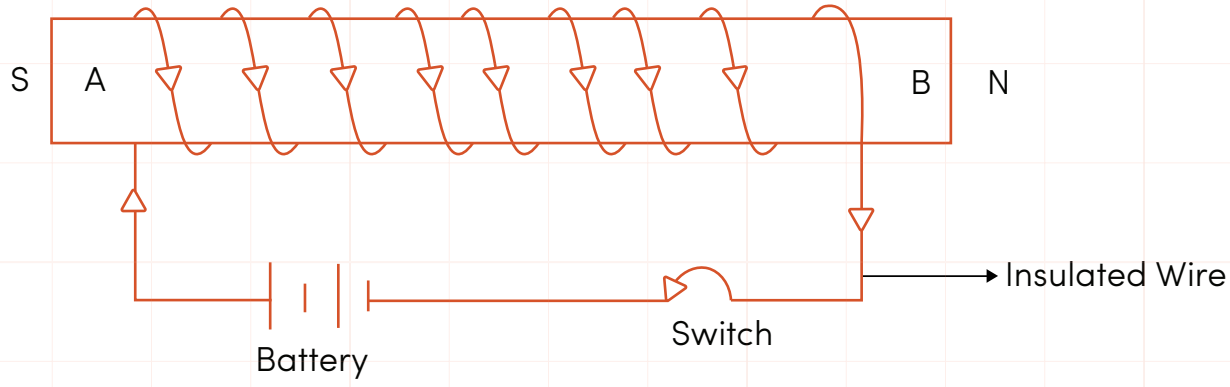


Fig. 3.14: Magnetization by Electrical method

DEMAGNETIZATION

The process of which magnet is losing it magnetism, they are:

1. **Electrical method:** When a soft iron rod is passed through a solenoid in reverse order, it loses it magnetism
2. **Mechanical method:** When a magnet is beating or hitting a magnet, it loses it magnetism.
3. **Thermal method:** When a magnet is heated, it loses it magnetism

Magnetic properties of soft iron and steel

1. Pure iron called soft iron is easily magnetized than steel and also loses its magnetism faster
2. Soft iron has stronger magnetization than steel under the same conditions, in these cases soft iron is used in electromagnetic

ELECTROMAGNETIC

Consists of a soft iron core in a solenoid carrying current connected to an electrical source. The arms of the soft iron core are in U shape.

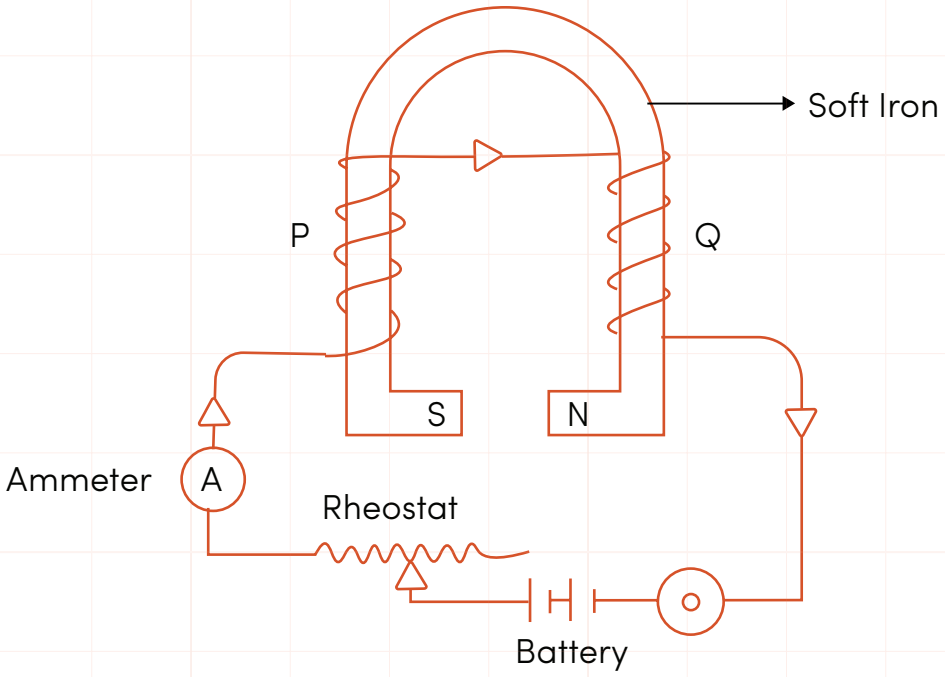


Fig. 3.15: Making an Electromagnetic

APPLICATIONS OF ELECTROMAGNETIC

1. It is used in generators and electric motors.
2. It is used for the separation technique of iron and other ferromagnetic materials.
3. It is used for the production of electromagnetic devices such as loudspeakers, electric bells.
4. For the lifting of heavy duty objects in cranes.

EARTH'S MAGNETIC FIELD

The earth magnetic field is also called a geomagnetic field that comes from the earth's interior out into space, where it has interaction with the solar wind and a stream of charged particles coming from the sun.

It is produced by the electric current due to the motion of convection current of the mixture of molten iron and nickel in the earth outer core which is called geodynamo.

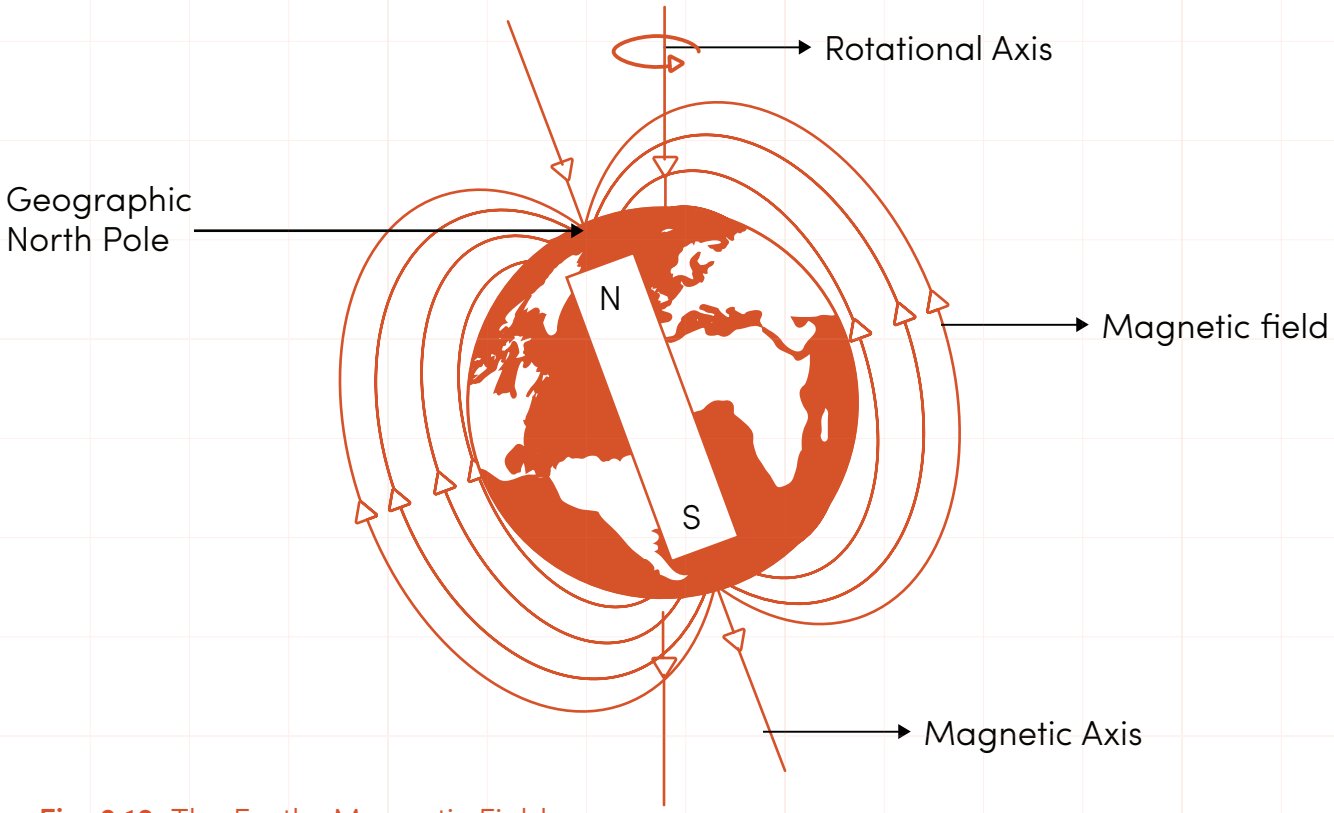


Fig. 3.16: The Earths Magnetic Field

The North and South magnetic poles are located near the geographic pole.

The magnetic elements of a place

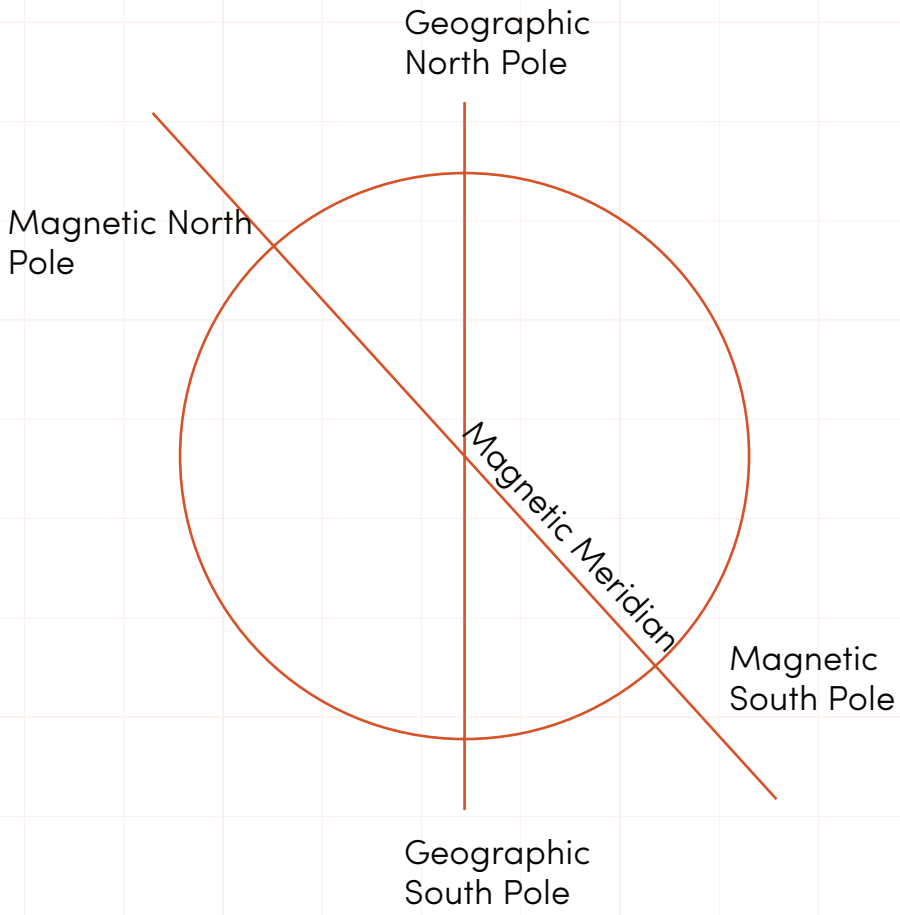


Fig. 3.17: Elements of the Earths Magnetic Field

1. **Magnetic meridian:** Of any place is a vertical plane passing through the magnetic axis of a freely suspended magnet at rest under the influence of earth's magnetic field.
2. **Angle of declination:** The angle between geographic meridian and magnetic meridian of a place.
3. **Geographic meridian:** The vertical plane containing the geographic north and South Pole of the earth.
4. **Angle of dip:** The angle between the direction of the earth resultant magnetic field and the horizontal.
5. **Horizontal component H:** The magnetic force acting in the horizontal direction.
6. **Vertical component V:** The magnetic force acting the vertical direction.

MAGNETIC FORCE ON A CHARGE MOVING IN A MAGNETIC FIELD

Magnetic field exerts a force on a charge moving in the field

$F = qVB\sin\theta$

Where F = force exerted

q = charge in coulomb

V = velocity of the moving charge

B = flux density or magnetic induction

θ = inclination angle.

SUMMARY

So far, we have learnt how to

1. Plot magnetic field.
2. Make a magnet from a soft iron bar.
3. Make an electromagnet.
4. Describe the working principle of electric bell and ear piece.
5. Locate the earth's magnetic north-south direction.
6. Explain the magnetic force on a moving charge.
7. State the relation between magnetic force and motion of a charge in a magnetic field.

INTERACTIVE ASSESSMENT QUESTIONS

1. Which of the following sets comprises magnetic materials only?

A Brass, nickel and steel

B Lead, copper and steel

C Nickel, brass and copper

D Iron, steel and nickel

E Iron, copper and steel

2. Which of the following statement explains why soft iron is used in making the armature of an electric bell?

A Decreases the magnetic effect of a direct current
B Is not easily magnetized
C Losses its magnetism readily
D Returns its magnetism for a long time
E It cannot loss its magnetism

3. Which of the following statement about an electromagnet is not correct?

A Its strength depends on the current
B It has permanent poles
C It is a temporary magnet
D Its strength depends on the number of turns in its coil
E Its magnetism can be loss easily

4. A magnetic needle suspended at its centre of gravity settles at an angle to the horizontal. This shows that the

A Earth's field has both horizontal and vertical components
B Earth rotates
C Needle has two poles
D Magnetic pole is different from the geographic pole
E Earth's magnetic field is from north pole to the south pole.

5. Find the magnetic force experienced by an electron projected into a magnetic field of flux density 20T with a velocity of $15x10^{7}$m/s in a 60^{0} direction, where the charge of electron $1.6x10^{-19}$C

A 6×10^{-10}N
B 4.2×10^{-10}N
C 5.2×10^{-10}N
D 7.2×10^{-10}N
E 4.6×10^{-10}N

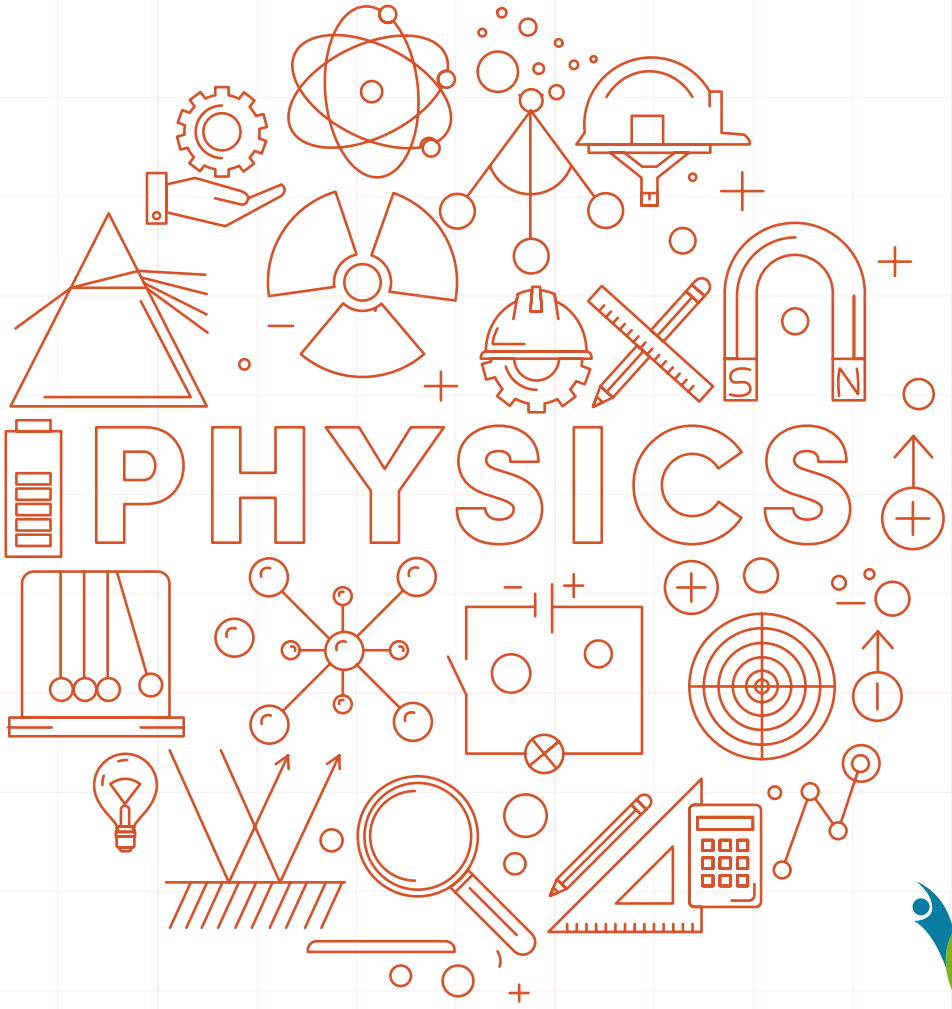
6. A conductor of length 1.8m carrying current of 5A is placed in a magnetic field of flux density 0.6T.Calculate the magnitude of the force on the conductor.

A 5.4N
B 2.7N
C 1.3N
D 0.9N
E 1.8N

ELECTROMAGNETIC FIELD

PERFORMANCE OBJECTIVES

1. Identify the direction of current and magnetic field.
2. Explain action of a loop wire carrying current in a magnetic field
3. Explain the basic working principle of galvanometer and motor
4. State and explain the implication of Lenz's law
5. Explain how the conservation principle is involved in both laws with regard to charge, energy and the principle of AC current production
6. State and explain Faraday's laws of electromagnetic induction
7. Explain the principle of AC current production
8. State the use of induction coil and transformer
9. Explain the core of the induction and lamination of the transformer.



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ELECTROMAGNETIC FIELD

The field formed from the interaction of magnetic and electric forces at right angles to each other.

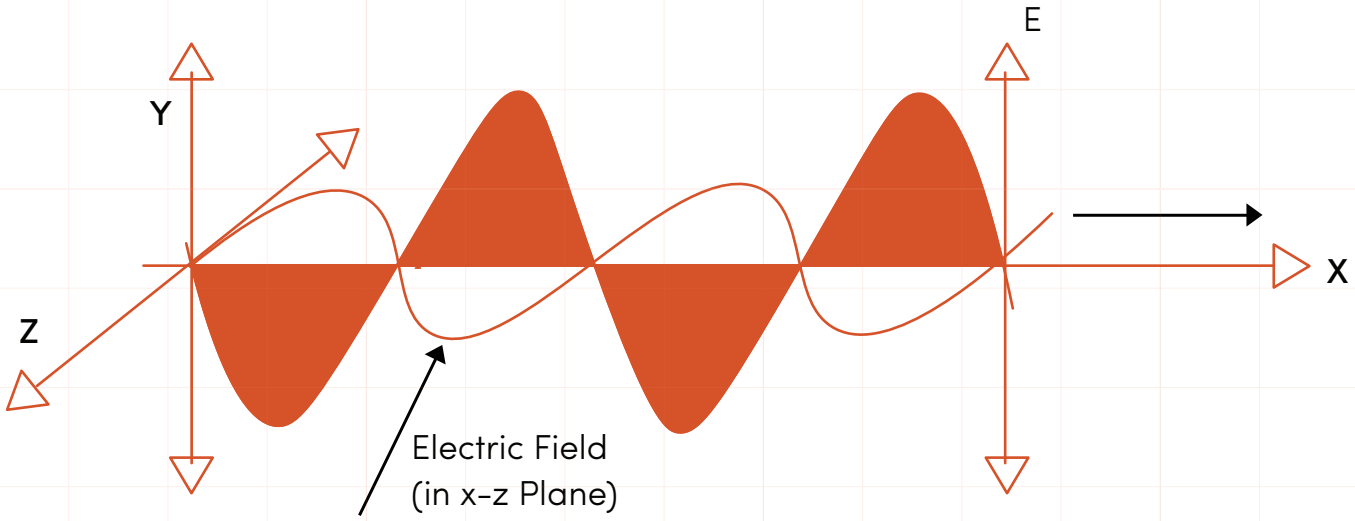


Fig. 3.18: Interaction between Electric and Magnetic Field (The Electromagnetic Field)

Electric force $F_e = qE$

Magnetic force $F_m = qvB\sin\theta$

At right angle $\theta = 90^0$, $\sin 90^0 = 1$

$F = F_e + F_m$

$F = qE + qvB$

$F = q(E + vB)$

Force on a current-carrying conductor in a magnetic field

Any conductor possesses an electric current, when placed in a magnetic field, sets up a mechanical force

The reasons are:

1. A mechanical force acts on a current carrying conductor when a conductor is placed in a magnetic field at an angle to the field.
2. The direction of the force is always perpendicular to the current direction and magnetic field

3. The magnitude of the force produced is proportional to the current and the field strength
4. The force decreases when the angle deviates from being perpendicular.

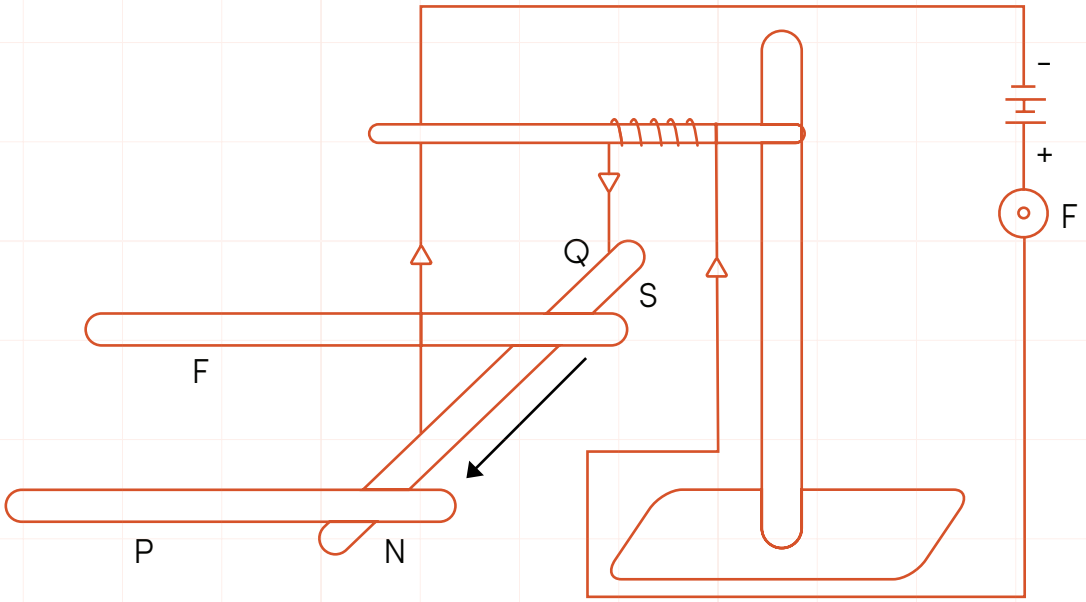


Fig. 3.19: Force on a current carrying conductor in a magnetic field

Force between conductors carrying current

Two parallel current carrying conductors are arranged side by side, each conductor is in a magnetic field of the other. The direction of the flow of the current determines the attractive or repulsive forces of the conductor, if the current flows in the same direction, there will be attraction, but in the opposite direction there will be repulsion.

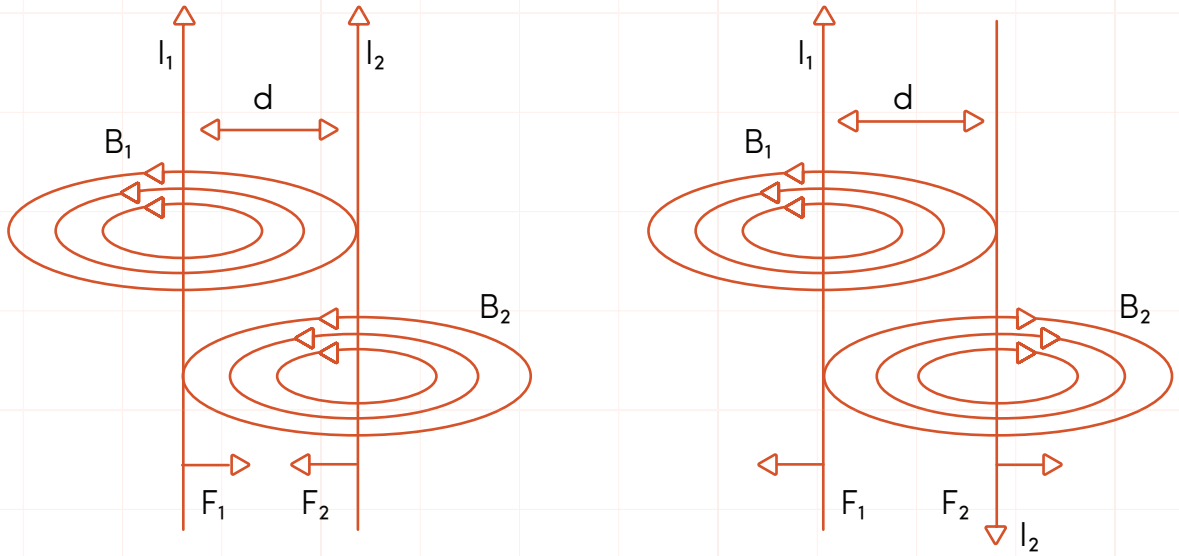


Fig. 3.20: Attentional and Repulsion Between two Parallel Current Carrying Conductor

Fleming left-hand rule: When the thumb, first-finger and the second finger are at right angles to each other, thuMb in the direction of motion, First-finger in the direction of field and seCond-finger in the direction of current.

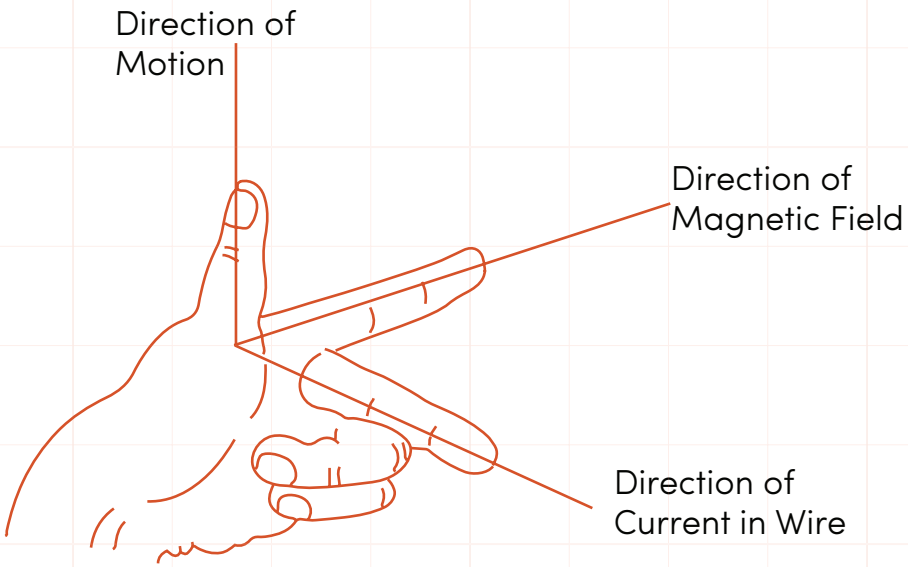


Fig. 3.21: Fleming's Left Hand Rule

Application of electromagnetic field

- For electric motors: Which uses the working principle of force on a current carrying conductor in a magnetic field, whenever a current carrying current in the magnetic field, mechanical rotation will occur.

Electric motors are used in the following

1. Motor devices for cars
2. Electric fans
3. Grinders
4. Washing machines
5. Microwaves.

Components of motor

1. A coil carrying current called armature
2. Magnetic field
3. Slip/split rings

4. Graphite-carbon brushes
5. Laminated soft iron cylinder.
    - For moving coil galvanometer
    - For induction coil: A device capable of producing a high e.m.f by EM induction from a low voltage d.c source.

USES

1 in motor car ignition system

2 in the operation of X-ray machines.

The energy losses in electric motor are due to the following:

1. Work done against friction in the commutator and bearing
2. Eddy current formed in the soft-iron cylinder
3. Heat losses.

Electromagnetic induction

This was discovered by Michael Faraday in the year 1831 that electric current or voltage could be produced whenever there is a relative motion between a magnet and a conductor.

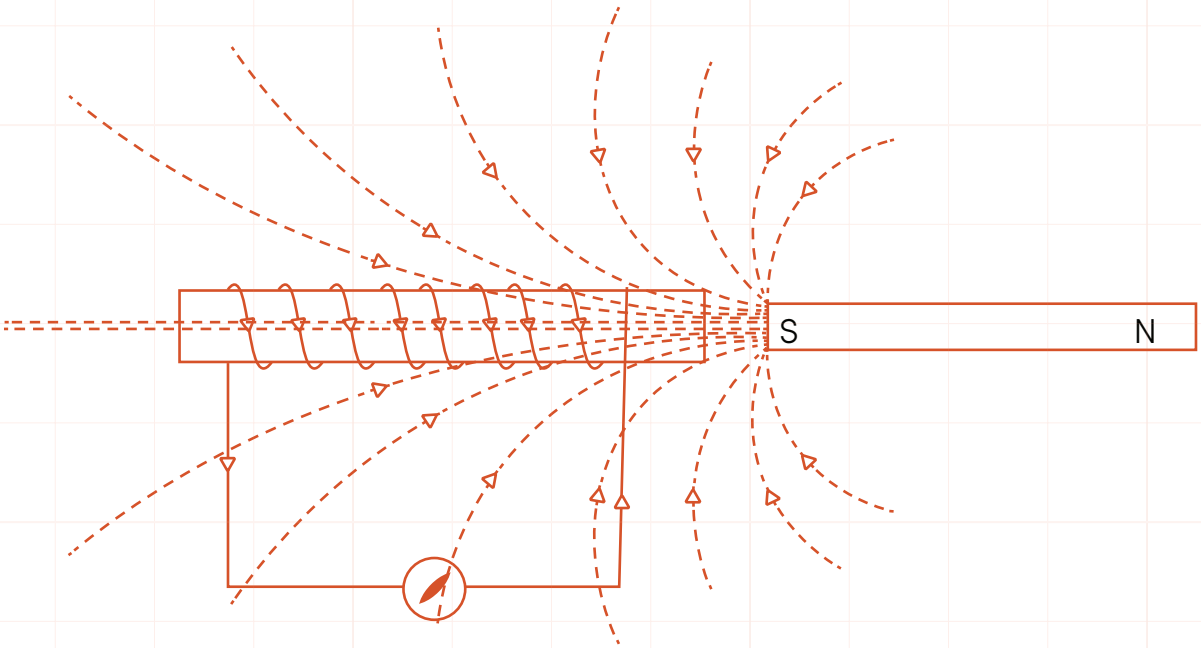


Fig. 3.22: Magnetic Lines (or Flux) Linking a Solenoid

Induced E.M.F in a straight conductor using Fleming's Right-hand rule

When the thumb, first-finger and the second finger are at right angles to each other, thumb in the direction of motion, First-finger in the direction of field and second-finger in the direction of current.

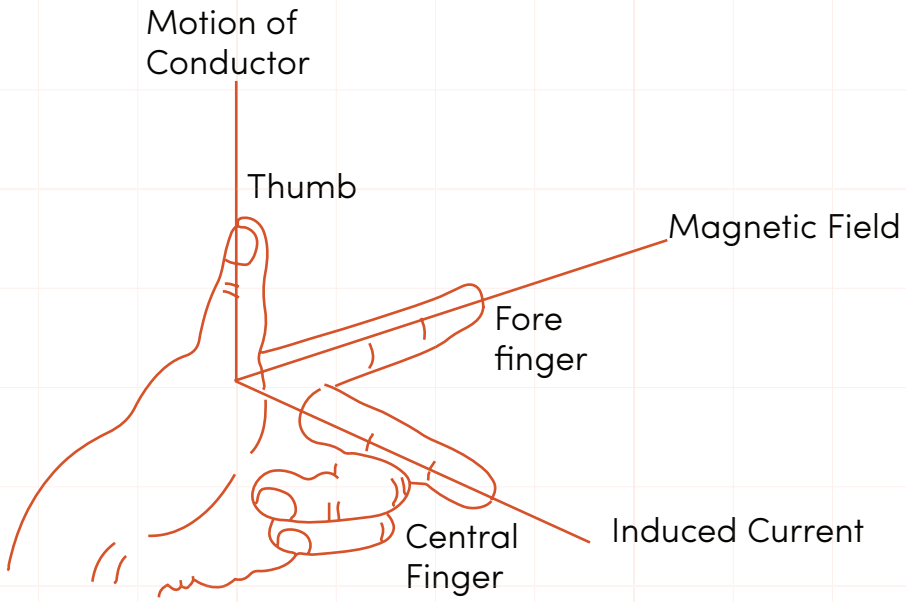


Fig. 3.23: Fleming's Right Hand Rule

FARADAY'S LAW OF ELECTROMAGNETIC INDUCTION

The law stated that, when there is a change in the magnetic line of force, e.m.f is induced the strength is proportional to the rate of change of flux linked with the circuit.

The magnetic flux or field lines linking a coil depend on the following:

1. Magnetic field strength
2. Number of turns of the coil
3. Area of each turn.

LENZ'S LAW

The induced e.m.f is in a direction to oppose the motion producing it.

GENERATOR

There are two type

D.C and A.C generator

Electricity can be produced when moving a conducting coils through a magnetic field as a result of induced e.m.f

The machine that converts mechanical energy to electrical energy is called dynamo or generator and when changing electrical to mechanical, it's called motor.

COMPONENTS OF AC AND DC GENERATORS

1. Armature:-a rectangular coil having a large number of turns of insulated coil wound on the laminated soft iron core.
2. Magnetic field produced by an electromagnetic or by the curved poles of a horse-shoe magnet
3. Copper slip/split rings:- they are connected to the end of the armature, the rings could be slip ring for A.C or split ring for D.C
4. Two stationary carbon brushes which are made to touch the rings gently.

When the armature is rotated in the pool of magnetic fields of the magnets,induced e.m.f will set in the coil and the rings which can be collected by the carbon brushes made of graphite.

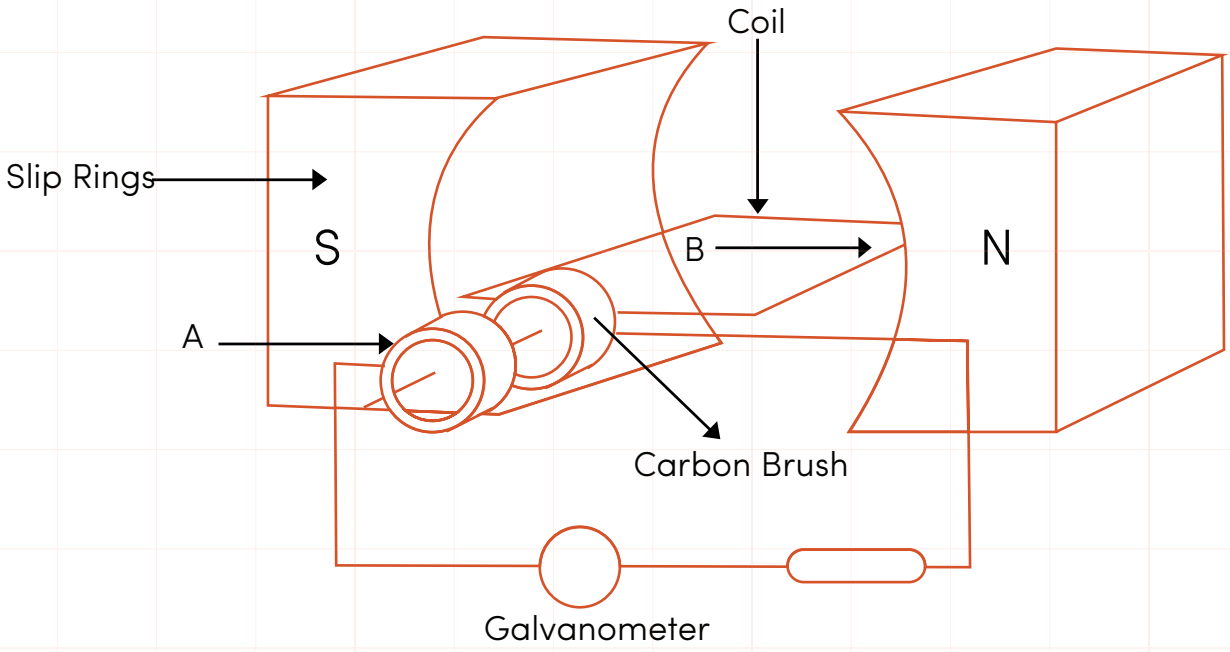


Fig. 3.24: A.C Generator

EDDY CURRENT

The opposing current formed in a conductor disc rotating in a magnetic field which damps the flow of an induced e.m.f. This can be reduced by laminating the soft iron core and the coils.

TRANSFORMER

A device that can change the size of an A.C voltage

The types are:

1. **Step down transformer:** when the number of turns of primary coils are more than the secondary

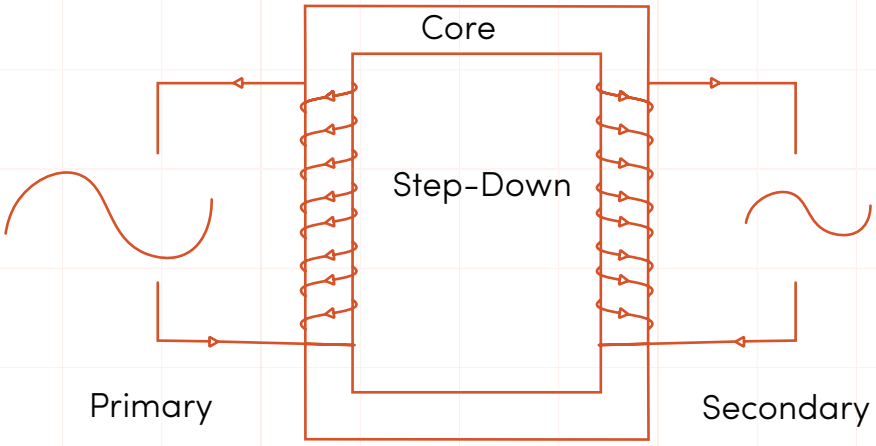


Fig. 3.25: Step Down Transformer

2. **Step up:** when the number of turns of secondary coils are more than the primary side

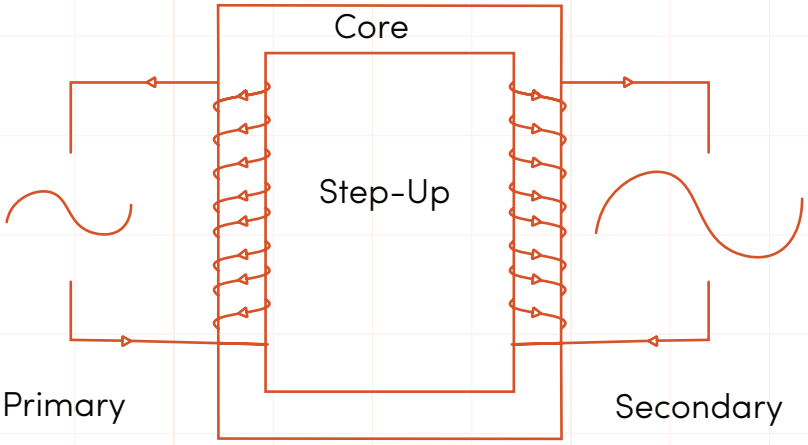


Fig. 3.26: Step Up Transformer

It consists of two separate coils, primary and secondary coils of different winding on the laminated soft iron core, which is working on the principle of mutual inductance. Transformer can be used with D.C when a make-and-break device is connected to the primary circuit.

Mutual inductance: The flow of induced voltage in a coil due to an alternating current in the second coil.

$$\frac{E_s}{E_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$$

Where Es = voltage in secondary coil

Ep = voltage in primary coil

Ns = number of turns in secondary

Np = number of turns in primary.

Is = current in the secondary coil

Ip = current in the primary coil.

$$\text{Efficiency} = \frac{\text{outputpower}}{\text{inputpower}} \times 100$$

$$\text{Efficiency} = \frac{\text{secpower}}{\text{prypower}} \times 100$$

Activity: Find the turn ratio of a transformer which has a voltage of 240v in the secondary coil from a primary voltage of 80v.

Solution

$$\frac{N_s}{N_p} = \frac{E_s}{E_p}$$

$$\frac{N_s}{N_p} = \frac{240}{80} = 3$$

POWER TRANSMISSION

Power generation is distributed over a long distance to consumers through conducting wires.

The transmission is done in high voltage and low current to avoid heating effects in the wire and energy loss. P=IV

In high tension A.C is preferred over D.C because it can be transformed

SUMMARY

So far, we have learnt how to

1. Identify the direction of current and magnetic field.
2. Explain action of a loop wire carrying current in a magnetic field
3. Explain the basic working principle of galvanometer and motor
4. State and explain the implication of Lenz's law
5. Explain how the conservation principle is involved in both laws with regard to charge, energy and the principle of AC current production
6. State and explain Faraday's laws of electromagnetic induction
7. Explain the principle of AC current production
8. State the use of induction coil and transformer
9. Explain the core of the induction and lamination of the transformer.

INTERACTIVE ASSESSMENT QUESTIONS

1. The force experienced by a current-carrying conductor moving in a magnetic field is employed in the working of the

   (i) Moving coil ammeter
   (ii) Electric bell
   (iii) Electric motor.

   Which of the statements above is correct?

   A (i) And (ii) only
   B (i) and (iii) only
   C (ii) and (iii) only
   D (i), (ii) and (iii)
   E None

2. If the direction of current flowing in a straight wire is reversed, the magnetic field

   A Remain the same
   B Ceases to exist
   C Becomes parallel to the conductor
   D Is oppositely directed
   E Unchanged

3. Fleming's right hand rule is also called the

   A Motor rule
   B Screw rule
   C Thumb rule
   D Dynamo rule
   E Lenz's rule

4. The main function of the commutator in a simple DC motor is to

A Increase the flux linking the armature windings
B Maintain a direct current in the armature
C Provide uniform magnetic field around the armature
D Enable the armature to rotate freely
E Reverse the direction of the current in the armature

5. Transformer can only change the phase of

A Current
B Resistance
C Voltage
D Induced current
E Magnetic field

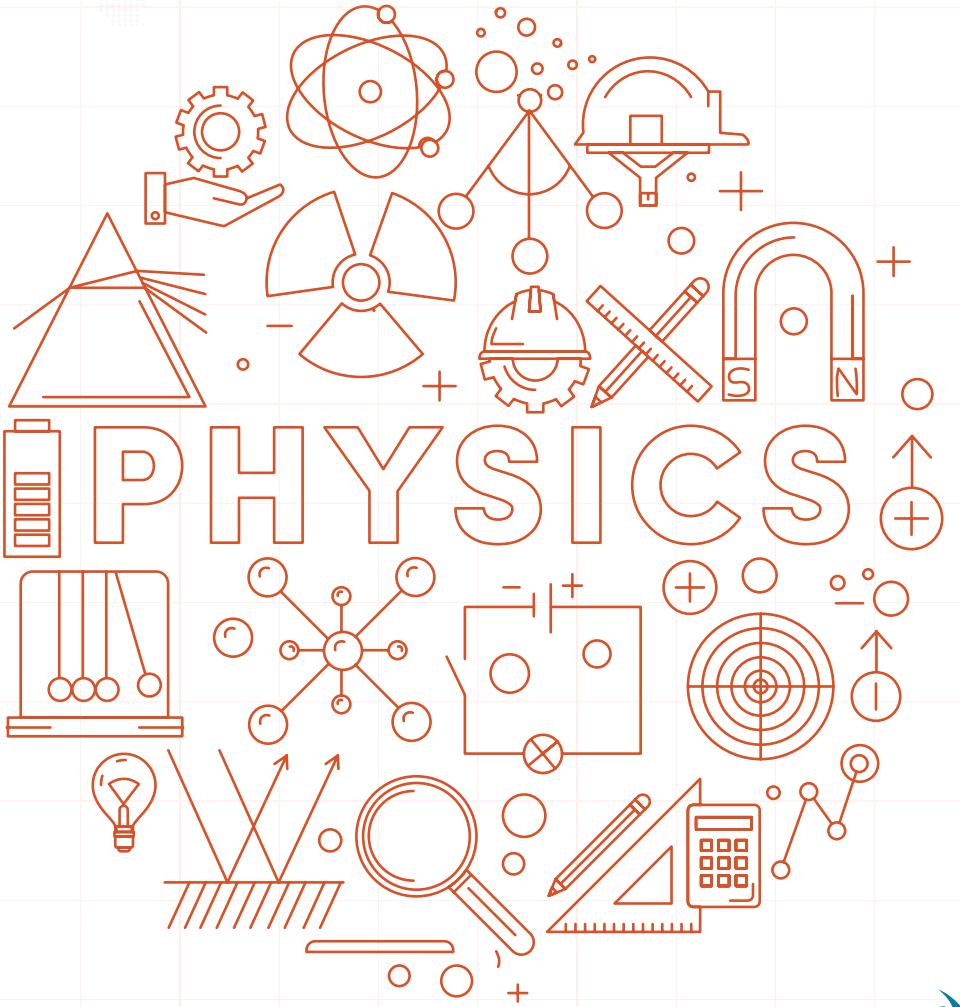
6. Energy losses due to eddy currents are reduced by using

A Low resistance wire
B Few turns of wire
C High resistance wire
D Insulated soft iron wires
E Opened soft iron wires

SIMPLE A.C CIRCUIT

PERFORMANCE OBJECTIVES

1. Explain peak, root mean square values of current and voltage.
2. Establish the phase relationship between current and p.d in A.C circuit
3. Explain reactance and impedance
4. Determine current in circuits containing
    a. Resistance and capacitance
    b. Resistance, inductance and capacitance
    c. Determine power in an A.C



AC CIRCUIT

Alternating current A.C is the current that change its direction periodically which is produced by an alternating voltage.

It is represented by

$I = I_0 \sin\omega t$

Where $\omega = 2\varpi f$

$I = I_0 \sin 2\varpi ft$

Also for $V = V_0 \sin 2\varpi ft$

Where I = instantaneous current V = instantaneous voltage

I_0 = peak or maximum current V_0 = peak or maximum voltage

f = frequency , t = time and ω = angular velocity

ωt = phase angle of current or voltage

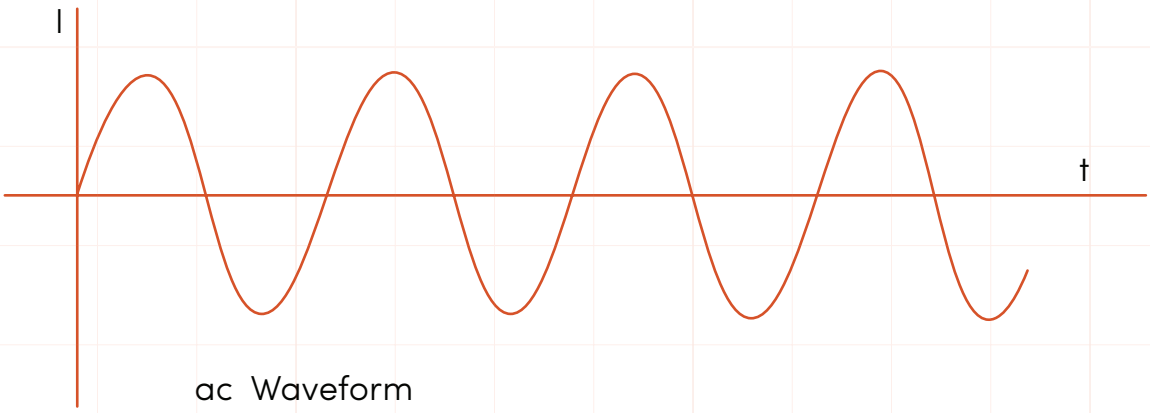


Fig. 3.27: Variation of Alternating Current or Voltage with Time

Instantaneous current or voltage: The amount of current or voltage passing through a conductor at time interval.

PEAK AND ROOT MEAN SQUARE (R.M.S) VALUES

Peak is the maximum value of current or voltage in an A.C cycle

Root mean square value is the steady current or voltage which produces the same heating effect per second in a given resistor.

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

AC circuit containing resistor

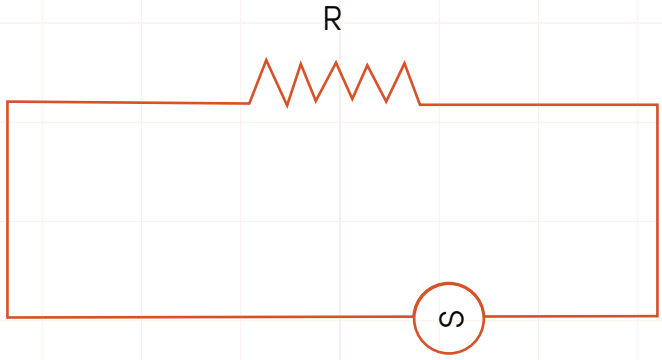


Fig. 3.28: A.C Circuit containing a Resistor

$$R = \frac{V}{I} = \frac{V_0 \sin\omega t}{I_0 \sin\omega t}$$

$$R = \frac{V_{rms}\sqrt{2}}{I_{rms}\sqrt{2}}$$

$$R = \frac{V_{rms}}{I_{rms}}$$

AC circuit containing an inductor

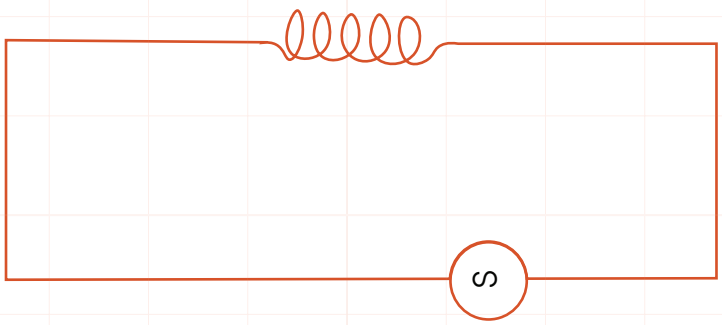


Fig. 3.29: A.C Circuit Containing an Indicator

For an inductor circuit the total resistance value is inductive reactance XL=ωL

XL=2ϖfL the unit is Ω

$$I_0 = \frac{V_0}{2\varpi fl} = \frac{V_0}{XL}$$

$$I_{rms} = \frac{V_{rms}}{2\varpi fl} = \frac{V_{rms}}{XL}$$

AC circuit containing capacitor

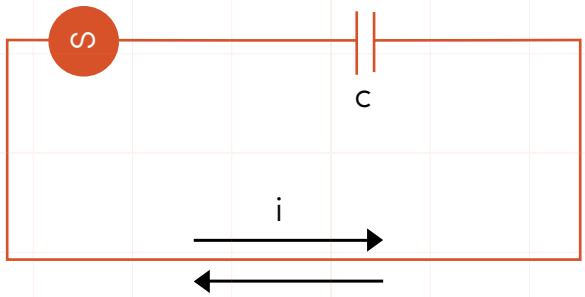


Fig. 3.30: A.C Circuit Containing a Capacitor

The total resistance value is capacitive reactance

$$X_c = \frac{1}{\omega C} = \frac{1}{2\varpi fC}$$

The unit is Ω

$$I_o = \frac{V_0}{X_c}$$

$$I_{rms} = \frac{V_{rms}}{X_c}$$

Impedance Z:

The total resistance value of the components of an AC circuit

1. **R – L circuit**

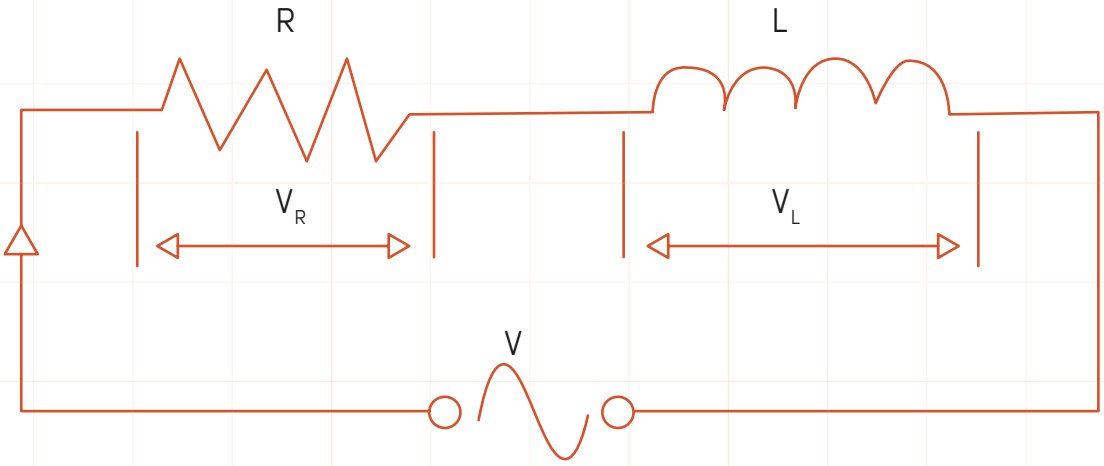


Fig. 3.31: R,L in Series In A.C Circuit

$Z = \sqrt{(R^2 + X_L^2)}$ and the unit is Ω

$$I_o = \frac{V_0}{Z}$$

$$I_{rms} = \frac{V_{rms}}{Z}$$

2. R - C circuit

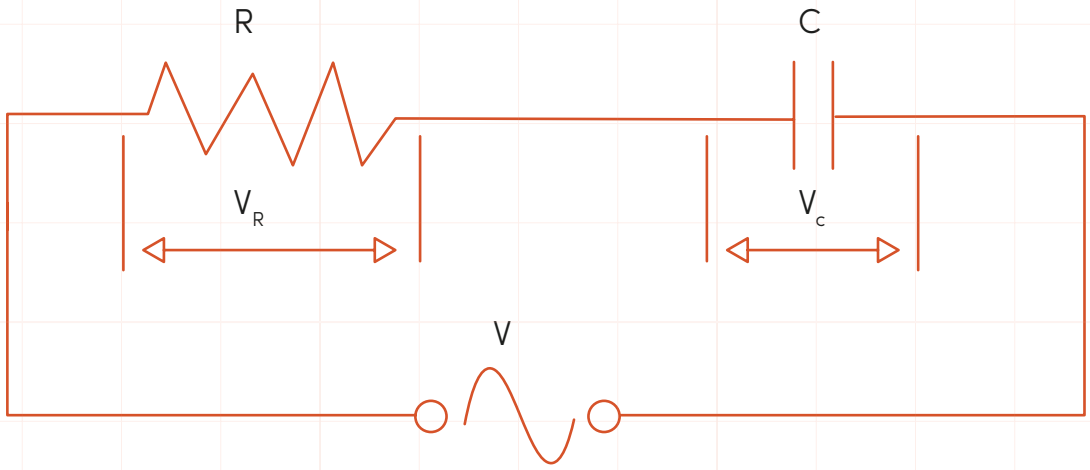


Fig. 3.32: R,C in Series In A.C Circuit

$$Z = \sqrt{R^2 + X_{c)}^2}$$

$$I_o = \frac{V_0}{Z} \quad \text{and} \quad I_{rms} = \frac{V_{rms}}{Z}$$

3. RLC circuit

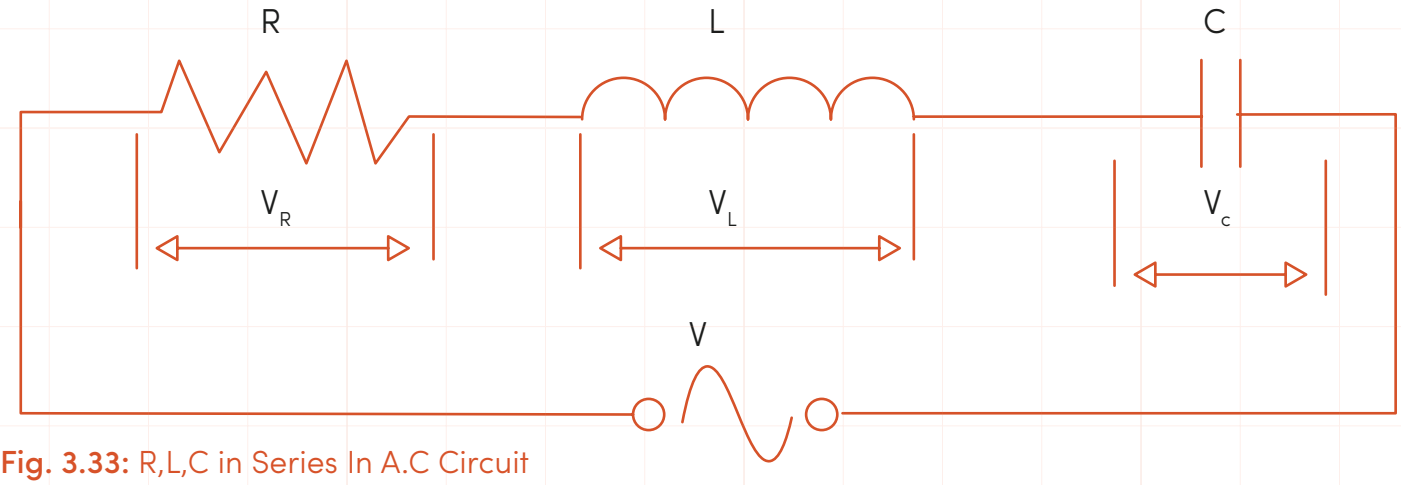


Fig. 3.33: R,L,C in Series In A.C Circuit

$$Z = \sqrt{R^2 + (X_L - X_{c)})^2}$$

$$I_o = \frac{V_0}{Z} \quad \text{and} \quad I_{rms} = \frac{V_{rms}}{Z}$$

4. L- C circuit

$$Z = \sqrt{(X_L - X_{c)}^{\ 2}}$$

Power in an AC circuit

The mean power in AC is $P = IV\cos\theta$

Where θ = phase angle,

$$\cos\theta = \frac{R}{V}$$

Where $I = I_0 \sin 2\varpi ft$ and $V = V_0 \sin 2\varpi ft$

I_C leads V_C by 90^0 and I_L lags V_L by 90^0

V_C lags I_C by 90^0 and V_L leads I_L by 90^0

Resonance Frequency

Resonance occurs when the maximum current is obtained in an AC circuit

The frequency at which this resonance occur is called resonance frequency f_0

The frequency at which $X_L = X_C$

$$2\pi\pi_0 L = \frac{1}{2\pi\pi_0 C}$$

$$4\pi^2 f_o^2 LC = 1$$

$$f_0^{\ 2} = \frac{1}{4\pi^2 LC}$$

$$f_0 = \sqrt{\left(\frac{1}{4\pi^2 LC}\right)} = \left(\frac{1}{2\pi\sqrt{(LC)}}\right)$$

$$\text{or } \omega_0 = \frac{1}{\sqrt{(LC)}} \quad \text{where } \omega 0 = 2\pi f0$$

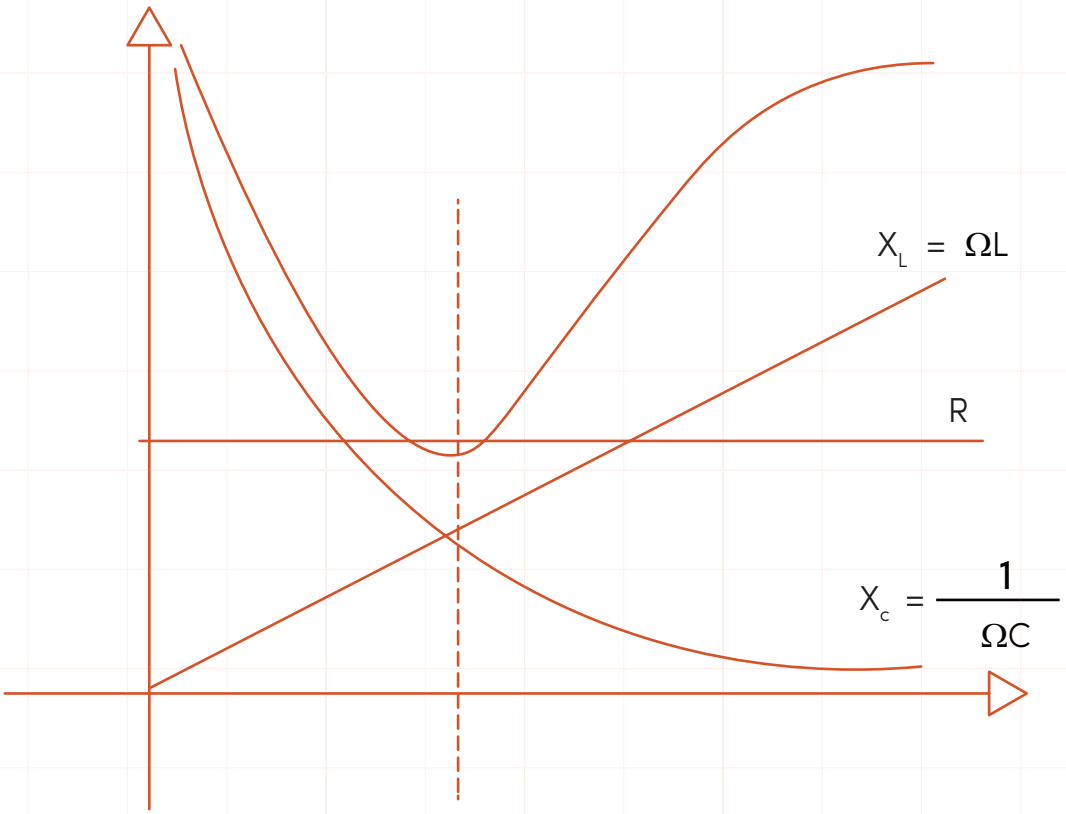


Fig. 3.34: Variation of frequency with Resistance(**R**), Capacitative Reactance ($\mathbf{X_c}$) and Indicative Reactance ($\mathbf{X_L}$) in **RLC** Series Circuit.

Applications of resonance

It is used for radio, TV, satellite signal tuning.

SUMMARY

So far, we have learnt how to

1. Describe carbohydrates
2. List the sources of carbohydrates

INTERACTIVE ASSESSMENT QUESTIONS

1. An ammeter connected to an AC circuit records 5.5A. The peak current is

   A 7.8A
   B 3.9A
   C 7.1A
   D 2.4A
   E 3.5A

2. In an RLC circuit, power is mainly dissipated by the

   A Inductive parts
   B Capacitive parts
   C Resistive parts
   D Reactive parts
   E Impedance parts

3. In a purely inductive circuit, the current

   A Lags behind the voltage in phase by 90^0
   B Leads the voltage in phase by 90^0
   C Is in the same phase with the voltage
   D Leads the voltage by 180^0
   E Lags the voltage by 180^0

4. Series RLC is said to resonate, when

A Capacitive reactance is zero

B Current is minimum

C Inductive reactance is zero

D Conductance is maximum

E Impedance is minimum

5. When an ac current given by I = 10sin(120π)t passes through a resistor of 10Ω,the power dissipated in the resistor is

A 500W

B 100W

C 770W

D 1400W

E 2000W

6. Using the parameters V_{rms}=240V, R=4Ω, X_L=3Ω, calculate the I_{rms}

A 60A

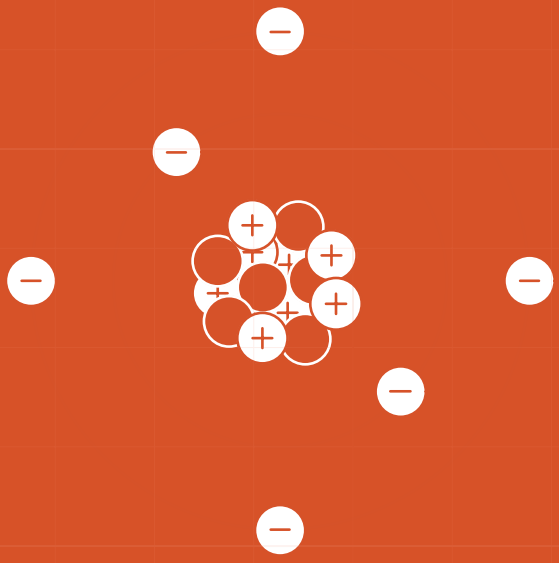
B 32A

C 48A

D 80A

E 84A

THEME 04



Conservation Principles

Wave, motion without material transfer

Field at rest and in motion

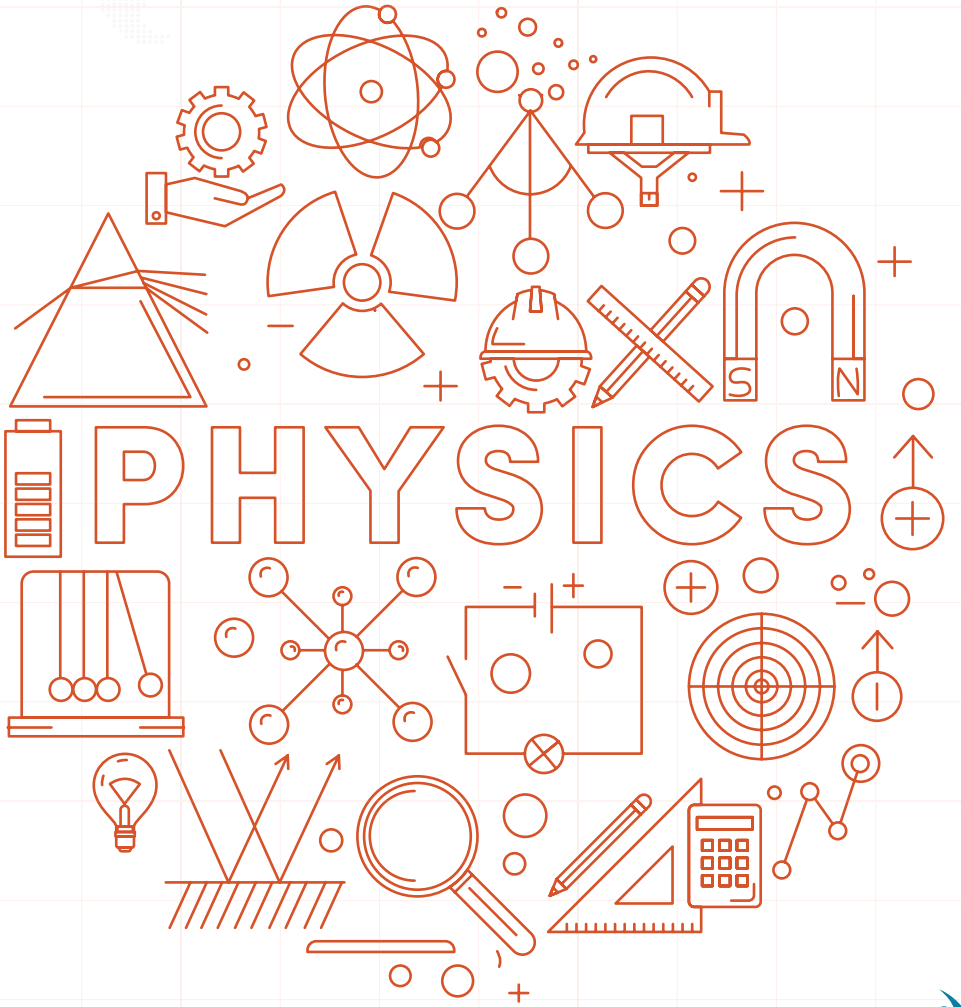
Energy quantization and duality of matter

Physics in Technology

MODELS OF THE ATOM

PERFORMANCE OBJECTIVES

1. State what chemical evidence there is for the existence of atom
2. State what experimental evidence for believing that matter is electrical in nature
3. Describe Bohr-Rutherford models of the atom.
4. Explain nucleon number and their relationship.



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INTRODUCTION

Atoms are the smallest particles that are made up of matter, they are so small which cannot be seen without the aid of a powerful microscope.

Atom has a diameter of about 10-10m,to understand atom

Scientists used models to explain it.

1. Plum-pudding model proposed by J.J Thomson
2. Planetary or nuclear model proposed by Ernest Rutherford
3. Bohr's atomic model
4. Electron cloud atomic models.

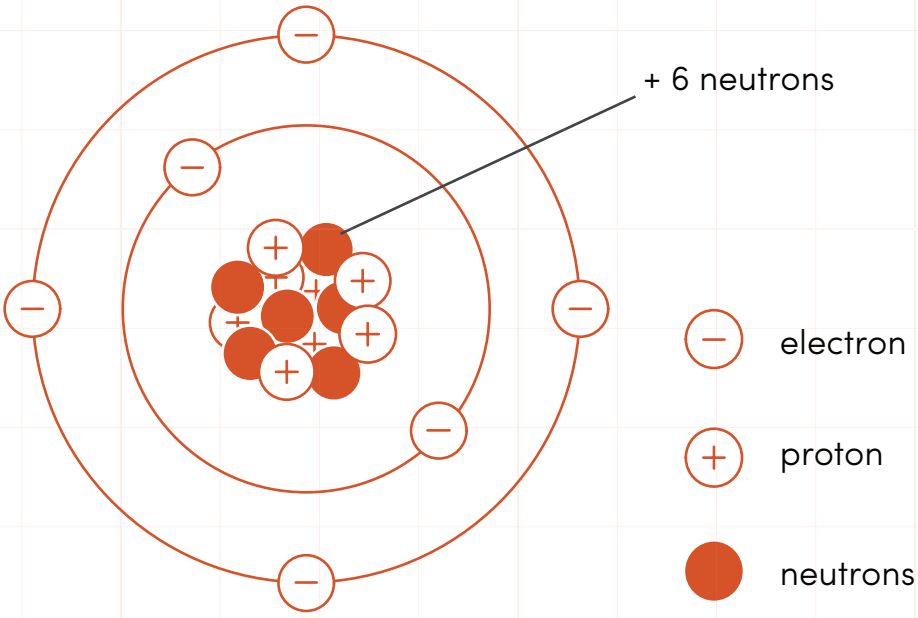


Fig. 4.1: Components of an Atom

J.J THOMSON'S ATOMIC MODEL

This model view atom as a hard sphere of positive charges (plum) with the electrons (pudding) embedded on it in a regular pattern. This model successfully explains why an atom is electrically neutral.

The limitation of this model is that it did not explain the alpha scattering experiment.

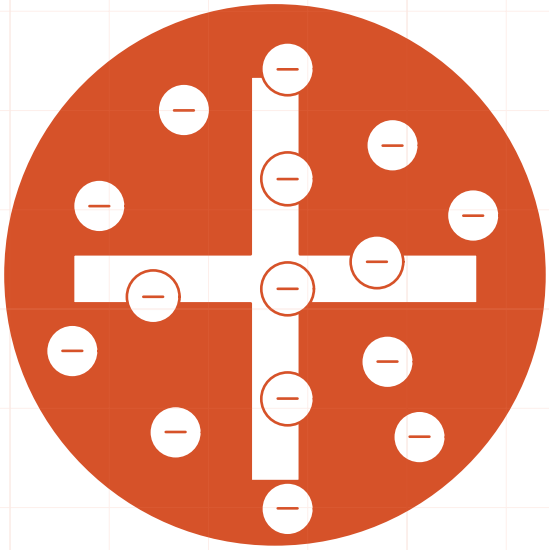


Fig. 4.2: Thomson's Model of The Atom

ERNEST RUTHERFORD NUCLEAR ATOMIC MODEL

From the limitation of Thomson's model Rutherford made an experiment and proposed another model called planetary or nuclear model of an atom, the features of the model are:

1. The nucleus is positively charged
2. The electrons which are negatively charged orbit the nucleus at high speed
3. The mass of an atom is concentrated at the centre of the atom which is called the centre nucleus.

The successes of the model

1. Introduction of the nucleus as a positive core of an atom
2. The concept of mass of an atom concentrating at the nucleus
3. Introducing that electrons orbiting the nucleus at high speed.

Limitation of the model

1. Prediction of an unstable atom
2. Did not explain why charged particle like electron could not radiate energy even it orbiting the nucleus at high speed.
3. Did not explain the existence of line spectra of atoms.

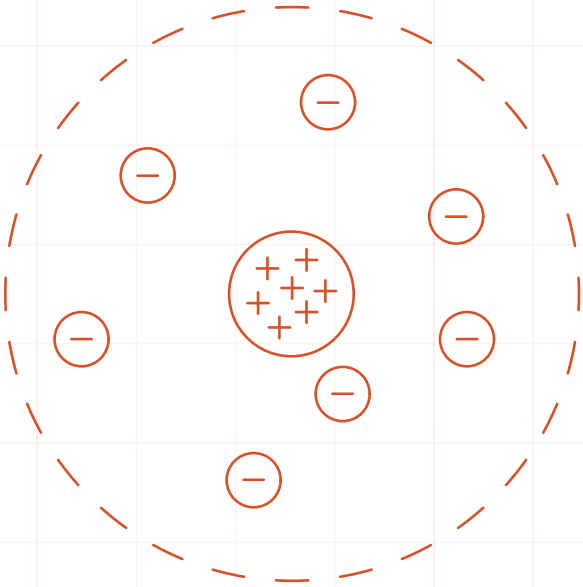


Fig. 4.3: Earnest Rutherford's Model of The Atom

NEIL BOHR'S ATOMIC MODEL

He studied under Thomson and Rutherford, he now used their limitations to proposed his own and postulated two rules as:

1. The perimeter of a circle at which the electrons orbiting the nucleus without energy radiation is such that the angular momentum is quantised.

$$mvr = \frac{nh}{2\pi}$$

Where $V = \omega r$

$m\omega r2 = nh/2\pi$

m = mass of the electron

v = speed of the electron

r = radius of the orbit

n = principal quantum number

h = Planck's constant

2. Electrons radiate energy is proportional to frequency when it jumps from higher energy state to lower energy state

$E_n - E_o = hf$

Success of Bohr's model

1. Very accurate in calculating the radius and total energy of hydrogen atoms.
2. It explains the arrangement of electrons in an atom with the determination of the chemical and physical properties of elements depending on arrangement of electrons around the nucleus.
3. He successfully explained the energy quantisation of photons.
4. He accurately determines the spectral lines of hydrogen atoms.

Limitation of Bohr's model

1. Did not explain the spectra lines of complex atoms.
2. Did not explain why electrons remain in their definite or fixed orbit without radiating energy.
3. He assumed orbit could not be fixed because electrons were being attracted by the positively charged nucleus.

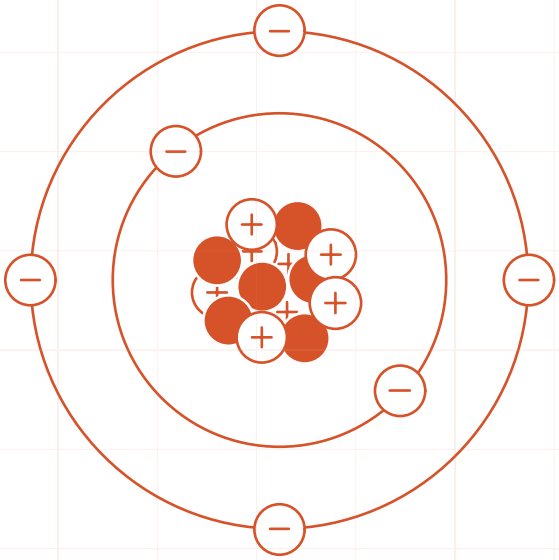


Fig. 4.4: Bohr's Model of The Atom

ELECTRON-CLOUD MODEL

It is a mathematics model of an atom, in which the electrons are treated as a wave and a particle. They do not move in a fixed orbit as Bohr stated but can be located easily in a region called high-density region.

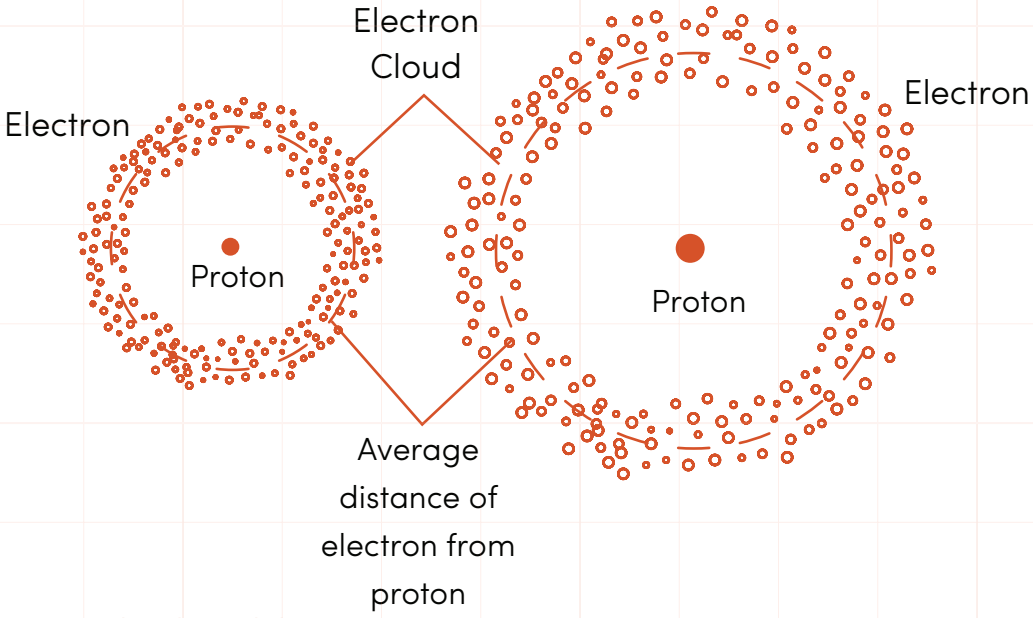


Fig. 4.5: Electron-Cloud Model.

SUMMARY

So far, we have learnt how to

1. State what chemical evidence there is for the existence of atom
2. State what experimental evidence for believing that matter is electrical in nature
3. Describe Bohr-Rutherford models of the atom.
4. Explain nucleon number and their relationship.

INTERACTIVE ASSESSMENT QUESTIONS

1. Plum-pudding model was proposed by?

A	Ernest Rutherford
B	Neil Bohr
C	J.J Thomson
D	Isaac Newton
E	John Dalton

2. The diameter of an atom is about

A 10^{-7}m
B 10^{-8}m
C 10^{-13}m
D 10^{-10}m
E 10^{-12}m

3. Who proposed that an atom has a concentrating mass at the centre

A J.J Thomson
B Neil Bohr
C Milikan
D John Dalton
E Ernest Rutherford

4. The limitation of Rutherford model is

A The model could not explain the alpha scattering
B The mass of an atom is concentrated at the centre
C The nucleus is positively charged
D Could not explain the existence of line spectra of atoms
E The perimeter of a circle at which the electrons orbiting the nucleus without energy radiation is quantised.

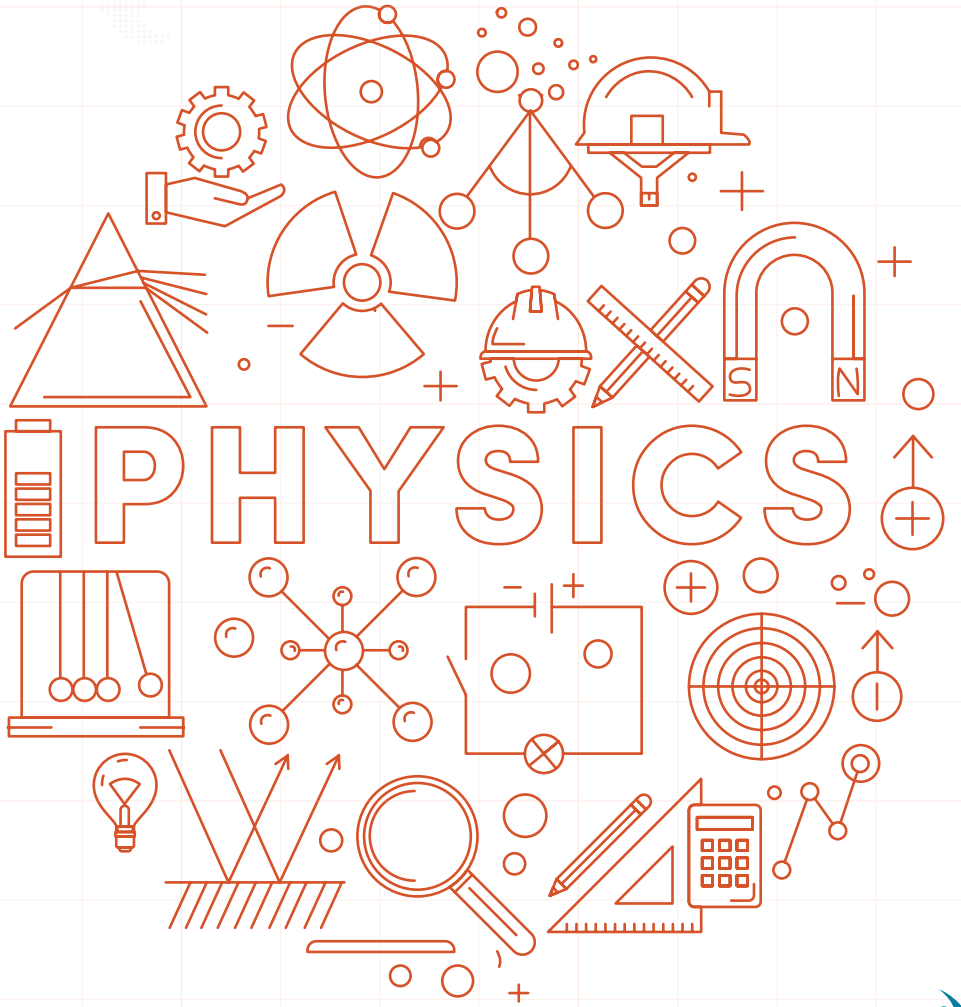
5. The limitation Bohr has is that

A It explains how electrons are arranged in an atom
B By calculating the total energy of an atom
C Could not explain the spectra lines of complex atoms
D Electrons are treated as a wave and particles
E By determine the spectra lines of hydrogen atom.

NUCLEUS

PERFORMANCE OBJECTIVES

1. Identify the radiation from radioactive substances using their characteristics
2. Solve simple problems involving half-life
3. State some uses of radioactive substance
4. Use the concept of nuclear fission and fusion for the development of a nuclear energy programme for Nigeria.



NUCLEUS

Atom is divided into two parts

1. Nucleus
2. Electrons (negatively charged)

But the nucleus comprises of:

1. Neutron neutral charge
2. Proton positive charge

In this case nucleus is positively charged because of the proton in it, where the mass of atom concentrated, and the heaviest part of the atom because of proton and neutron are massive particles.

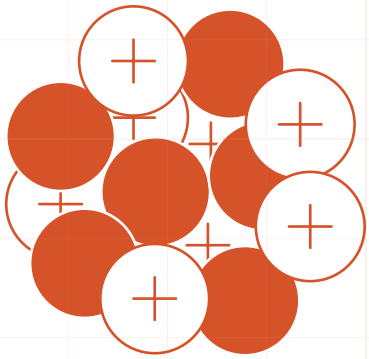


Fig. 4.6: The Nucleus of an Atom

Atomic (proton) Number:

The total number of protons in the nucleus of an atom. This determines the properties of an atom in this case all elements with the same proton number have same chemical properties.

Mass number:-The total number of neutrons and protons in the nucleus of an atom.

Isotopes:-Atoms of the same element with the same number of protons but differ in the number of neutrons.

$_{1}^{1}H$, $_{1}^{2}H$, $_{1}^{3}H$

RADIOACTIVITY

The spontaneous splitting of a nucleus of the atom of a radioactive element with the emission of radiations.

RADIOACTIVE ELEMENTS

The elements that can decay to release radiations and energy, such as Uranium, Plutonium, Polonium, Radium, Thorium, Radon, Ionium etc.

The radioactive particles are: Alpha particles, Beta particles and Gamma radiation.

In 1896, Henri Becquerel discovered the concept of radioactivity when he used uranium metal which released radiations.

Table 4.1: Properties of radioactive particles

	α particle	β particle	γ particle
Nature	Helium nuclei $_2{}^4H$	High energy electrons	Electromagnetic waves of very short wavelength
Velocity	7% speed of light	At approximately speed of light	Travel at speed of light
Charge	Positive	Negative	Neutral
Effect of magnetic and electric fields	Slightly deflected towards the south pole or negative charge	Strongly deflected towards north pole or positive charge	No effect
Ionizing power	It causes heavy radiation because of it longer wavelength	It causes mild radiation due to short wavelength	It causes small radiation due to very short wavelength
Penetrating power	It has little penetrating power	It has high penetrating power	
Fluorescence	It causes fluorescence on ZnS	It causes no fluorescence	It causes no fluorescence

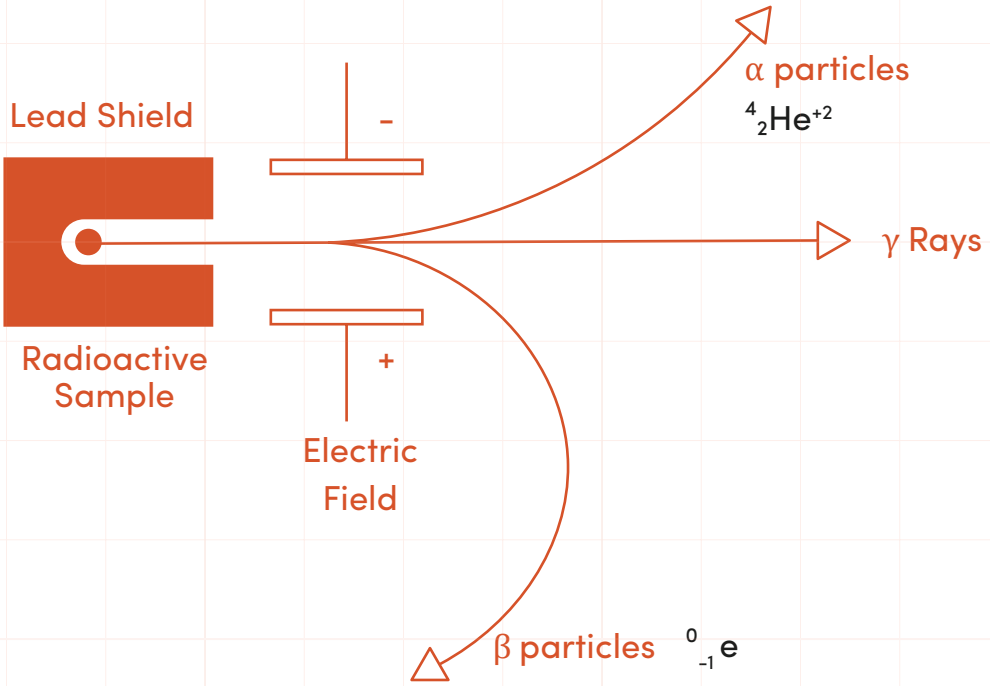


Fig. 4.7: Deflection of Particles in an Electric Field

RADIOACTIVE DECAY

The spontaneous splitting of radioactive material with the emission of radiations.

RATE OF DECAY

Is directly proportional to the number of radioactive atoms present at the beginning in a given sample of radioactive element.

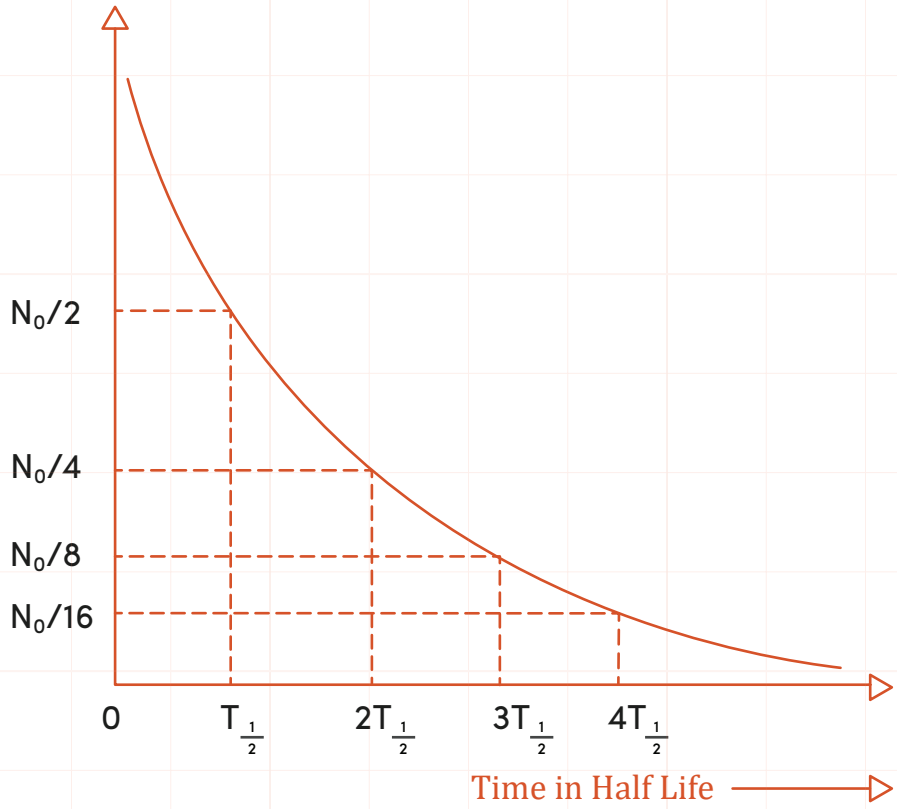


Fig. 4.8: Decay Curve

$n = Ne^{-\lambda t}$

Where n=new mass

N = original mass

t = decay time

λ = decay constant

HALF - LIFE T

The time taken by half of the original atom present in the element to decay.

Decay constant:-The ratio of the number of atom decaying per second to the number of atom present at the beginning.

$$T = \frac{0.693}{\lambda}$$

λ = K decay constant

The equations are:

$$T = \frac{0.693}{\lambda}$$

$t = KT$

$$n = \frac{N}{2^{\lambda}}$$

Activity:

A substance has a half-life of 3mins. After 6mins the count rate was observed to be 400. What was its count rate at zero time?

Solution

T = 3, t = 6, n = 400

Using $t = \lambda T$ we get $6 = \lambda \times 3$

$$\lambda = \frac{6}{3} = 2$$

Then use, $n = \frac{N}{2^{\lambda}}$ We get $400 = \frac{N}{2^{\lambda}}$

Hence N = 400 x 4 = **1600**

TYPES OF RADIOACTIVITY

1. Natural radioactivity:-The spontaneous splitting of the heavy nucleus with emission of radiations and huge amount of energy

$$^{226}_{88}Ra + \alpha \longrightarrow {}^{222}_{86}Rn + E$$

Radium Radon

It occurs naturally.

2. Artificial radioactivity:-By bombarding the nucleus of radioactive elements with radioactive particles this is called transmutation.

$$^{9}_{4}Be + \alpha \longrightarrow {}^{12}_{6}C + {}^{1}_{0}n + E$$

Radioisotopes:-The isotopes made artificially by bombarding radioactive particles at elements

NUCLEAR REACTION

This is the reaction that takes place in the nucleus of an atom by changing the structure of the nucleus with the release of a huge amount of energy.

The reactions are:

1. **Nuclear fission:** The splitting of heavy radioactive nucleus into two approximate equal parts when bombarding with slow-moving neutrons with the release of a huge amount of energy and neutrons.

$$^{235}_{92}U + {}^{1}_{0}n \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3{}^{1}_{0}n + \Delta E$$

Fission occurs with most of the very massive nuclei (Uranium, Polonium, and Plutonium) and has been produced by slow-moving neutrons, high-energy alpha particles, protons, X-rays and gamma rays.

Chain reaction: The continuous bombardment and splitting of a radioactive nucleus which leads to a nuclear reaction that sustains itself. Chain reaction is a multiplying and self-maintaining reaction, when the size of uranium exceeds a certain critical mass there is a rapid production of neutrons with the release of energy in nuclear explosion.

Uses

1. For atomic and nuclear fission bomb
2. For nuclear power stations.

Critical mass: The minimum mass of the radioactive element needed to induce and sustain a chain reaction.

2. **Nuclear fusion:** The combination of two or more light nuclides to form a heavy nuclide with the release of a huge amount of energy.

$$^{2}_{1}H + {}^{3}_{0}H \longrightarrow {}^{4}_{2}H + {}^{1}_{0}n + E$$

Table 4.2: Differences between Nuclear Fusion and Nuclear Fission

	Nuclear **Fusion**	Nuclear **Fission**
1	It is achieved with light elements	It is done with heavy elements
2	The elements are cheaper	The elements are costly
3	The radioactive particles produced are less dangerous	The particles are more dangerous
4	No limit to mass of element to explode	There is limit of mass to explode
5	Fission is incorporated into it before it works	Nothing is incorporated into it before it works
6	It produces higher energy	Energy produced is not as high as fusion

Nuclear Reactor

The components are:-

i. **Nuclear fuel:** Uranium-235 rod
ii. **The moderator:** Graphite and heavy water to slow-down neutrons to induce nuclear reaction.
iii. **The control rod:** Boron and cadmium to absorb neutrons produced in order to
iv. **Heat exchanger:** Where the heat produced and converted to steam.

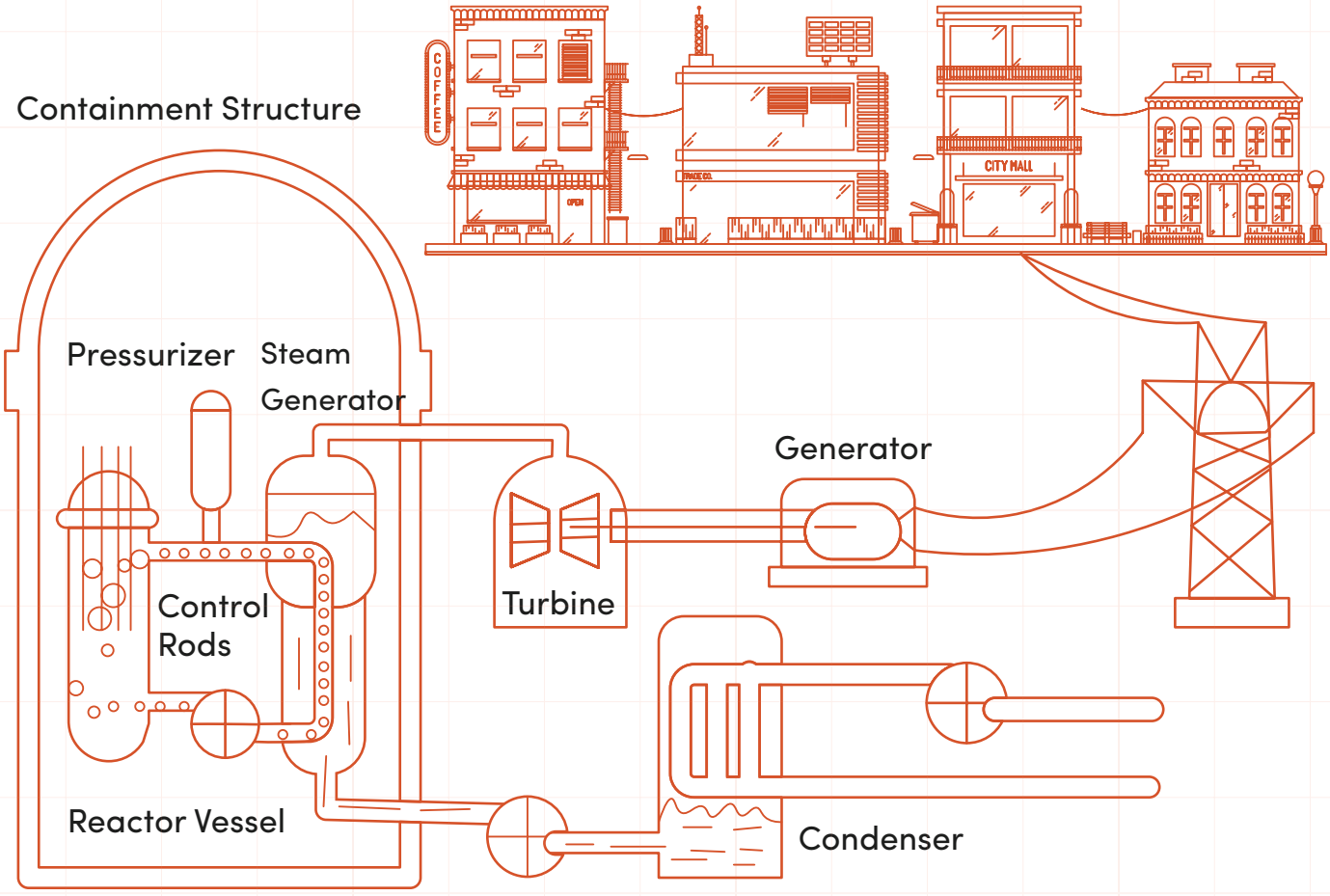


Fig. 4.9: Nuclear Reactor

USES OF NUCLEAR ENERGY

1. Medical uses
   - Radiations used locate tumour in the brains
   - Radiations used for sterilizing and killing germs
   - Radiation used for detecting fractures in bones
   - Radiations for killing cancerous cells
   - For radiotherapy
2. Industrial use
   - To locate leakages in pipe carrying oil
   - To detect fractures in metals
   - In archaeology, carbon-14 is used for carbon dating to know the age of dead plants, animals, rocks and fossils
   - For radioisotopes
3. In agricultural use
   - As a radioactive tracer to induce mutation in plants and animals

- for preservative

4. Spacecraft, ships, submarines are power by nuclear energy
5. For nuclear power stations to generate electricity through thermal process.

Nigeria Nuclear Energy Programme

Nigeria Atomic Energy Commission NAEC proposed a nuclear road map to generate electricity to solve Nigeria power problems and not depend too much on hydro-power and fossil fuels.

The problems facing the programme are:

1. Technical know-how: About handling of radioactive materials and nuclear wastes, because safety and security of the radioactive materials are the priorities.
2. Lack of storage facilities of the nuclear materials
3. Lack of detecting capacity at point of entry
4. Lack of radioactive waste dumping sites.

The international Atomic Energy Agency IAEA has certified Nigeria having met the first requirement, but Nigeria projected the programme till 2027 to take off.

NUCLEAR ENERGY CALCULATION

Binding energy:-The minimum amount of energy absorbed by a nucleus to break up into its constituent particles (protons and neutrons).

Mass defect:

The gain in mass produced when the particles of the nucleus are separated

$$\Delta m = \Sigma (m_p + m_n) - m_x = Zm_p + (A - Z)m_n - m_x$$

Where Δm = mass defect

m_p = mass of proton

m_n = mass of neutron

m_x = mass of nucleus

A = mass number

Z = atomic number

Einstein Energy Equation

$E = mc^2$

E = energy released in joules

m = mass defect

c = speed of light in space about 3×10^8 m/s

SUMMARY

So far, we have learnt how to

1. Identify the radiation from radioactive substances using their characteristics
2. Solve simple problems involving half-life
3. State some uses of radioactive substance
4. Use the concept of nuclear fission and fusion for the development of a nuclear energy programme for Nigeria.

INTERACTIVE ASSESSMENT QUESTIONS

1. The heaviest part of an atom is

   A Proton
   B Electron
   C Neutron
   D Nucleus
   E Orbit

2. The radioactive particle that is deflecting towards the south pole of magnet is

   A Beta particle
   B Gamma particle
   C Positron
   D Alpha particle
   E Neutron

3. This type of radioactivity is

$$^{226}_{88}Ra + \alpha \longrightarrow {}^{222}_{86}Rn + E$$

   A Artificial
   B Fusion
   C Natural
   D Alpha radioactive
   E Radioisotopes

4. An element whose half-life is 3years has N atoms would have decayed after 9years?

   A 6/8 N atoms
   B 7/8 N atoms
   C 5/8 N atoms
   D 1/8 N atoms
   E 3/8 N atoms

5. The half-life of a radioactive substance is 14days. If 48g of this substance is stored, after how many days will 1.5g of the original substance remains?

   A 75days
   B 70days
   C 65days
   D 60days
   E 55days

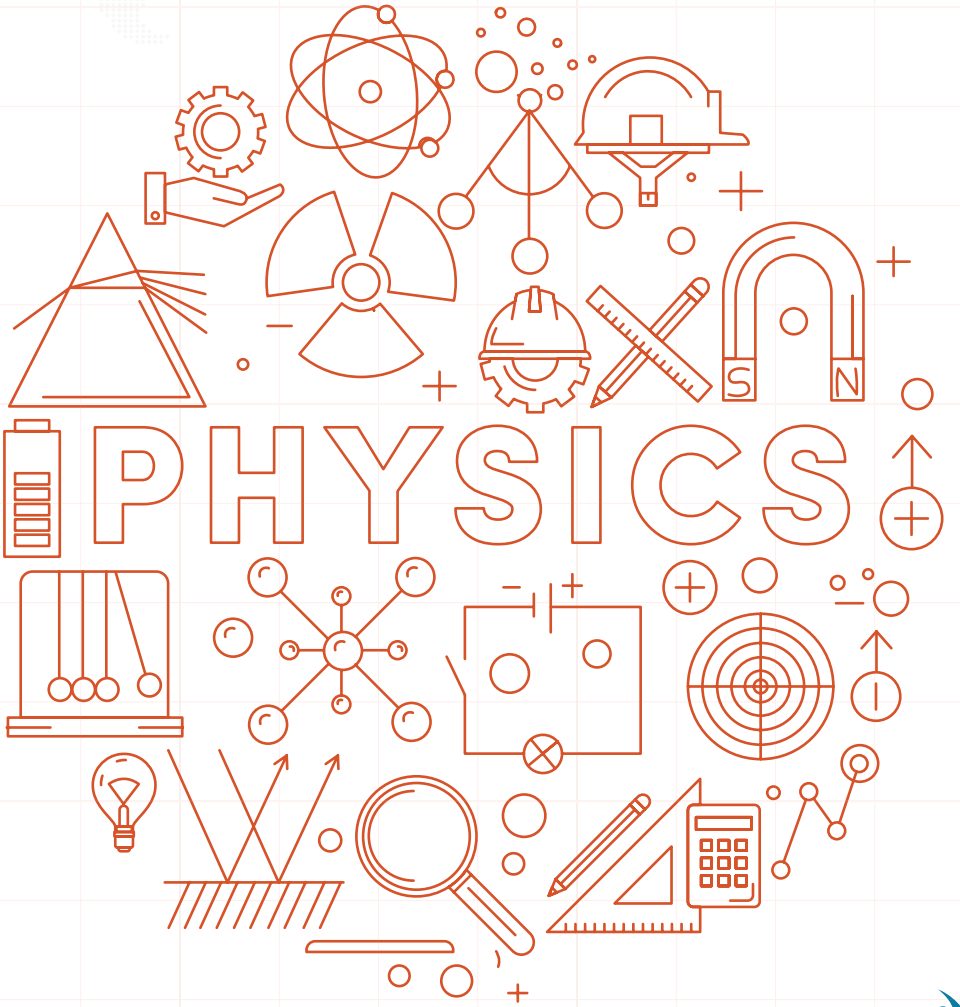
6. Eight α-particles and six β-particles are emitted from an atom of uranium-238 (92) electrons before it achieves stability, the nucleon number of the final product in the chain reaction is

   A 206
   B 210
   C 200
   D 204
   E 214

ENERGY QUANTIZATION

PERFORMANCE OBJECTIVES

1. Explain the concept of energy quantization
2. Use the photon concept to explain the effect of electrons in the photoelectric effect
3. Describe X-rays production and state its characteristics, properties and uses.



MALEZI
EMPOWERING THOSE WHO CARE

ENERGY QUANTIZATION

Quantum energy was discovered by Max Planck who studied the energy of radiation emitted by black body and detected that energy is not continuous but being released in small units or packets called quanta.

The energy is proportional to the frequency of the source. It is also called photon or wave packet

E = hf

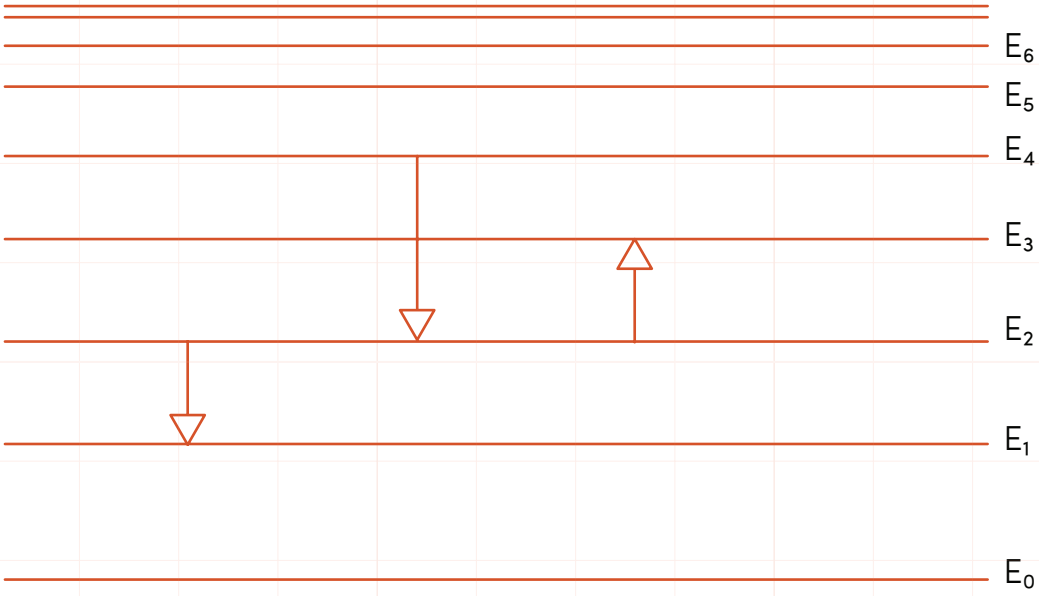


Fig. 4.10: Energy Levels in an Atom

Energy levels in atoms

Based on Bohr, electrons stay at different orbits called energy levels, the lowest level is the first principal quantum number (n=1),the electron in this orbit is always stable and does not radiate energy in this case the level is called ground state energy level E0.

When an electron gains more energy, it jumps to higher levels called excited state energy level.

First excited state has second principal quantum number n=2

Table 4.3: Energy Levels in a Nutshell

Energy level	Principal quantum number
E_0	n_1
E_1	n_2
E_2	n_3
E_3	n_4
E_4	n_5
E_n	n_{n+1}

The difference between two energy levels determines the size of the energy released.

$E_n - E_o = hf$

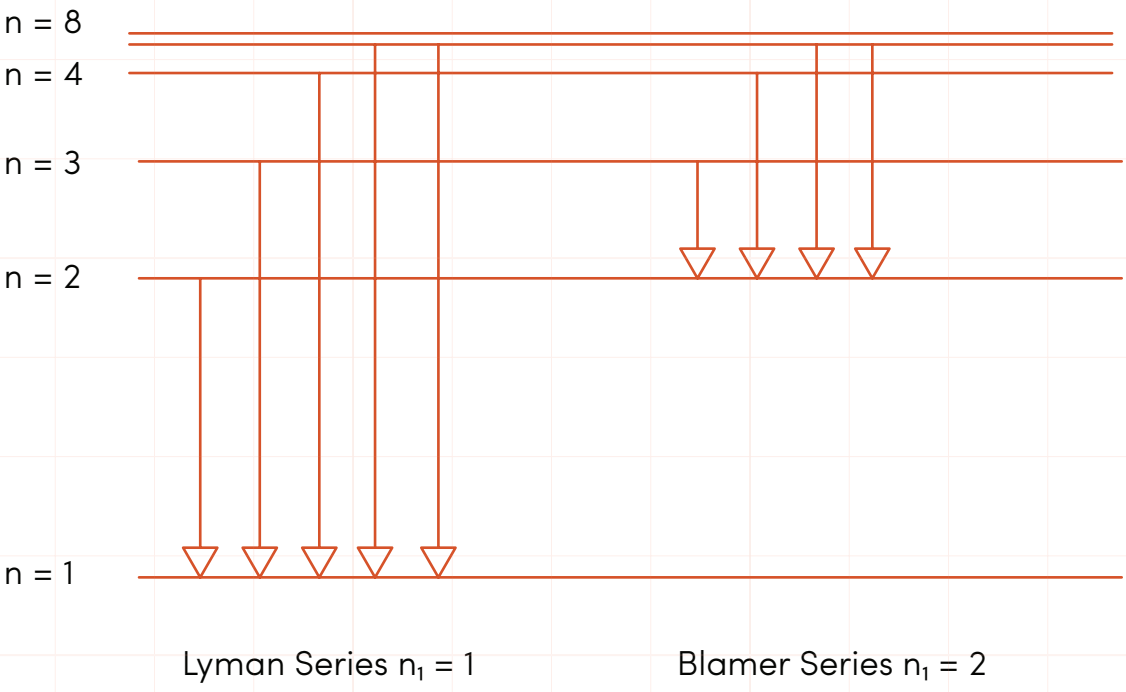


Fig. 4.11: Lyman Series ($n_1 = 1$) and Blamer Series ($n_1 = 2$)

Excitation energy:-The minimum energy gained by an electron to jump to higher energy level

Ionization energy:-The energy gained by an electron to be removed completely from the atom

The energy state

$$E_n = \frac{-21.8 \times 10^{-19} J}{n^2}$$

$$E_0 = \frac{-21.8 \times 10^{-19}}{1^2} = -21.8 \times 10^{-19}$$

$$E_1 = \frac{-21.8 \times 10^{-19}}{2^2} = -5.45 \times 10^{-19}$$

$$E_2 = \frac{-21.8 \times 10^{-19}}{3^2} = -2.24 \times 10^{-19}$$

ATOMIC SPECTRA

When the ground state electron gains energy, it jumps to a higher level and becomes excited and when it jumps down the energy level, it emits light, the light emitted or absorbed is called atomic spectra.

The types of atomic spectra are:

1. **Emission line spectra:** Are series of distinct and separated bright lines of definite wavelength or frequency in a dark background.

Types are:

a. **Bright line spectra**: It comprises a series of lines of different colours and each colour corresponds to light of a particular wavelength or frequency, example is hydrogen gas.

b. **Band spectra:** A series of bright lines grouped into bands, this type is produced by complex atoms, example is chlorine gas.

c. **Continuous spectrum:** The light consists of all frequencies or wavelengths, example electrical sparks and hot solid objects.

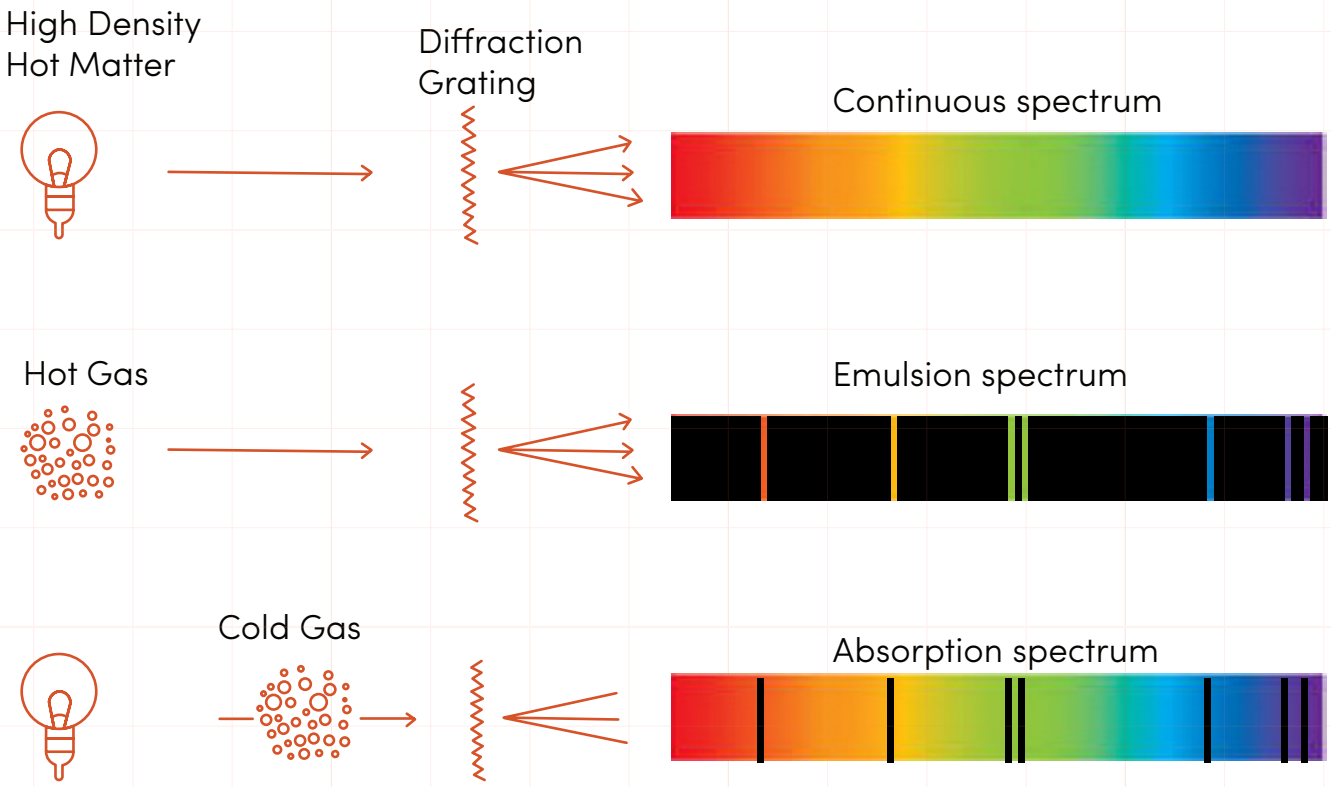


Fig. 4.12: Sources of the Atomic Spectra

2. **Absorption line spectra**: Are series of distinct and separated lines of definite frequency or wavelength absorbed when light passes through cool gases.

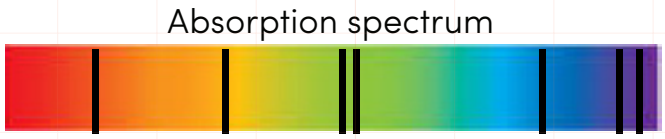


Fig. 4.13: Absorption Spectrum

PHOTOELECTRIC EFFECTS

The emission of electrons from the surface of metal when light falls on its surface, and the emitted electrons are called photo-electrons.

And this was discovered by Lenard in 1902.

Characteristics of photoelectric effects

1. Existence of threshold frequency (a minimum frequency needed to emit electrons from a metal surface)
2. The maximum kinetic energy of the photo-electrons depends on the frequency of the incident radiation.
3. The number of electrons emitted is proportional to the intensity of the incident radiation.

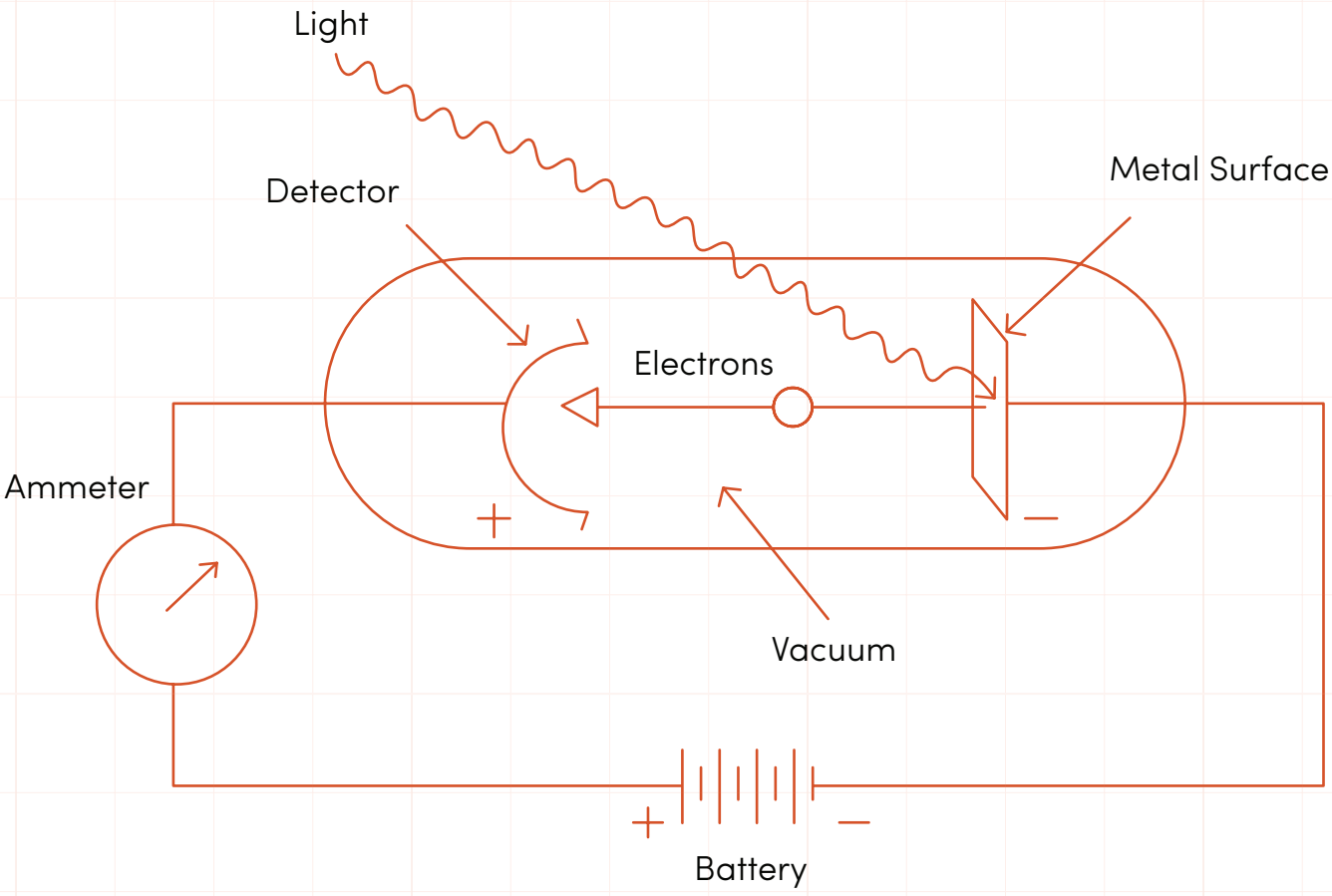


Fig. 4.14: The Photoelectric Effect

Einstein photo-electric effect equation

1. **Work function:** The work done to remove electrons from the metal surface. The minimum energy needed by an electron to be removed from the surface.

$$W = hf_0 = \frac{hc}{\lambda_0}$$

$$f_0 = \frac{c}{\lambda_0}$$

Where f_0 = threshold frequency

λ_0 = threshold wavelength

K.E = hf - W

$$E = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

$$\frac{1}{2} mV^2 = hf - W$$

PHOTOCELLS

A photocell converts light energy to electrical energy, the components are:

1. Anode in the form of rod
2. Cathode made of photosensitive metal like caesium
3. Glass envelop.

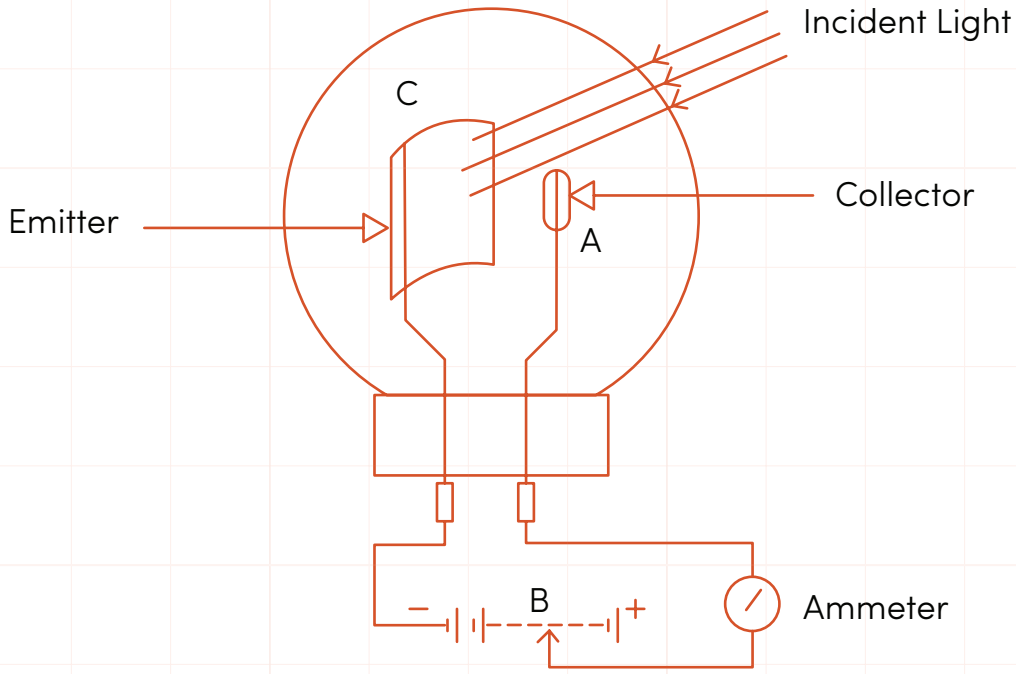


Fig. 4.15: A Photocell

Uses of photocells

1. For electronic circuit to open door
2. To operate burglar alarm
3. To power street light
4. In camera as light meter
5. To generate electricity for the household when used with inverters.

X-RAYS

It was accidentally discovered by William Roentgen in 1895, its production is the inverse of photo-electric effect and can also be interpreted the same way.

X-rays are electromagnetic radiation of high penetrating power, and have similar properties as gamma rays but the difference is that gamma rays originate from the nucleus during radioactive decay.

Production

It is produced when a fast-moving high-energy electron beam is suddenly slowed down by the atoms of the target. The kinetic energy of the fast moving electrons is converted to heat energy with less than 1% converted to X-rays.

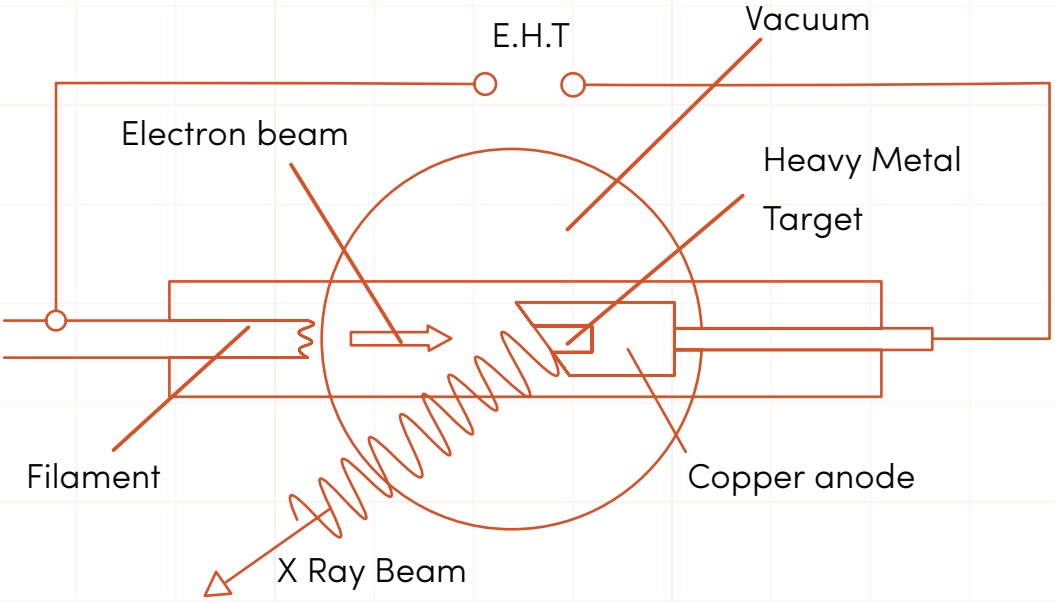


Fig. 4.16: A X-Ray Tube

COMPONENT PARTS

1. Electron gun to shoot out electrons
2. A target to stop fast moving electron beam
3. Enclosed container to stop air from affecting the motion of the electron beam

High voltage of 100KV is used

TYPES OF X-RAYS

1. Hard X-rays:-The X-rays that have shorter wavelength and higher frequency or higher penetrating power.
2. Soft X-rays:-The X-rays that have longer wavelength and lower frequency or lower penetrating power.

PROPERTIES OF X-RAYS

1. It is an electromagnetic radiation of shorter wavelength and higher frequency
2. The electrons are travelling with the speed of light.
3. It travels in straight line
4. It produces fluorescence
5. It affects photographic film
6. It penetrates opaque materials
7. It cannot be deflected by electric and magnetic field
8. It can be interfered, diffracted, reflected, refracted and polarised
9. It ionises gases
10. It liberates electrons when falls on metal surface
11. It is diffracted by crystals.

USES OF X-RAYS

1. Medical uses
   - -to reveal fracture, bullets and dense objects in the body
   - -it reveals obstruction in the internal organs
   - -it is used to kill cancerous cells

-for sterilization to kill germs

2. Industrial uses
   - To reveal fracture in metals
   - X-rays diffraction to reveal how atoms are arranged
   - To reveal the structure of complex molecules
   - To reveal covered painting

SUMMARY

So far, we have learnt how to

1. Explain the concept of energy quantization
2. Use the photon concept to explain the effect of electrons in the photoelectric effect
3. Describe X-rays production and state its characteristics, properties and uses.

INTERACTIVE ASSESSMENT QUESTIONS

1. Quantum energy was discovered by

   A Isaac Newton
   B De Broglie
   C Carl Max
   D Max Planck
   E Becquerel

2. Which of the following gives rise to the line spectra observed in atoms?

A Kinetic energy of moving atoms
B Potential energy of an electron inside an atom
C Excitation of an electron in the atom
D Change of an electron from higher to a lower energy level in the atom
E Disturbed proton in the nucleus.

3. The figure below represents

A Absorption spectra
B Bight line spectra
C Band spectra
D Continuous spectra
E Emission spectra

4. An electron makes a transition from a certain energy level E_n to the ground state E_0,if the frequency of emission is $8x10^{14}$Hz,the emitted energy is

A $8.25x10^{-19}$J
B $5.20x10^{-19}$J
C $5.28x10^{-19}$J
D $52.8x10^{19}$J
E $825x10^{19}$J

5. Which of the phenomenon is called photoelectric effect ?

A Two electrons are created from a quantum of light
B A metal absorbs quanta of light and then emits electrons
C A high energy photon emits photons as it is slowed down
D High energy electrons impinge on a metallic anode which then emits photons
E Low energy photon emits electrons

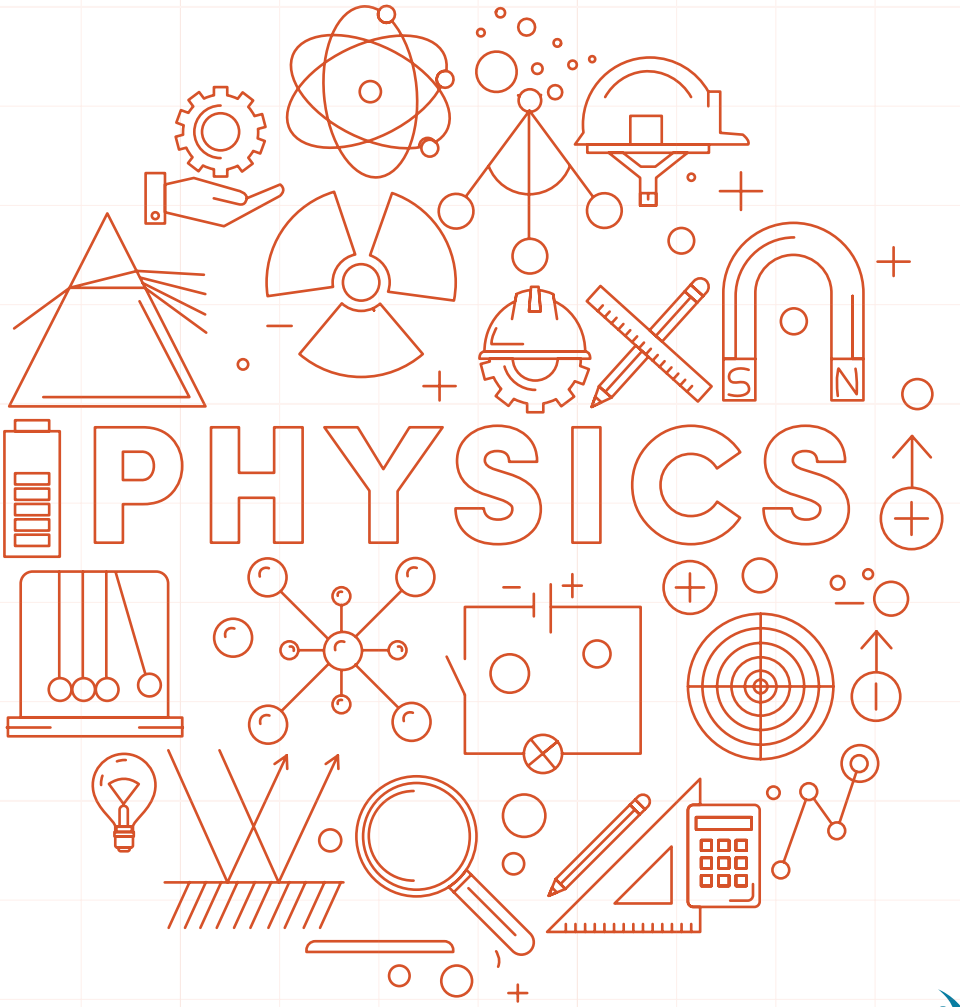
6. When a radiation strikes a metal surface, electrons may be ejected from the metal. The maximum kinetic energy which may be acquired by an ejected electron depends on the

A Source of the radiation
B Intensity of the radiation
C Wavelength of the radiation
D Frequency of the emitted electrons
E Detection device for the electron.

DUALITY OF MATTER

PERFORMANCE OBJECTIVES

1. Identify the phenomena which are only satisfactorily explained by assuming that matter behave like
   - Waves
   - Particles.



DUALITY OF MATTER

Duality of matter means matter behaves as a wave as well as a particle but cannot be displayed simultaneously.

Light has wave and particle (corpuscle) properties.

The wave properties of light are: diffraction, interference, polarisation, reflection and refraction.

The particle or corpuscle properties of light are: photoelectric effect, Compton effect, thermionic emission, radiation from heated bodies, and absorption of light, ionisation ability, momentum and mass.

Evidence of particle nature of matter

1. Absorption of radiation by Gold objects
2. Emission of electrons from a metal surface when it is irradiated by light of sufficient frequency
3. Emission of light by hot objects.

Evidraction by crystals

1. Proton diffraction by crystals

Electron diffraction by crystalsence of wave nature of matter

2. Neutron diff

Louis De Broglie stated that particles should have wave properties when they move at a speed close to the speed of light.

$$\lambda = \frac{h}{mv}$$

Where λ = Wavelength

p = Momentum

h = Pack constant

But $p = \sqrt{2mV}$, Where V = Voltage

$$\lambda = \frac{h}{\sqrt{2meV}}$$

eV = electron volt

HEISENBERG'S UNCERTAINTY PRINCIPLE

States that it is not possible to determine the exact position and momentum of a particle simultaneously.

The uncertainty in the position and the uncertainty in the momentum is equal to the Planck's constant.

$\Delta x.\Delta p > h$

$\Delta x.\Delta p > h$

$\Delta x.\Delta p > h$

1. Position and Momentum
2. Position and Velocity
3. Energy and Time

The variable above are known as complementary variables. $h = \frac{h}{2\pi}$

SUMMARY

So far, we have learnt how to

1. Identify the phenomena which are only satisfactorily explained by assuming that matter behave like
   - Waves
   - Particles.

INTERACTIVE ASSESSMENT QUESTIONS

1. Which of the following are not complementary variables

   A Energy and position
   B Energy and time
   C Velocity and position
   D Energy and mass
   E Acceleration and time

2. The particle nature of matter are

A Emission of light by hot objects
B Emission of electrons from a metal surface when it is irradiated by light of sufficient frequency
C Neutron diffraction by crystals
D Proton diffraction by crystals
E Electron diffraction by crystals

3. Duality of matter means

A Absorption of radiation by Gold objects
B Neutron diffraction by crystals
C Electron diffraction by crystals
D Matter behaves as a wave as well as a particle but cannot be displayed simultaneously.
E Emission of light by hot objects

4. The equation below is known as

$$\lambda = \frac{h}{mv}$$

A Einstein equation
B Max Planck equation
C De Broglie equation
D Becquerel equation
E Marie curie equation

5. Which of the following statement is a correct consequence of the Uncertainty Principle?

A A particle kinetic energy cannot be measure accurately at any time

B Both momentum and energy of a particle can be known with absolute certainty

C The uncertainty in our knowledge of energy and the duration taken to measure it, are each less than Planck's constant

D The complete knowledge of the position of a particle implies the complete ignorance of its energy

E It is possible to measure exactly both the position and momentum of a particle at the same time.

THEME 05

Conservation Principles

Wave, motion without material transfer

Field at rest and in motion

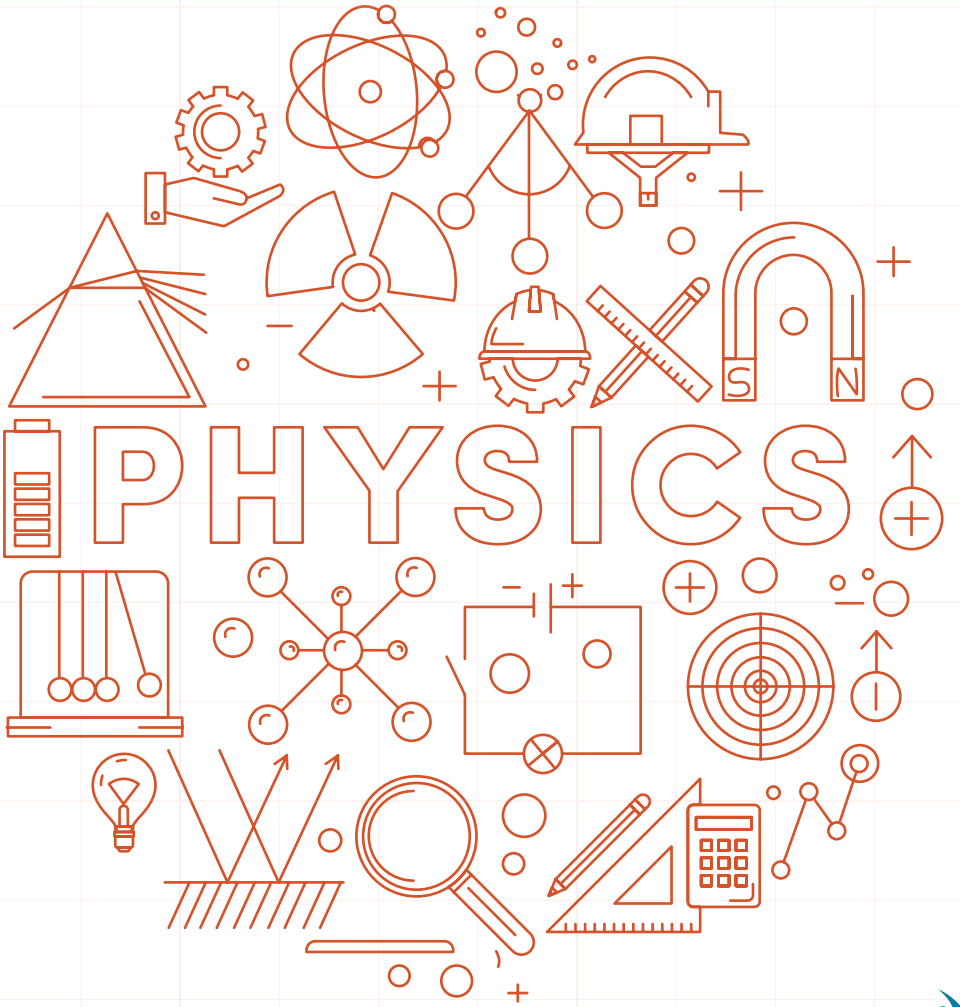
Energy quantization and duality of matter

Physics in Technology

BATTERY

PERFORMANCE OBJECTIVE

1. Construct a battery



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BATTERY

A Battery is a device that converts and stores chemical energy and to electrical energy, the chemical reaction of a battery involves the flow of charges in the electrode in an external circuit. The flow of charges produce an electric current that can be used to do work, to balance the flow of charges, it also flows through the electrolyte solution in contact with the electrodes, different electrolytes and electrodes produce different chemical reactions that are affecting how the battery works, how much energy it can store and its voltage.

The invention of the battery was credited to the Italian scientist Alessandro Volta, who put together the first battery to prove a point to another Italian scientist, Luigi Galvani. In 1780, Galvani showed that the legs of frogs hanging on brass or iron hooks could produce charges when touched with a metal. He discovered that this was caused by electricity from the frog's tissues, and called it bio-electricity.

Volta was impressed with Galvani's discovering, later believed that the electric current was from the two different metals (the metal of the probe and the hooks on which the frogs were hanging) and was being transmitted through not from the frog's tissues. He experimented with stacks of layers of silver and zinc with paper or cloth soaked in saltwater and found that electric charges did flow through a wire applied to the two ends of the pile.

Electrodes

The conductors placed in the electrolyte for the flow of charges from one electrode called the anode (negative electrode) to another electrode cathode (positive electrode).

ELECTROCHEMICAL CELLS

An electrochemical cell is two different metals in contact in an electrolyte (a liquid with free-moving ions).

A set of connected cells is called a battery. Batteries come in two basic types: primary and secondary. The chemical reaction that powers a primary cell is one way. Once the chemicals are used up the battery will be dead. In contrast, the chemical reaction in a secondary cell is reversible. When the reaction runs in its spontaneous direction, the battery produces a potential difference. When the same potential difference is

applied to the battery from an external source, the chemical reaction runs in reverse. A battery made up of secondary cells is said to be rechargeable.

- Luigi Galvani (1737–1798) Italy discovered biological electricity.
- Alessandro Volta (1745–1827) Italy (Lombardy) constructed the first battery in 1800, the voltaic pile.
- John Daniell (1790–1845) England, Daniell cell 1836
- Georges Leclanché (1839–1882) France, Leclanché Cell 1866
- William Hyde Wollaston (1766–1828) England showed that electricity from voltaic piles was the same as the electricity produced by friction.

Voltage, current, power, capacity

Voltage is the driving force in the battery and that can push electrons through the cell.

Current is the number of electrons that are passing through any one point of a circuit at a given time. The higher the current, the more work it can do at the same voltage.

Power is the voltage x current. The higher the power, the quicker the rate at which a battery can do work

Capacity is the power of the battery as a function of time, which is used to describe the length of time a battery will be able to power a device. A high-capacity battery will be able to keep going for a longer period before running down.

Energy density is the amount of energy a device can hold per unit volume

TYPES OF BATTERIES

Batteries are classified into 2 types:

- Non-rechargeable batteries (primary batteries)
- Rechargeable batteries (secondary batteries)

NON-RECHARGEABLE BATTERIES

These are the primary batteries because they are only used once, these batteries cannot be recharged and use again.

ALKALINE BATTERIES

It is constructed with the chemical composition of Zinc (Zn) and manganese dioxide (MnO_2), as the electrolyte used in it is potassium hydroxide which is purely an alkaline substance the battery is named as an alkaline battery having the power density of 100 Wh/Kg.

Advantages:

1. Cycle life is more
2. Highly efficient.
3. Compatible and efficient for powering portable devices.
4. Shelf life is more.
5. Leakage is low
6. Small in size.
7. Low internal resistance and less discharge state.

Disadvantages:

It is costly

Applications: It is used in wall clocks, torches, small portable gadgets, and remote controls

COIN CELL BATTERIES

Lithium and silver oxide chemicals will be used to manufacture these batteries which are more efficient in providing steady and stable voltage in such small sizes. It has a Power density of 270 Wh/Kg.

Advantages:

1. Light in weight
2. Small in size
3. Easy to get high voltages by arranging serially
4. Low cost
5. High nominal voltage (up to 3V)
6. Long shelf life
7. High density

Disadvantages:

1. Low current draw capability
2. Needs a holder

Applications:

Used in miniature electronic products, wall clocks, watches

RECHARGEABLE BATTERIES

These are called secondary batteries which can be recharged and can be used again. It is costly but they can be recharged and reused and can have a huge life span when properly used

LEAD-ACID BATTERIES

It consists of lead-acid which is very cheap and found mostly in cars and vehicles to power the lighting systems. These are preferable where the size and weight do not matter. They come with a nominal voltage ranging from 2V to24V and most commonly seen as 2V, 6V, 12V, and 24V batteries. It has a Power density of 7 Wh/Kg.

Advantages:

1. Cheap in cost
2. High power output capability
3. Easily rechargeable

Disadvantages:

1. Very heavy
2. Power density is very low
3. Occupies large space

Applications:

Used in heavy machinery, cars, UPS (uninterrupted Power Supply), robotics,

NI-CD BATTERIES

These batteries are made of Nickel and Cadmium chemical composition. These are rarely used, these are very cheap and their discharge rate is very low when compared to Ni-MH batteries. These are available in all standard sizes like AA, AAA, C, and rectangular shapes. The nominal voltage is 1.2V, often connected in a set of 3 which gives 3.6V. It has a Power density of 60 Wh/Kg.

Advantages

1. Cheaper in cost
2. It is used in all environments
3. Comes in all standard sizes
4. Easily to recharge

Disadvantages

1. Low power density
2. Needed to be changed frequently to avoid the growth of crystals on the battery plate.
3. They contain toxic metal

Applications:

Used in solar lights and mostly in the applications where the price is important, RC toys, cordless phones,

NI-MH BATTERIES

The Nickel – Metal Hydride batteries are much preferable than Ni-Cad batteries because of their lower environmental impact. Its nominal voltage is 1.25 V which is greater than Ni-Cad batteries. It has less nominal voltage than alkaline batteries and they are a good replacement due to their availability and less environmental impact. The power density of Ni-MH batteries is 100 Wh/Kg.

Advantages:

1. Easy to recharge.
2. A good alternative to alkaline which has almost all similarities and also it is rechargeable.
3. Available in all standard sizes.
4. High power density.

Disadvantages:

1. Expensive than Ni-Cad batteries.
2. Self-discharge is very high.

Applications:

Used in all applications similar to the alkaline and Ni-Cad batteries.

LI-ION BATTERIES

These are made up of Lithium metal and are the latest in rechargeable technology. These are compact, they can be used in most of the applications where high power specification is needed. These are the best rechargeable batteries available. These have a nominal voltage of **3.7V** (most commonly we have **3.6V** and **7.2V**) and have various ranges of power capacity (starting from 100s of mAh to 1000s of mAh). Even the C-rating ranges from 1C to 10C and the Power density of Li-ion batteries is **126** Wh/Kg.

Advantages:

1. Power density is very high.
2. Cell voltage is high.
3. High C-rating.
4. Very light in weight

Disadvantages:

1. They are a bit expensive.
2. A battery protection circuit is needed.
3. If the terminals are short-circuited the battery might explode.

LI-PO BATTERIES

These are also called as Lithium-Ion polymer rechargeable batteries because it uses high conductivity polymer gel/polymers electrolyte instead of liquid electrolyte. These come under the Li-ion technology. These are a bit costly. But the battery is very highly protected when compared to the Li-ion batteries. It has a Power density of 185 Wh/Kg.

Advantages:

1. They are highly protective compared to Li-ion batteries.
2. They are thin in structure when compared to Li-ion batteries.
3. Power density, nominal voltages are comparatively very high compared to Ni-Cad and Ni-MH batteries.
4. They very light in weight

Disadvantages:

1. It is expensive.
2. It should not be exposed to high temperatures which can cause an explosion.
3. It can explode if connected wrongly.

Applications:

Can be used in all robotics, RC toys, the portable devices which need rechargeable advantage like drones,

DEFECTS OF CELLS

Local action: The covering of zinc electrode by hydrogen gas, which is caused by impurities in the zinc electrodes.

CONTROL

Using pure zinc as a negative electrode

Coating the zinc electrode with mercury to stop the impurities from reacting.

Polarisation: The covering of copper electrode by hydrogen gas bubbles, which can cause the emf of a cell to drop

CONTROL

1. Brushing the terminals of the electrodes to remove the junks
2. Depolariser: This converts hydrogen gas to water before reaching the electrodes.

SUMMARY

So far, we have learnt how to

1. Construct a battery

INTERACTIVE ASSESSMENT QUESTIONS

1. The first scientist that discovered the battery was

   A Luigi Galvani
   B Alessandro Volta
   C John Daniell
   D William Hyde Wollaston
   E Georges Leclanché

2. Biocell was discovered by

   A Allesandro Volta
   B Luigi Galvani
   C John Daniell
   D Williams Hydes
   E Georges Leclanché

3. The type of cell found in the car is

   A Coin cell
   B Lithium cell
   C Lead-acid cell
   D Lechlanche cell
   E Daniell cell

4. The scientist that showed that electricity from voltaic piles was the same as the electricity produced by friction was

   A John Daniell
   B Georges Leclanché
   C William Hyde Wollaston
   D Alessandro Volta
   E Luigi Galvani

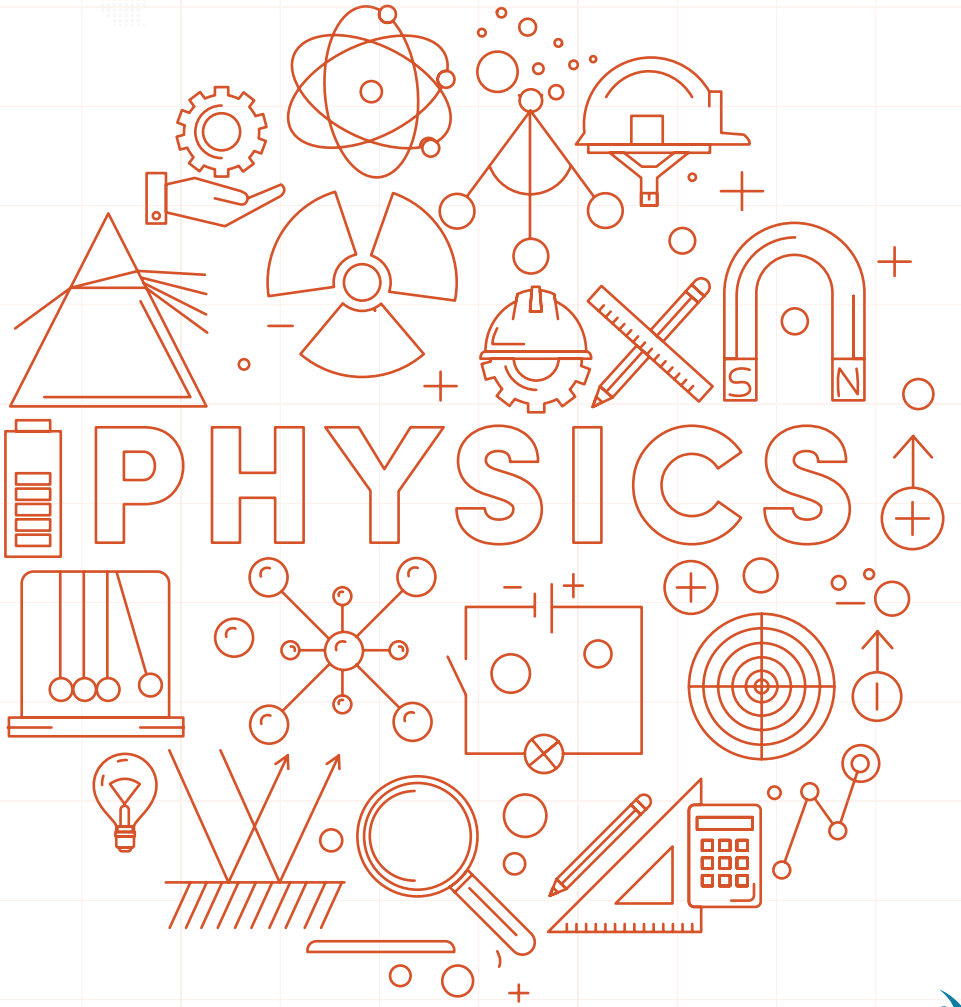
5. The type of cell used for uninterrupted power supply is

   A Lead-acid
   B Ni-Cd
   C Ni-MH
   D Li-ion
   E Li-Po

ELECTROPLATING

PERFORMANCE OBJECTIVES

1. To electroplate a suitable electrode.
2. Define electroplating
3. Define and explain electrochemistry
4. Explain electroplating
5. Name the uses of electroplating



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ELECTROPLATING

Electroplating is the process of plating or coating a metal onto the other by hydrolysis to prevent corrosion and for decorative purposes.

Electroplating is by passing electric charge through a solution called an electrolyte. This is done by inserting two electrodes into the electrolyte solution and connecting them to a circuit with a power supply. The electrodes and electrolyte are made from chosen elements or compounds. When the electricity flows through the circuit they make the electrolyte splits up and some of the metal atoms it contains are deposited in a thin layer on top of one of the electrodes and becomes electroplated.

The process is using an electric charge to reduce dissolved metal cations to develop a tiny metal coating on the electrode. Electroplating is always used in the electrical oxidation of anions on a solid substance.

Electroplating is applied in changing the surface features of an object (like corrosion protection, abrasion and lubricity), but the process can be used to build thickness or make objects by electro-forming. All kinds of metals can be plated in this way,including gold,silver,tin,zinc,copper,cadmium,chromium,nickel,platinum, and lead.
Electroplating is the same as electrolysis (using electricity to split up a chemical solution),which is the reverse of the process by which batteries produced electric currents. All these are examples of electrochemistry.

Electrochemistry: The chemical reactions caused by or producing electricity that give scientifically or industrially useful end-products.

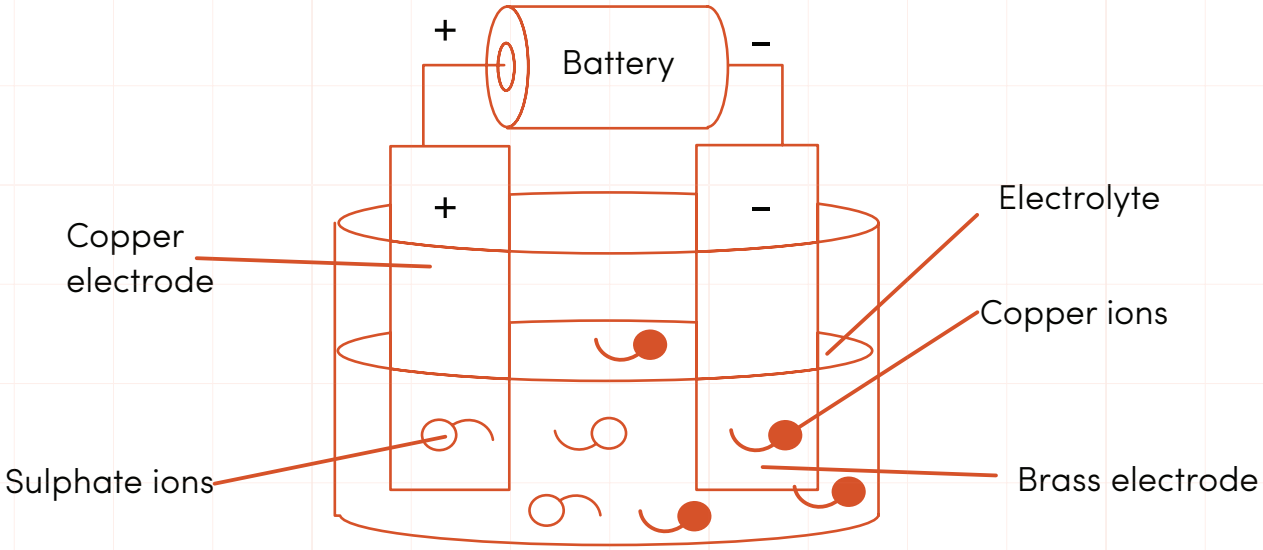


Fig. 5.1: Electroplating

THE ANODE AND CATHODE

In electroplating the current is always introduced from external sources and the anode is the positive electrode and cathode is a negative electrode. The cathode is the electrode where the electrochemical reduction reactions occur, while the anode is where the electrochemical oxidation reactions occur.

The electroplating process is using an anode and a cathode, the metal dissolved from the anode can be plated onto the cathode. The anode is provided with direct current, oxidizing and dissolving its metal atoms in the electrolyte solution, at the cathode the dissolved metal ions are decreased and the metal is placed on the product.

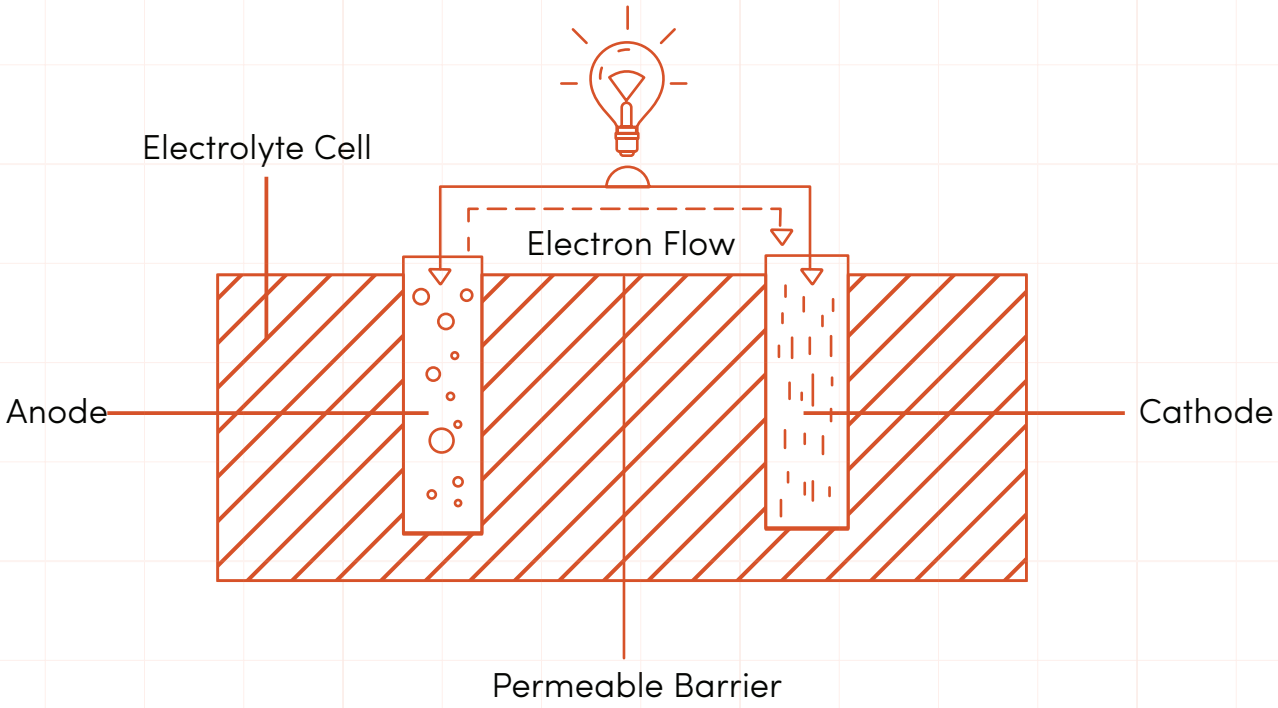


Fig. 5.2: The Voltmeter (A device for studying the flow of current through a liquid)

How does Electroplating Work?

To understand the concept better, a layer of gold is to be electro-deposited on metallic jewelry to enhance its appearance.

The gold plating is connected to the anode (+ve charged electrode) of the circuit and the jewelry is placed at the cathode (-ve charged electrode). Both are immersed in an electrolytic solution. DC current is supplied to the anode that oxidized the gold atoms and dissolved them into the solution.

The dissolved gold ions are reduced at the cathode and coated on the jewelry

There are major factors that affect the coating. These are:

1. The current length of time
2. The temperature and chemical composition of the bath.
3. The voltage level of current
4. The distance between the cathode and the anode

Uses of Electroplating

common applications of electroplating involve:

1. Improving the thickness of the metal surface.
2. Enhancing the electrical conductivity like plating a copper layer on an electrical component.
3. Improving wear resistance.
4. Improving surface uniformity.
5. Minimizing Friction.
6. Electroplating is also used for making duplicates of printing plates in a process called electro-typing
7. For electro-forming (an alternative to casting objects from molten metals).

Why use electroplating?

Electroplating is generally done for two quite different reasons:

1. Decoration
2. Protection.

Metals such as gold and silver are plated for decoration: it's cheaper to have gold- or silver-plated jewelry than solid items made from these heavy, expensive, precious substances. Because different metals have different colors, electroplating can be used to give things like rings, chains, badges, medals, and similar items a wide range of attractive, decorative finishes, including shiny, matte, and antique variations on gold, silver, copper, nickel, and bronze. Metals such as tin and zinc (which are not attractive) are plated for protective. For example, food containers are tin plated to make them resistant to corrosion, while many items made from iron are plated with zinc (in a process called galvanization) for the same reason. Some forms of electroplating are both protective and decorative. Car fenders and trim are plated with chromium to make them attractively shiny and rust-resistant (inexpensive and naturally rustproof plastics are now more likely to be used on cars instead). Alloys such as brass and bronze can be plated too, by arranging for the electrolyte to contain salts of all the metals that need to be present in the alloy. Electroplating is also used for making duplicates of printing plates in a process called electro-typing and for electro-forming (an alternative to casting objects from molten metals).

The thickness of electroplating

Whether plating for decoration or protection, the thickness of the plated layer is important. the thicker the plating the longer it lasts and the more protection it gives, even the thickest plating is much thinner than you can expect. The typical thickness of plated metal varies from about 0.0005 millimeters up to about 0.02 millimeters, so that is extremely thin.

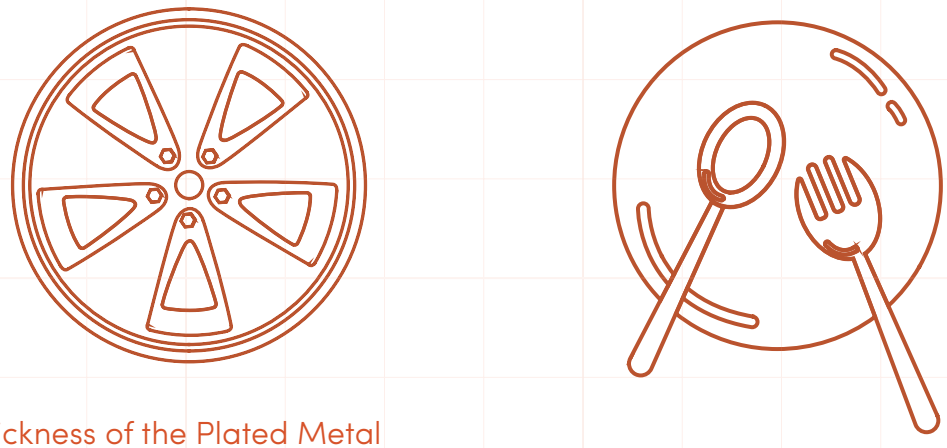


Fig. 5.3: Thickness of the Plated Metal

SUMMARY

So far, we have learnt how to

1. Define electroplating
2. Define and explain electrochemistry
3. Explain electroplating
4. Name the uses of electroplating

INTERACTIVE ASSESSMENT QUESTIONS

1. The process of plating a metal onto the other by hydrolysis to prevent corrosion of metal and for decorative purposes.

   A Electoplating
   B Eletroplating
   C Electroplating
   D Hydrolysis
   E Electropainting

2. The place where the electrochemical reduction reactions occur

   A Anode
   B Cathode
   C Anode-Anode
   D Cathode-Cathode
   E Anode-Cathode

3. The place where the electrochemical oxidation reactions occur

A Anode
B Cathode
C Anode-Anode
D Cathode-Cathode
E Anode-Cathode

4. Making duplicates of printing plates in a process called

A Electroplating
B Electrophorus
C Electrocoating
D Electroforming
E Electro-typing

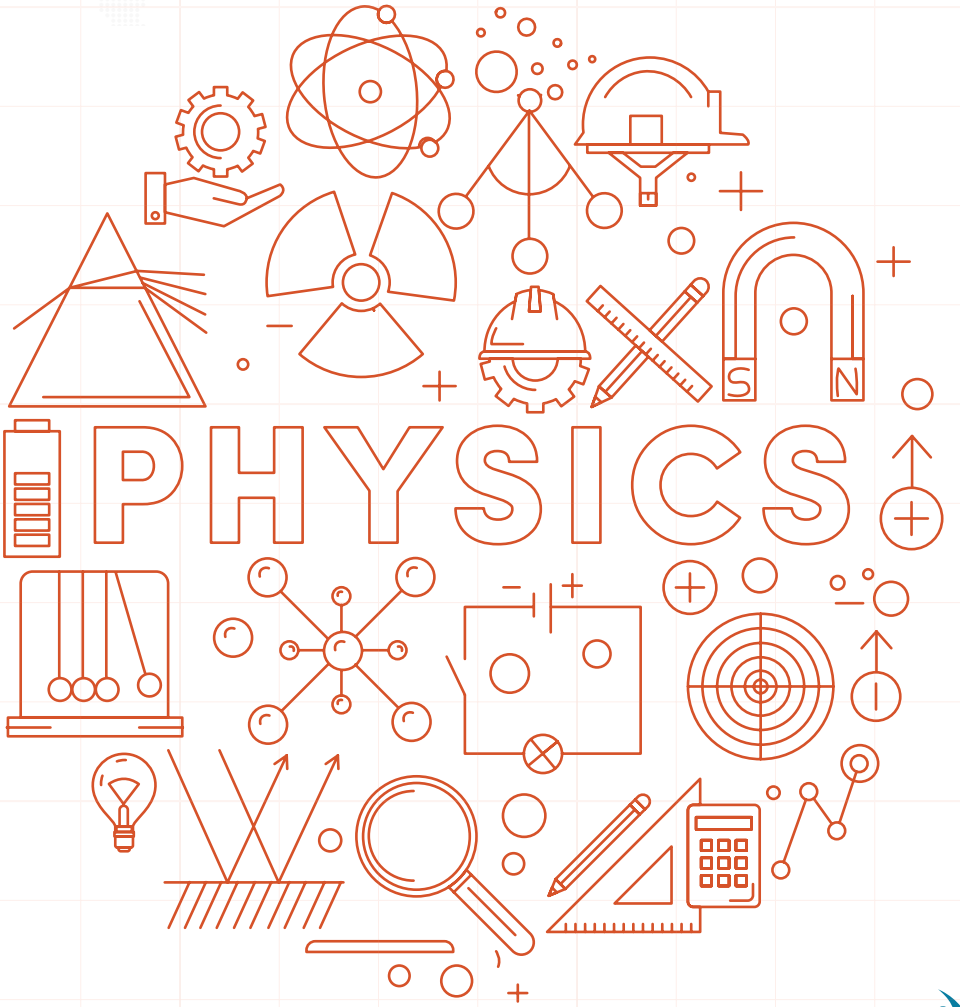
5. Galvanization means

A Coating with Gold
B Coating with copper
C Coating with bronze
D Coating with zinc
E Coating with tin

APPLICATIONS OF ELECTROMAGNETISM

PERFORMANCE OBJECTIVES

1. Construct and use a galvanometer
2. Construct and use an electric motor
3. Construct and use a generator.



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APPLICATIONS OF ELECTROMAGNETISM

A branch of physics that deals with electric fields and magnetic fields and their interaction with substance or matter is called Electromagnetism. Electromagnetism has created a great impact and revolution in the field of engineering applications. This has a significant impact on various fields such as medical, industrial, space. The practical applications of electromagnetism in everyday life ranging from domestic appliances to research applications.

In domestic applications, we observed the phenomena in lighting, heating, and kitchen appliances, in communication systems which exist in all telecommunication equipment and communication network, in industrial systems this can be used in motors, generators, sensor and actuator devices.

If a current-carrying conductor wound on a high permeability iron core creates an electromagnet effect. If this electromagnet is excited, then the magnetic field is produced. The strength of the magnetic flux depends on the current flowing through the electromagnet and the number of turns wounds on it.

The magnetic fields produced by an electromagnet used for special device purpose. Such devices include transformers, motors, relays. In a transformer, the magnetic field produced causes the e.m.f to generate in the secondary coil such that voltage transfer is carried between two magnetically coupled circuits.

Moving iron meter

The moving iron meter uses the magnetic effect of current to measure the strength of the current flowing through it.

The galvanometer is one of the most sensitive and accurate methods for detecting or measuring very small currents or potential differences.

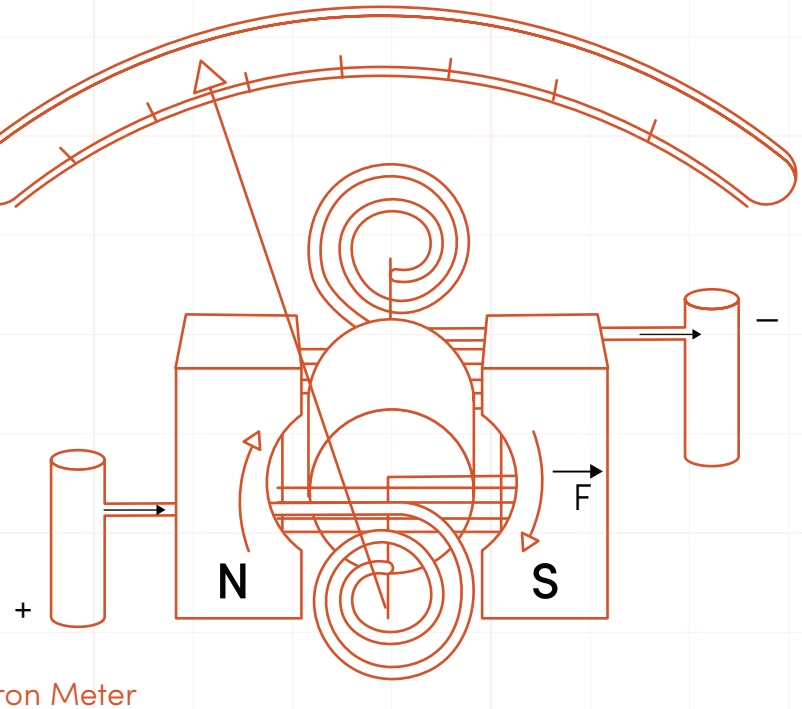


Fig. 5.4: Moving Iron Meter

Structure

It contains the following

1. Two curved pieces of poles N and S of a horse-shoe magnet and soft -iron core
2. A light rectangular vertical coil pivoted in jeweled bearing such that it moves in a vertical plane
3. Two spiral non-magnetic control springs of bronze
4. A pointer attached to the axle moves over a uniform scale.

Working principle

The current to be measured is passed into the galvanometer from a terminal through a spring to the other, when the current flows in the coil, forces act on the arms and create two forces whose torque tends to rotate the coil in a clockwise direction

The sensitivity of the galvanometer is its ability to detect small currents while its accuracy is its ability to indicate the values of a close value

To increase the sensitivity of the galvanometer

1. The magnetic field is made stronger
2. The number of turns in the rectangular coil is increased
3. The area of the coil is increased
4. The spring should be made of thinner wire to enable twisting more easily

Advantages of moving coil galvanometer

1. The high sensitivity enables very small currents to be detected or measure
2. It has a uniform scale in which equal division represents equal steps of currents
3. By fitting on a suitable resistance, it is made to read different ranges of current or
4. It has a strong magnetic field shielding against any external forces

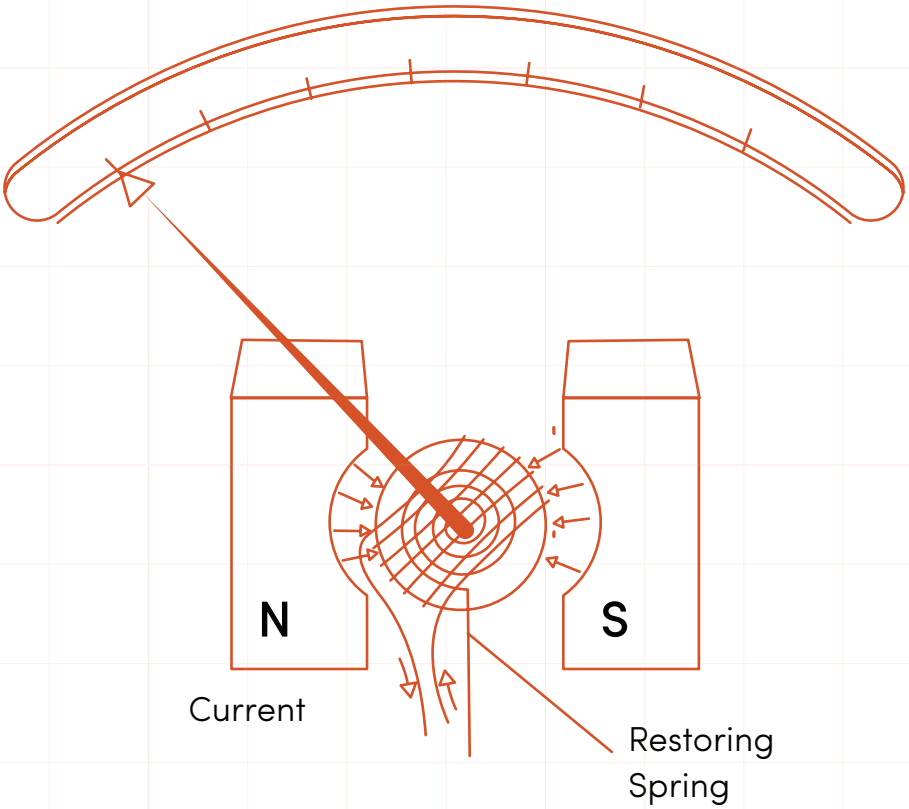


Fig. 5.5: The moving Coil Galvanometer

Electric motor

A device for converting electrical energy to mechanic energy, it consists of the following:

1. A rectangular coil of an insulated wire called an armature
2. A powerful magnetic field in which the armature lies in between
3. A commutator of ship rings or split-rings
4. Carbon brushes

Working principle

When current enters the armature placed in the pool of magnetic field, electromagnetic

fieldset in which the field is always perpendicular to reach other and always opposing each other which now cause the armature to roll in the pool of magnetic field using the principle of the current-carrying conductor in a magnetic field.

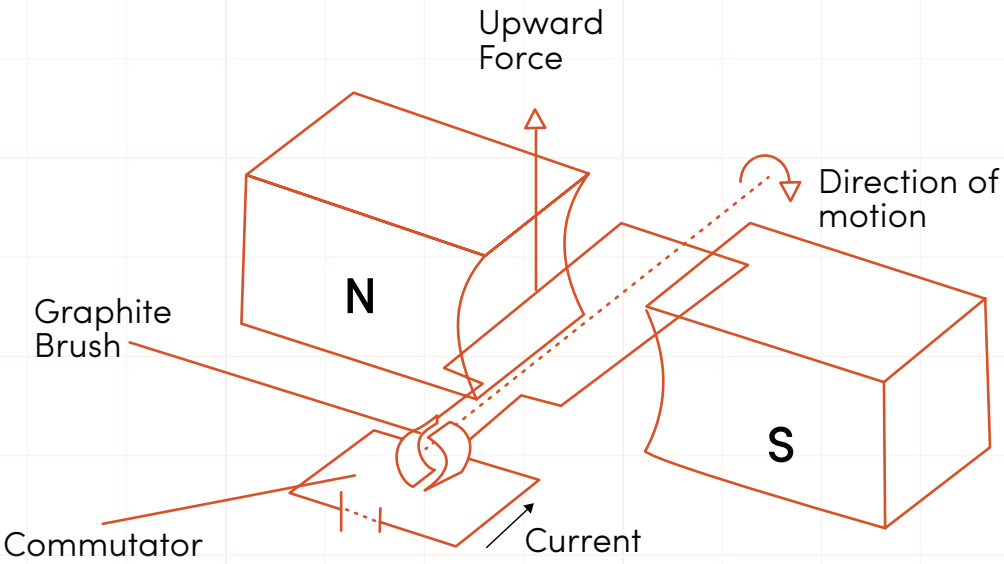


Fig. 5.6: Electric Motor

In relays, the magnetic field produced caused the plunger movement so that contacts get closed or opened and in motors this field causes the motor to rotate in a specific direction. Therefore, the usage of electromagnetism is wide and everywhere. So let us discuss some of the application areas where electromagnetism is used.

1. Household appliances
2. Industrial Applications
3. Magnetic Levitation Trains
4. Communication System
5. Medical System

Household appliances

Electromagnetism serves as a basic principle of working for many of the home appliances in household applications. These applications include lighting, kitchen appliances, air conditioning systems

1. The most dominant use of power in homes, as well as commercial buildings, is lighting systems. These lighting systems used numerous fluorescent lighting fixtures. Ballasts used in the fluorescent lamps use the electromagnetism principle so that at the time of turn ON of the light it produces a high voltage.
2. Electric fans, blowers, and other cooling systems use electric motors. These motors work on the principle of electromagnetic induction which is the branch of electromagnetism.
3. Kitchen appliances like induction cookers, microwave ovens, electric mixers and grinders, bread toasters, use electromagnetism for their operation.
4. Alarming systems use electrical bells which work based on electromagnetic principles. In these bells, the sound is produced by electromagnetic coils which move the striker against the bell. As long as the coil is energized, the iron striker gets attracted by it, hence it strikes the bell.
5. Security systems use locking systems for doors which are generally magnetic locking systems. These systems are unlocked either by a magnetic card swiping or having a security code.
6. The electromagnets will be demagnetized when the striker gets in contact with the bell and by the spring tension striker comes back to its original position and again electrical contact will be made once again. This process repeats until the switch gets opened.

Electric Bell

1. The magnetic card reader on the doors reads the number of keys stored in the magnetic tape of the card. When the key stored in memory matches with data on the card, then the door opens.
2. Security systems use locking systems for doors which are generally magnetic locking systems. These systems are unlocked either by a magnetic card swiping or having a security code.

Security systems

1. Entertainment systems like television, radio, or stereo systems use the loudspeaker. This device consists of an electromagnet which is attached to the membrane or cone surrounded by the magnetic flux produced by the permanent magnet.
2. When the current through the electromagnet is varied, the electromagnet and membrane of the speaker get moved back and forth. If the current is varied at the same frequencies of the sound waves, results in a vibration of the speaker which will further create sound waves.

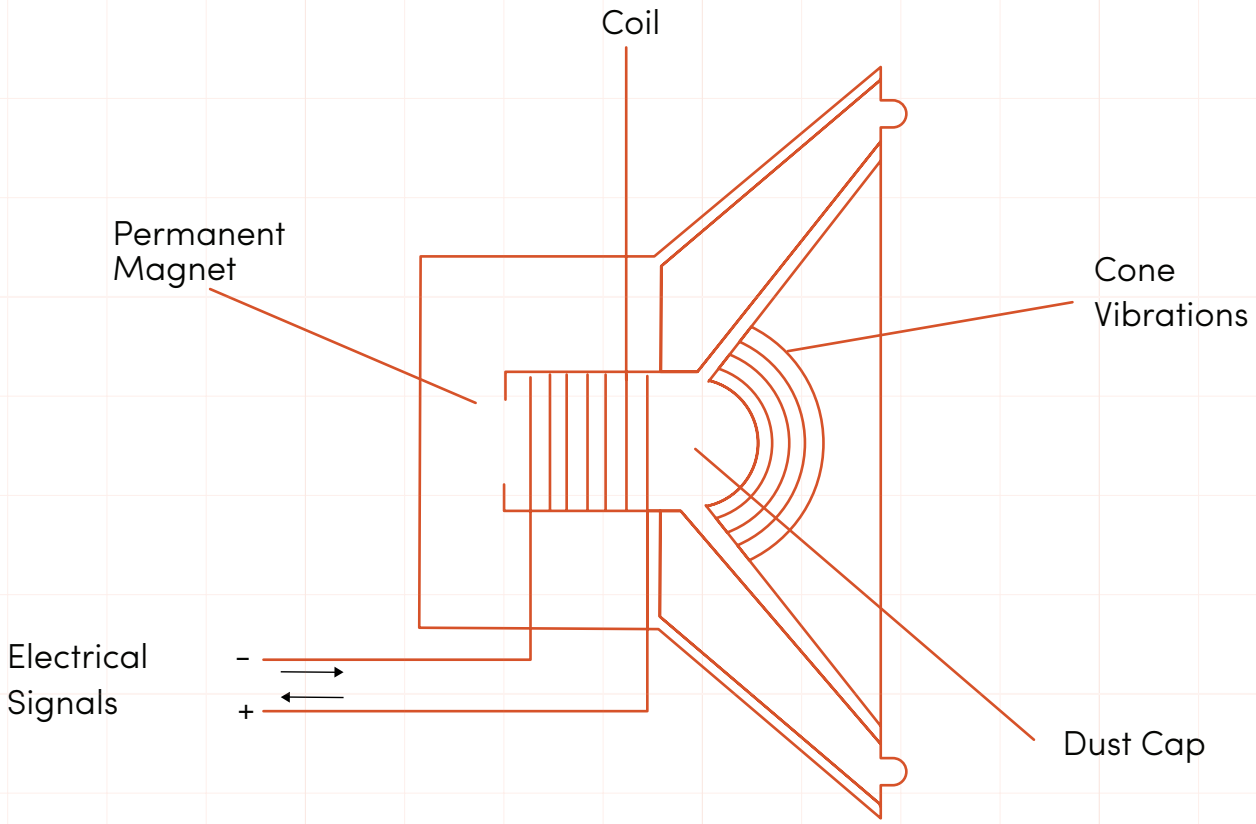


Fig. 5.7: Electric Speaker

Industrial Applications

All of the instruments or devices used in industries are based on electromagnetism. Materials used in constructing such devices include iron, cobalt, nickel, which naturally responds to the magnetic fields.

Starting from small control instruments to the large power equipment, electromagnetism is used at least at one stage of their working.

1. Generators and motors dominate in most of the industries which are the primary power source and driving systems respectively. Generators convert the mechanical to electrical energy whereas the motors convert electrical energy to mechanical energy.
2. Generators supply the electrical energy in the time of mains power interruption and in most of the cases, these are driven by the IC engines. There are different classes of motors which are employed in industries. These are used for cranes, hoists, lifts, conveyor systems, etc.

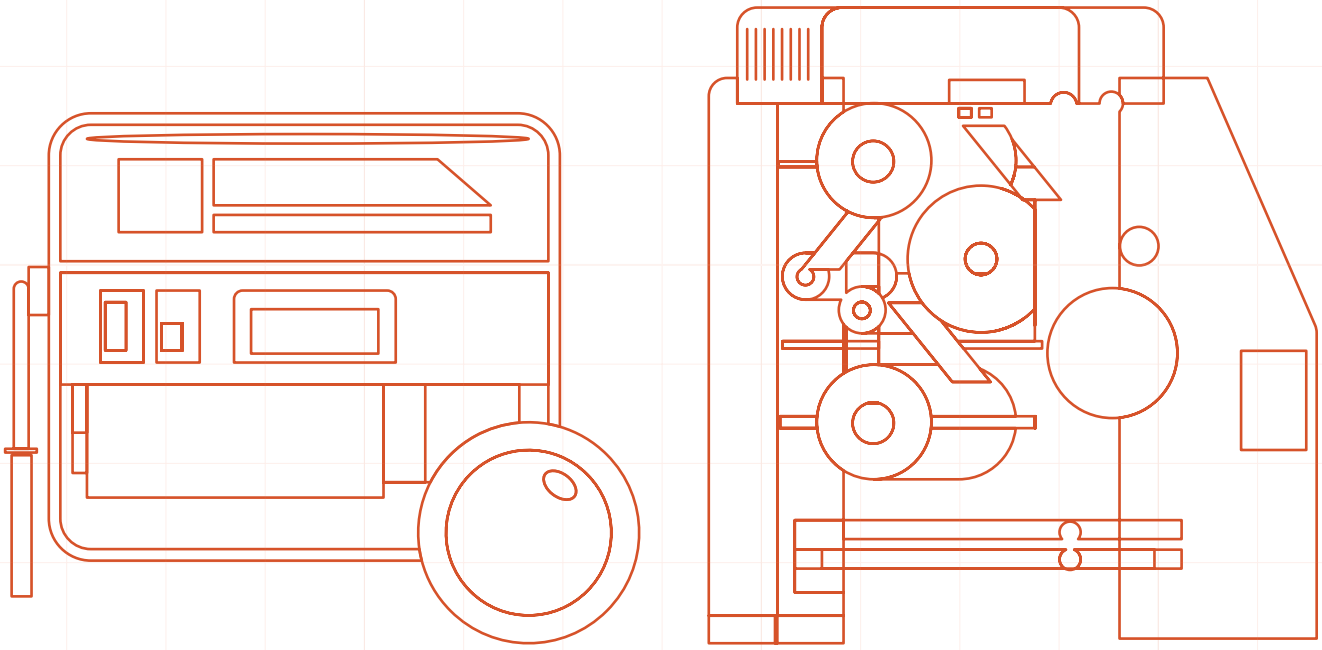


Fig. 5.8: Industrial Machines

Industrial Machines

1. Various sensors and actuating devices are work based on electromagnetism. Electromagnetic sensors include Hall-effect sensors, magnetoresistive sensors, fluxgate sensors, etc. These sensors convert the physical quantity such as flow, pressure, level, proximity, into an electrical signal.
2. Actuators are the final control elements that drive the load at specific conditions. These actuator devices include solenoid valves, relays, motors, etc., and all these works on the principle of electromagnetism.

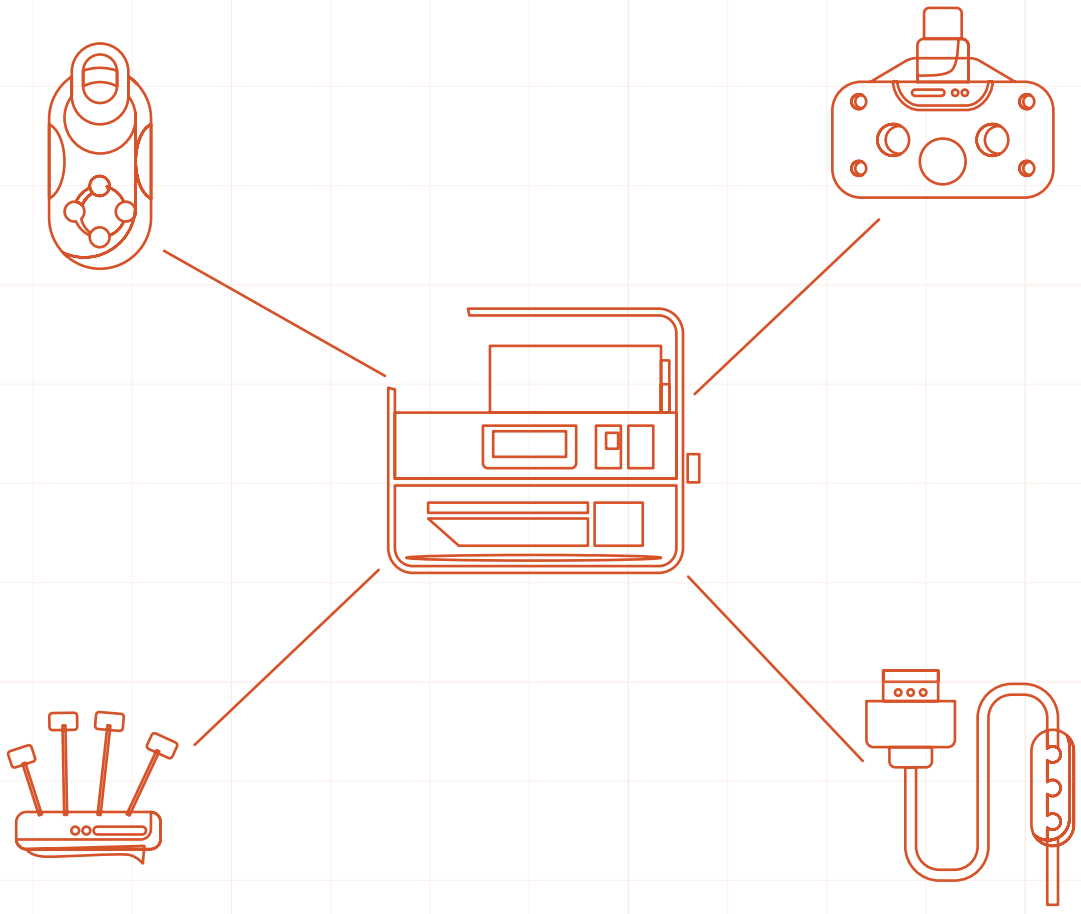


Fig. 5.9: Sensors and Actuators

Magnetic Levitation Trains

This is the modern technology of transportation systems that use the concept of electromagnetism. These are called highspeed trains which use powerful electromagnets to develop the speed.

These trains will float over a guideway using the basic principles of magnets such as electromagnetic suspension (EMS) and electrodynamic suspension (EDS). In EMS, electromagnets employed on the train body are attracted to the iron rails.
These magnets wrap around the guided rails and attractive force between the guideways and magnets lifts the train upwards. In EDS, the train is levitated by the repulsive force in the conductive guideways by induced currents.

A guideway is nothing but an arrangement of specially designed magnetic coils and tracks at regular intervals. Along this guideway, a maglev train is suspended by the phenomenon of magnetic levitation with no supports other than magnetic fields.

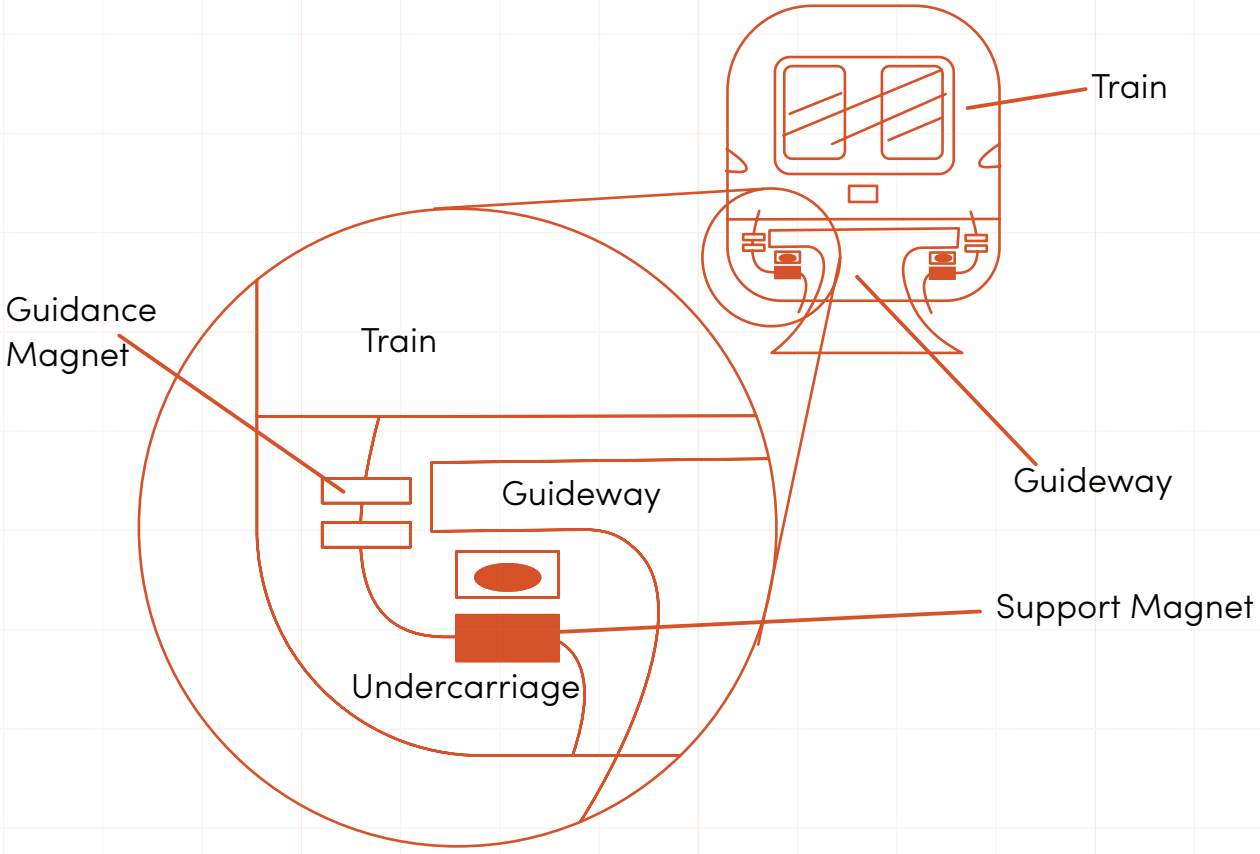


Fig. 5.10: Magnetic Levitation Trains

The above figure shows the EMS magnetic levitation system in which electromagnets are attached to the body of the train and are powered by the batteries in the train. The guideway consists of electromagnetic coils built on the surface of the track.

These coils are constructed with core material and coil windings. When the electromagnets are energized, the train will be levitated by the attractive force between the electromagnets and the coils.

Hence this type of system needs a large electrical power source, electromagnetic coils lining a guideway, and guidance magnets attached to the underside of the train.

Communication System

It is the process of transmitting information from a source to a receiver. This transmission of energy over long distances is carried out through electromagnetic waves at high frequencies. These waves are also called microwaves or high-frequency radio waves.

Suppose in the case of mobile phones, sound energy is converted into electromagnetic energy. By using radio transmitters, this electromagnetic energy is transferred to the receiver. At the receiver, these electromagnetic waves are again transformed back into sound energy.

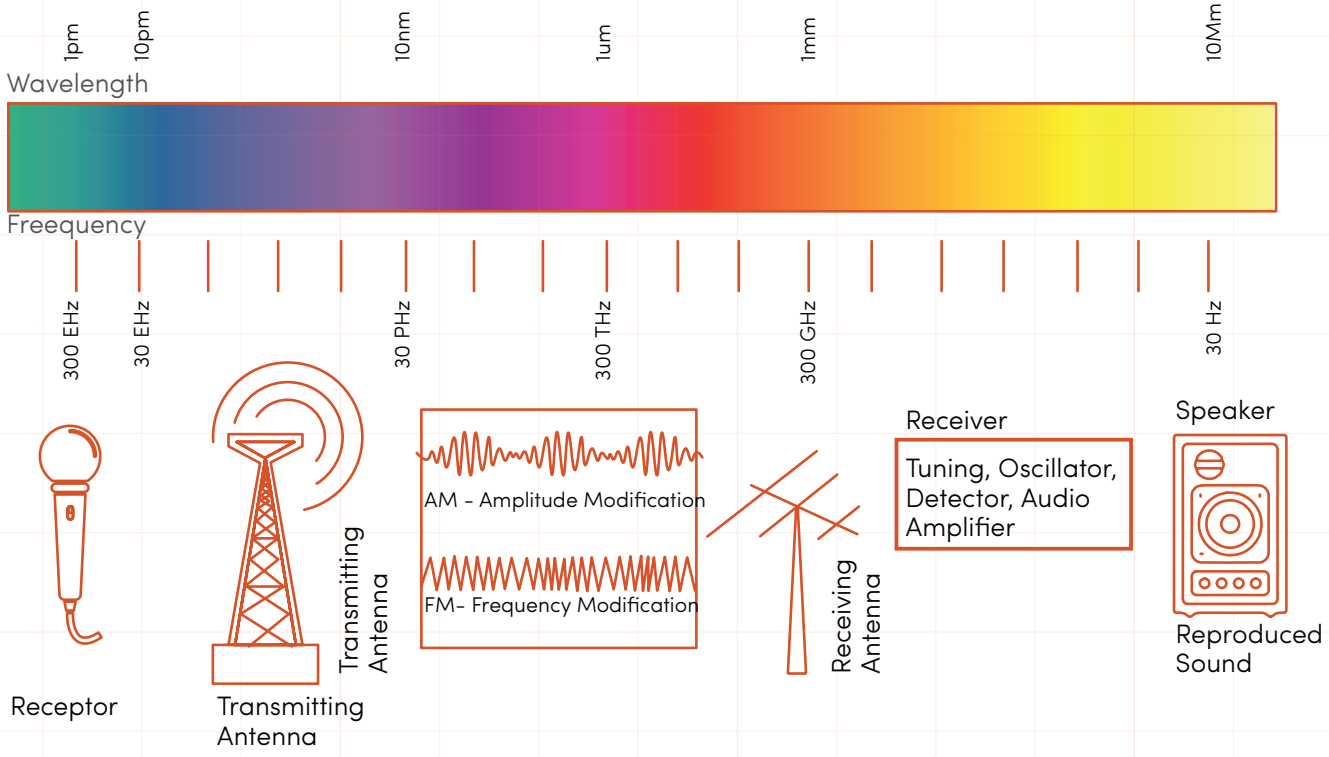


Fig. 5.11: Electromagnetic Radiation

Depending on the nature of the baseband signal, communication systems can be analog or digital communication systems. Depending on the nature of the transmitting signal, this system is categorized as baseband and carrier communication systems.
Electromagnetic fields produced by the time-varying sources are propagated through a waveguide or transmission line. Electromagnetic wave radiation is formed when these electromagnetic fields are propagated away from the sources without any connection or conducting medium to the sources.

Medical System

Electromagnetic fields play a key role in advanced medical equipment such as hyperthermia treatments for cancer, implants, and magnetic resonance imaging (MRI). RF range frequencies are mostly used in medical applications. In MRI scans, sophisticated equipment works based on electromagnetism can scan minute details of the human body.

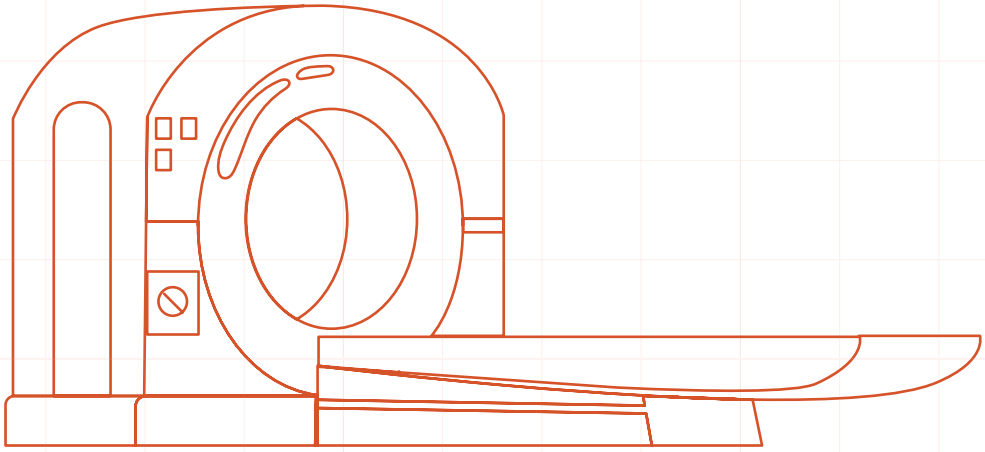


Fig. 5.12: Medical System

Electromagnetic therapy is an alternate form of medicine that claims to treat disease by applying pulsed electromagnetic fields or electromagnetic radiation to the body. This type of treatment is used for a wide range of ailments such as nervous disorders, diabetes, spinal cord injuries, ulcers, asthma, etc.
Many of the medical equipment such as scanners, x-ray equipment, and other types of equipment use the electromagnetism principle for their functioning.

Generator

There are two type

D.C and A.C generator

Electricity can be produced when moving a conducting coil through a magnetic field as a result of induced e.m.f

The machine that converts mechanical energy to electrical energy is called dynamo or generator and when changing electrical to mechanical it's called a motor.

Components of AC and DC generators

1. Armature:-a rectangular coil having a large number of turns of an insulated coil wound on the laminated soft iron core.
2. The magnetic field produced by an electromagnetic or by the curved poles of a horseshoe magnet
3. Copper slip/split rings:- they are connected to the end of the armature, the rings could be slip ring for A.C or split ring for D.C
4. Two stationary carbon brushes are made to touch the rings gently.

When the armature is rotated in the pool of magnetic fields of the magnets, induced e.m.f will set in in the coil and the rings which can be collected by the carbon brushes made of graphite.

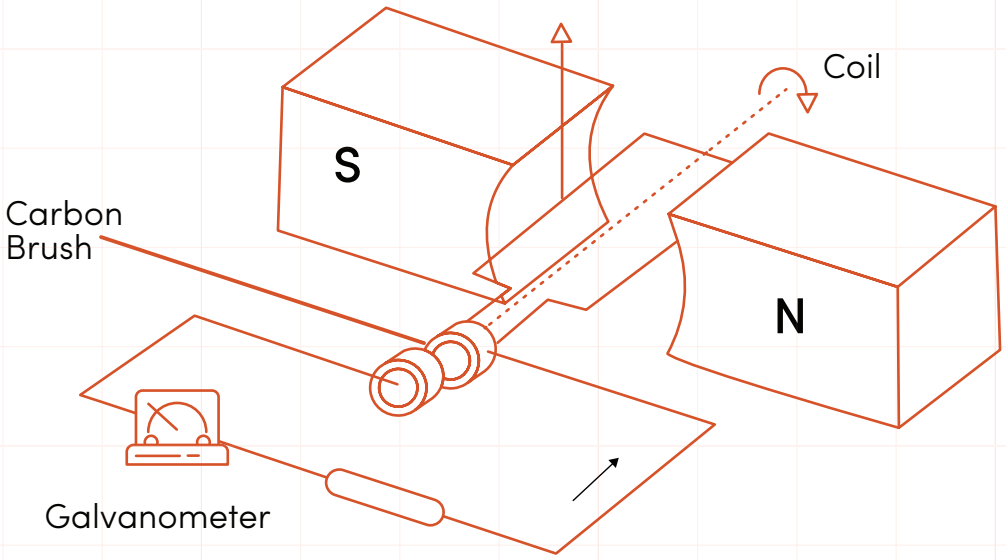


Fig. 5.13: Generators

SUMMARY

So far, we have learnt how to

1. Construct and use a galvanometer
2. Construct and use an electric motor
3. Construct and use a generator

INTERACTIVE ASSESSMENT QUESTIONS

1. The high sensitivity enables

   A Very high currents to be detected or measure
   B Very small currents to be detected or measure
   C Very small resistance to be detected or measure
   D Currents to be detected or measure
   E High currents to be detected or measure

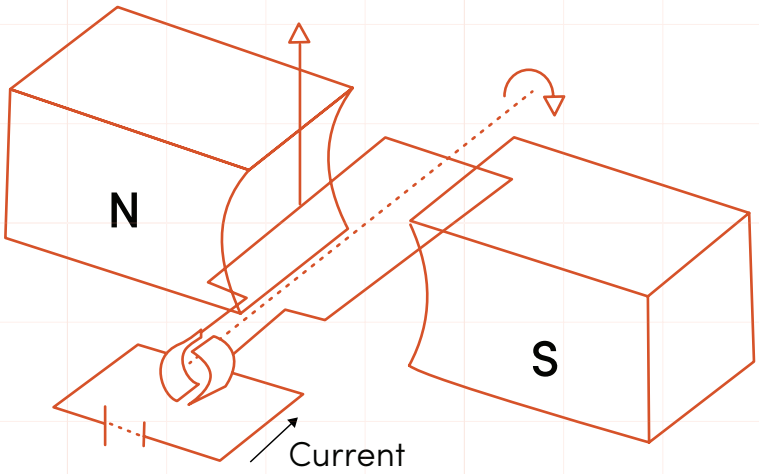
2. A device for converting electrical energy to mechanical energy is

   A Dynamo
   B Motor
   C Generator
   D Bulb

3. If a current-carrying conductor wound on a high permeability iron core creates

   A a magnetic effect
   B an electric effect
   C an electromagnetic effect
   D an electric field

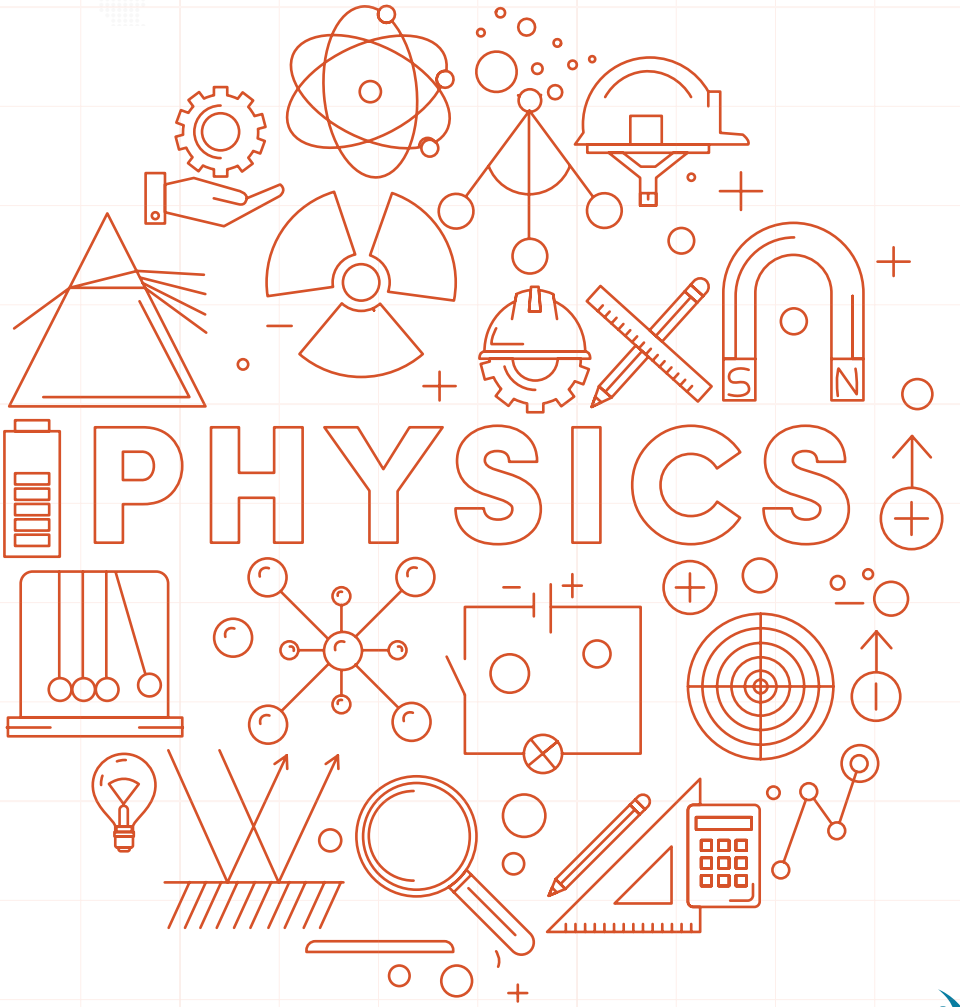
4. Identify the figure below.



TRANSMISSION SYSTEM

PERFORMANCE OBJECTIVES

1. Construct a simple transmission system
2. Explain why it is preferred to have a high potential difference instead of a high current



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TRANSMISSION SYSTEM

Electric power transmission is the bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation to the consumers. This is distinct from the local wiring between high-voltage substations and consumers, which is referred to as electric power distribution.

Basics of an electrical power transmission system.

Transmission lines are conductors that carry electric power from generating plants to the substations that can deliver power to consumers. At a generating plant, electric power is stepped up to a thousand volts by transformers and delivered to the transmission line. In a transmission, line power is transmitted at high voltage and low current to avoid over-heating and melting in the wires.

Electrical power transmission is the bulk movement of electrical energy from a generating site, such as a power station or power plant, to an electrical substation where voltage is transformed and distributed to consumers or other substations.

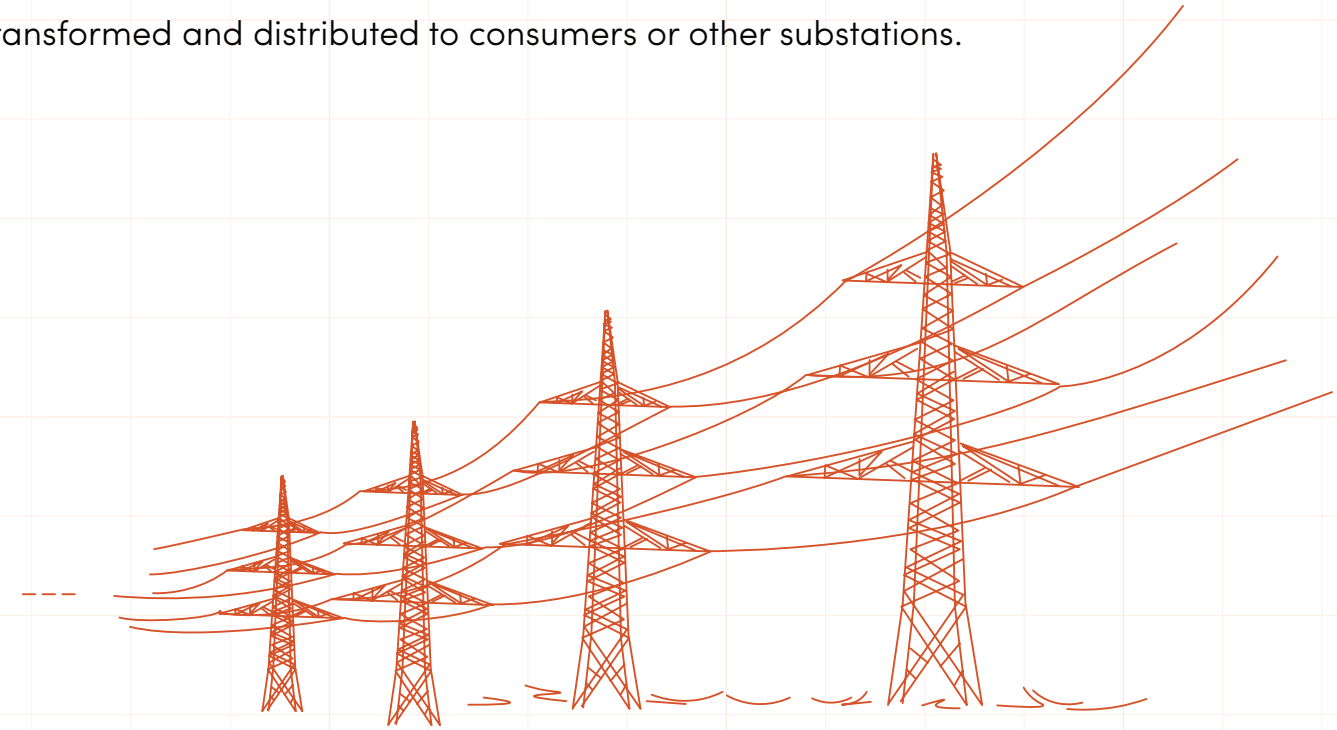


Fig. 5.14: Electrical Power Transmission

Electric transmission and distribution technologies with the components used to transmit and distribute electricity from the generation station to consumers

The interconnected lines that enable the movement of electrical energy are called transmission networks, and these form an electrical power transmission system commonly known as the power grid.

Primary Transmission

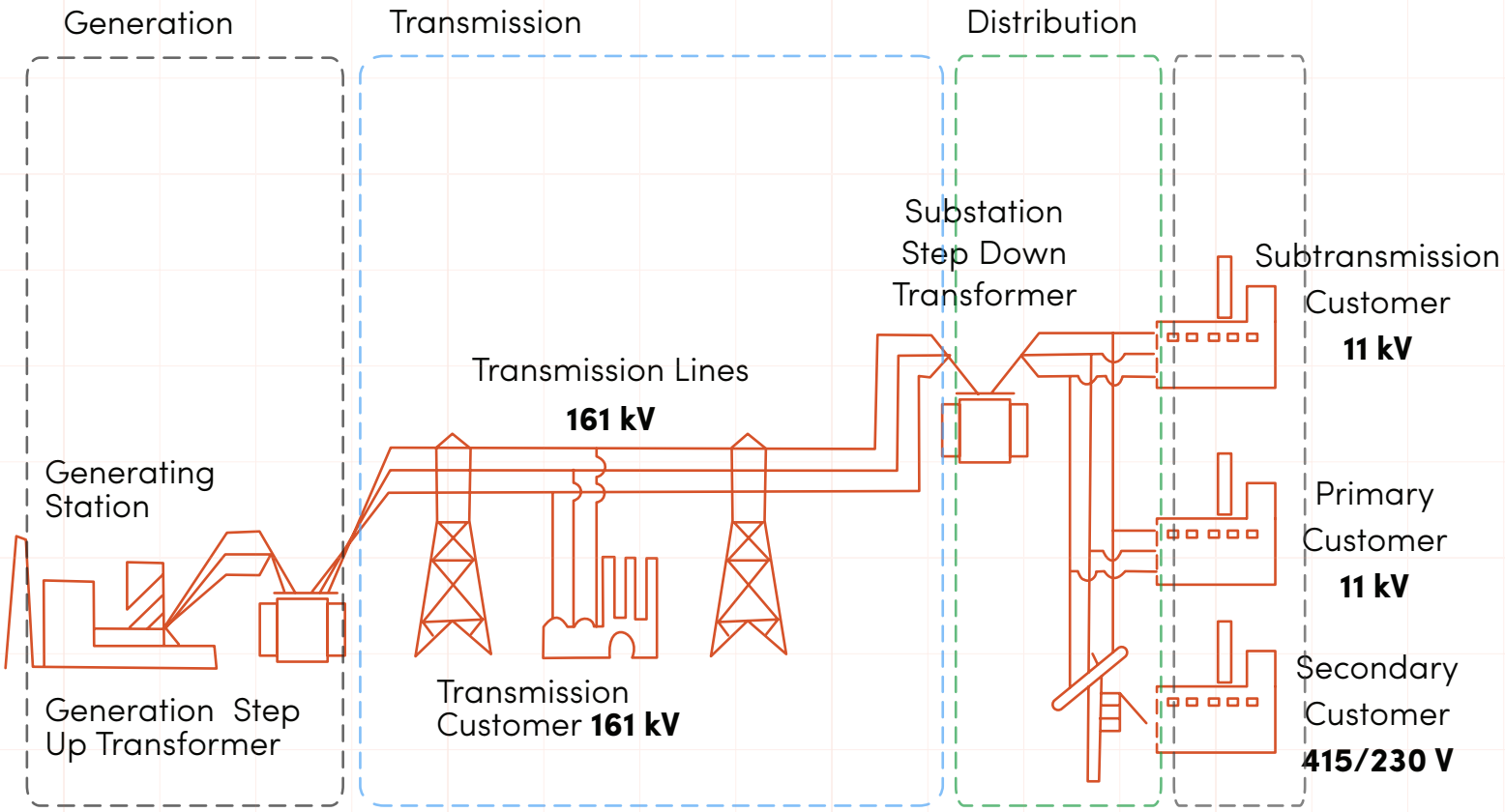


Fig. 5.15: A Basic Representation of a Power Grid with Transmission Highlighted in Blue.

A basic representation of a power grid, with transmission highlighted in blue.
When it is generated at a power station, electrical energy will be anywhere between 11kV and 33kV. Before it is transmitted to distribution centers via transmission lines, it is stepped up using transformers to a voltage level that can be anywhere between the range 100kV and 700kV or more, depending on the distance that is needed to be transmitted, the longer the distance, the higher the voltage level.

The reason for the electrical power step up is to make the voltage levels more efficient by reducing the I_2R losses that take place when power is transmitted. When voltage is stepped up, the current reduces relative to the voltage so that power remains constant, then reducing these I_2R losses.

TYPES OF POWER TRANSMISSION

Primary transmission

The transfer of a large quantity of electrical power from the generating station to the substation through over-head electrical conducting wires or lines. Some countries use underground cables for transmission over a shorter distance.

Secondary transmission

When electrical power reaches the receiving station, the high voltage is stepped down to a voltage range between 33kV and 66kV. It is sent to transmission lines coming from the receiving stations to electrical substations closer to load centers such as cities, villages, and urban areas. The process is known as secondary transmission.

When the electrical power reaches a substation, it is stepped down once more by a step-down transformer to voltages closer to the generated voltage from the power plant, usually around 11kV. From there the transmission phase graduates to the distribution phase, and electrical power is now ready for usage to meet demand from primary and secondary consumers.

SUMMARY

So far, we have learnt how to

1. Construct a simple transmission system
2. Explain why it is preferred to have a high potential difference instead of a high current

INTERACTIVE ASSESSMENT QUESTIONS

1. The bulk movement of electrical energy from a generating site, such as a power plant, to an electrical substation to the consumers is called

   A Transmission system
   B Electric energy
   C Electrical power
   D Transformer
   E Regulator

2. In transmission, line power is transmitted at high voltage and low current

   A to avoid over-heating and melting in the wires
   B to avoid low heating and high voltage
   C to avoid heating and freezing in the wires
   D to avoid over-heating and freezing in the wires
   E to avoid high resistance and melting in the wires

3. The minimum voltage produced from the generating plant to the step-up transformer is

   A 132V
   B 161KV
   C 132KV
   D 220V
   E 100KV

4. The figure below represents what?

5. The standard voltage distributed to a household in Nigeria is about

A 180V
B 220V
C 100V
D 260V
E 132V

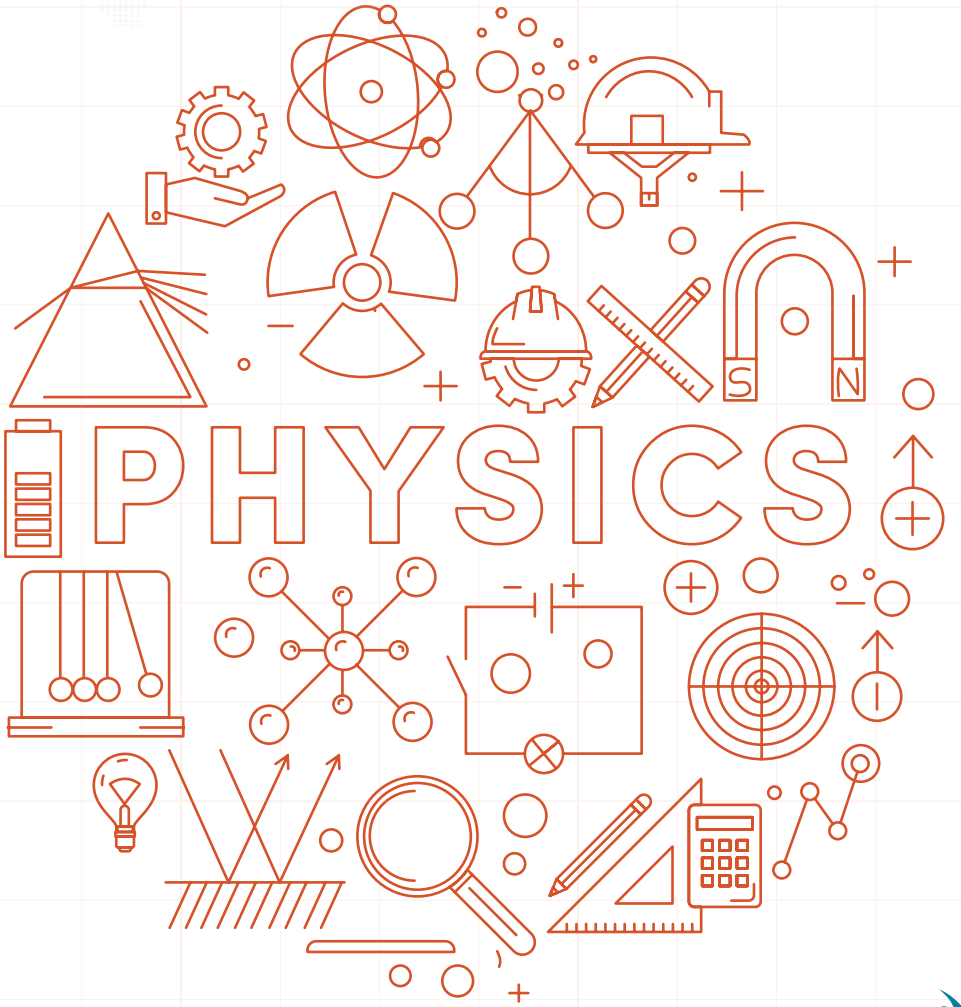
6. The conducting wire used for power transmission in Nigeria is

A Copper
B Zinc
C Silver
D Aluminum
E Iron

USES OF MACHINES

PERFORMANCE OBJECTIVES

1. State the common types of machine
2. State the need for the use of machines
3. Explain the terms by which operating principles of the machine are based on
4. State the instances where machines are used
5. Explain the levers and the pulley system



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USES OF MACHINES

Machines are devices that are used to do work faster and easier.

The common types of machine are:

- Lever system
- Pulling system
- Wheel and axle
- Screw
- Inclined plane
- Wedge
- Hydraulic press

The operating principles of the machine are based on some terms.

- Effort or input force
- Load or output force
- Force ratio or mechanical advantage
- Velocity ratio
- Efficiency.

$$\textbf{M.A} = \frac{\text{output force}}{\text{input force}} \times \frac{L}{E}$$

$$\textbf{V.R} = \frac{\text{distance moved by effort}}{\text{distance moved by load}}$$

$$\textbf{Efficiency} = \frac{\textbf{M.A}}{\textbf{V.R}} \times \frac{100}{1}$$

LEVERS

Levers are very simple machines, designed to rotate about a fixed point called the fulcrum.

Orders of levers

1. First-order - when the fulcrum is in between the load and effort. Example: crowbar, scissors, pliers, claw, hammer
2. Second-order: when the load is in between the fulcrum and the effort. Example: wheelbarrow, Nutcrackers, egg slicer, bottle opener.
3. Third-order: when the effort is in between the fulcrum and the load. Example: forceps, sugar tong, tweezer, force arm.

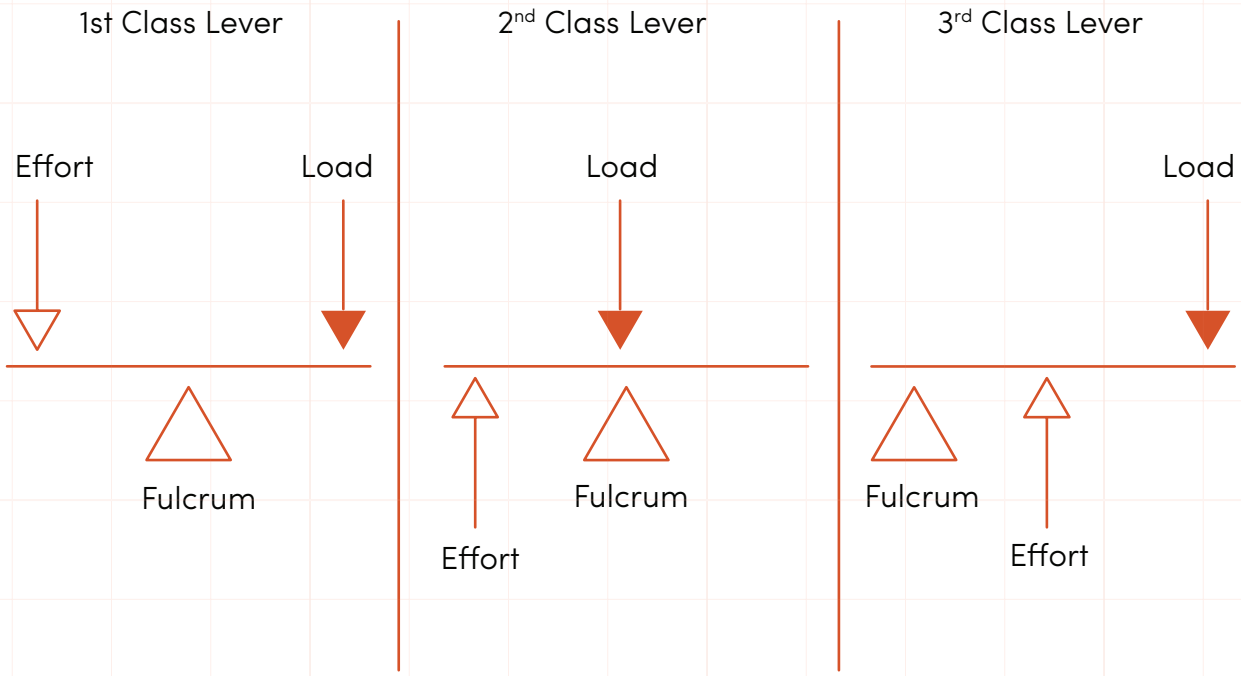


Fig. 5.16: Order of Levers

PULLEY SYSTEM

1. A simple machine which can easily be used to lift heavy loads such as being used in cranes.
2. A simple pulley consists of s wheel with an axle that is block and tackle

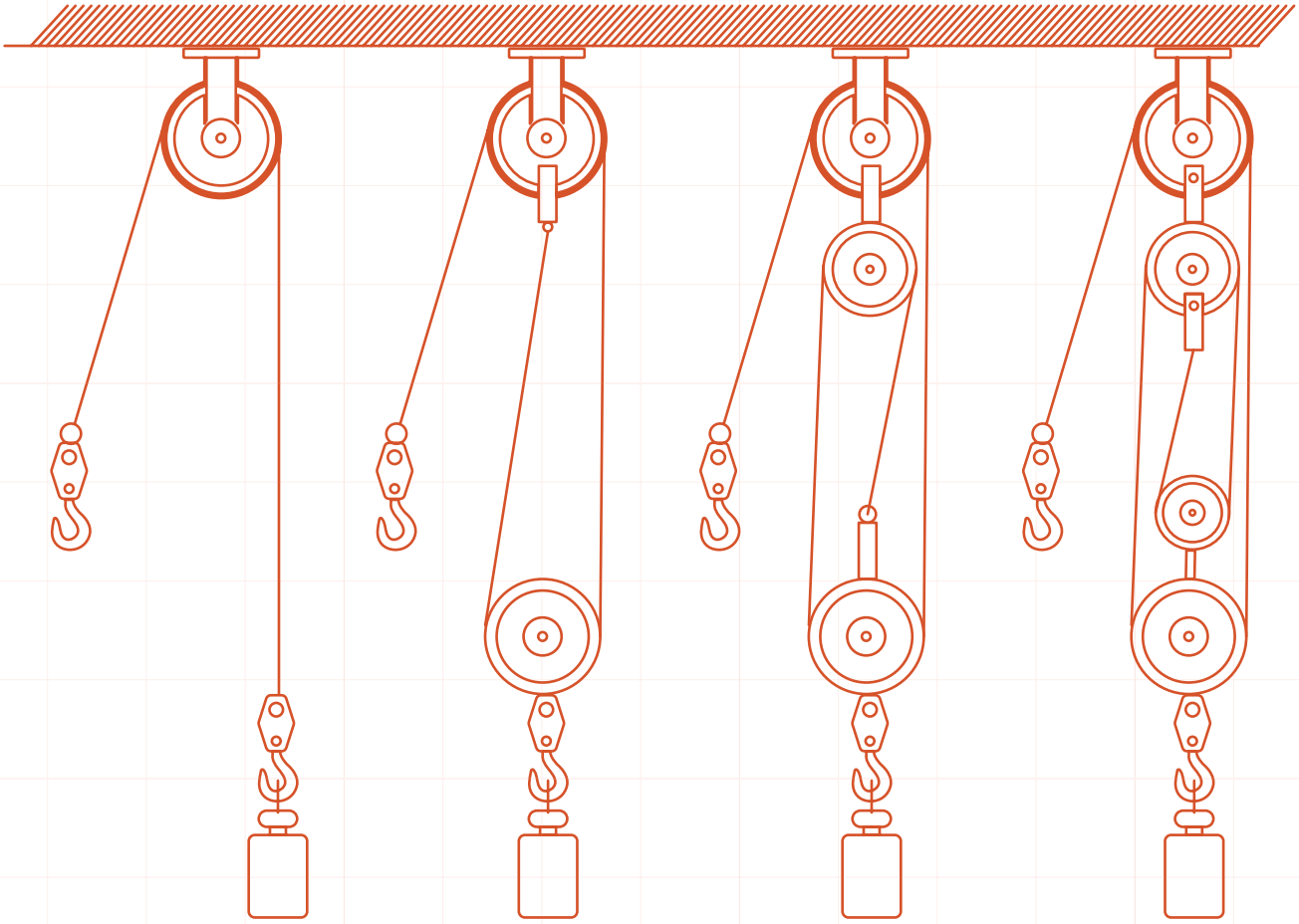


Fig. 5.17: The Pulley System

The number of pulleys in the pulley system gives the velocity ratio V.R

The following are also noted

A. The greater the load, the greater the efficiency

B. The **M.A.** is equal to **V.R.** if efficiency is 100%

C. Efficiency is always less than 100% due to friction and weight of the pulley

D. As the number of pulley increase, the efficiency reduced

WHEEL AND AXLE

The machine is used in lifting heavy loads from the deep well.

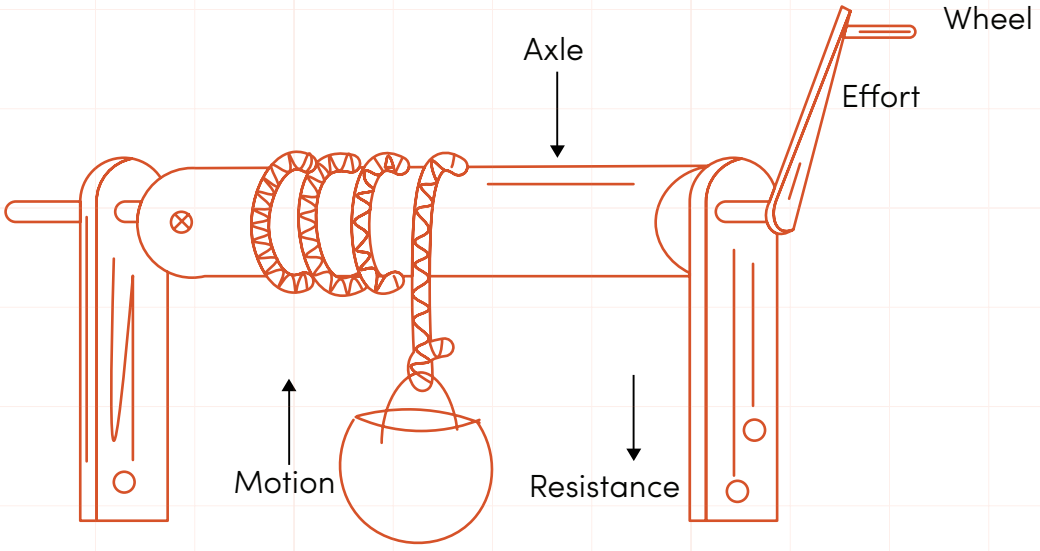


Fig. 5.18: The Wheel and Axle

$$V.R = \frac{2\pi R}{2\pi r} = \frac{R}{r}$$

$$M.A = V.R = \frac{R}{r}$$

GEAR WHEEL

This is also operating with the principles of wheel and axle

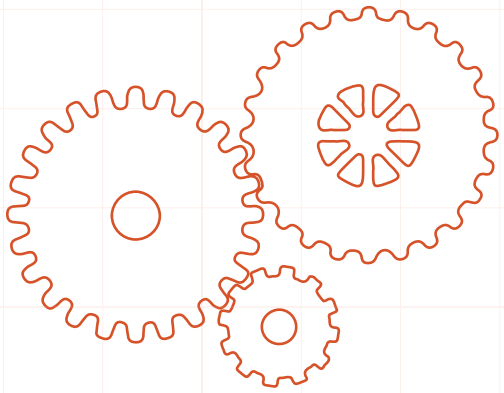


Fig. 5.19: The Gear Wheel

$$V.R = \frac{\text{number of teeth on the driven gear}}{\text{number of teeth on the driving gear}}$$

Inclined planed

For lifting heavy load through a difficult height with ease.

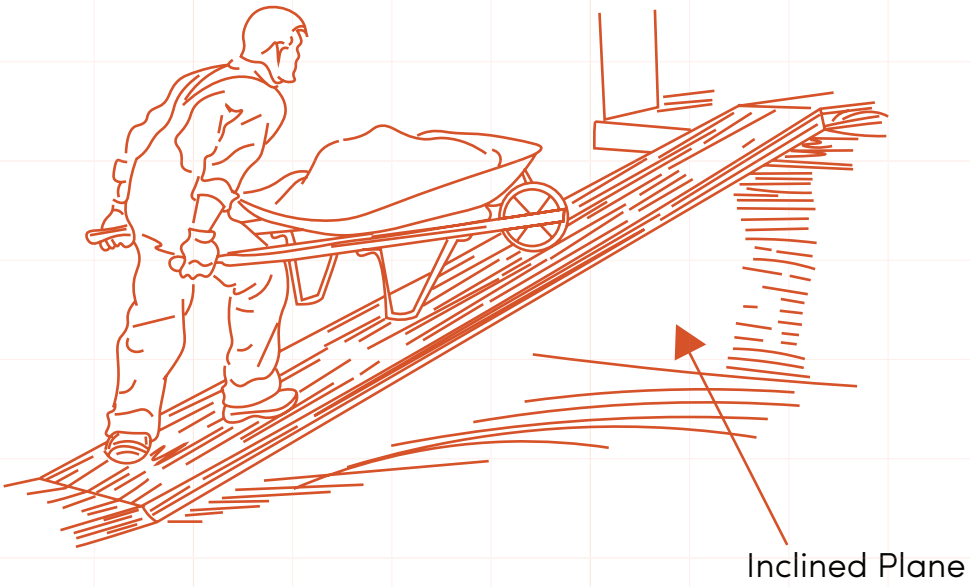


Fig. 5.20: The Inclined Plane

$$V.R = \frac{1}{\text{Sin } \theta} = \frac{l}{h}$$

WEDGE

It consists of two inclined planned merged

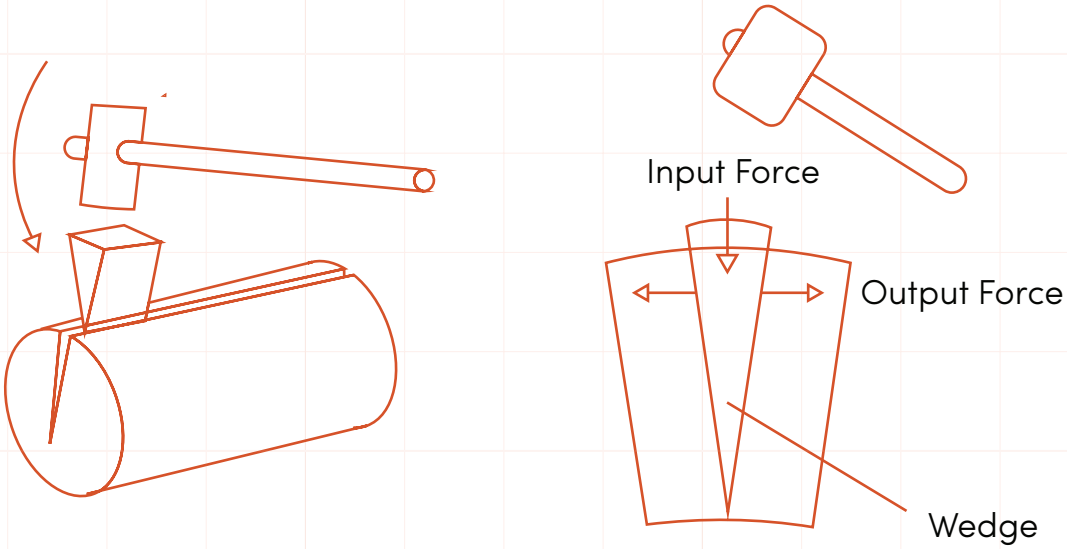


Fig. 5.21: The Wedge

$$V.R = \frac{X_1}{X_0}$$

The thinner a wedge is, the greater and easier for it to separate a body.

SCREW

$$V.R = \frac{2\pi r}{\text{pitch}} = \frac{l}{h}$$

HYDRAULIC PRESS

This is another machine for lifting heavy loads using a smaller force.

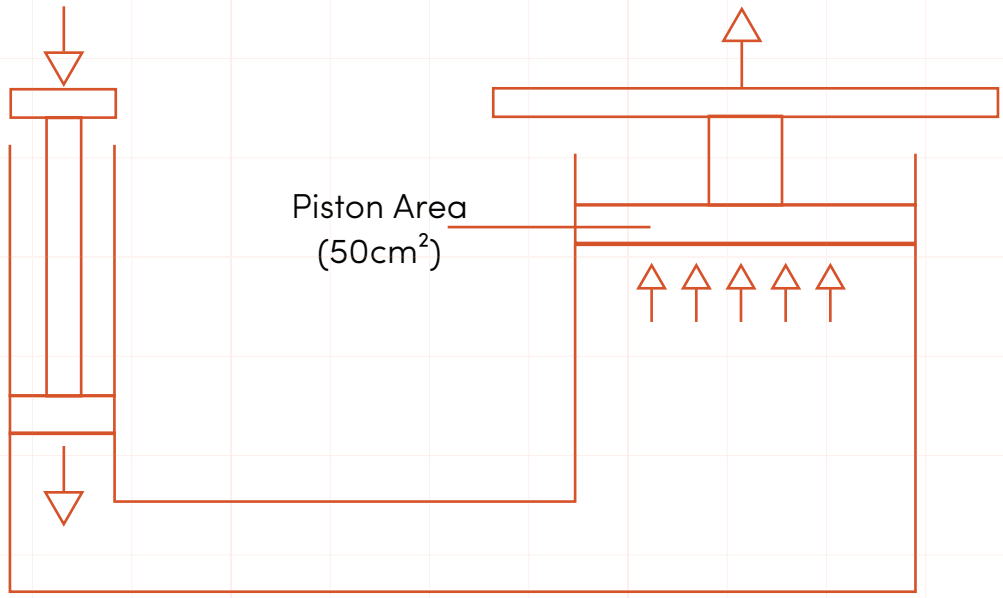


Fig. 5.22: The Hydraulic Press

$$V.R = \frac{f}{a} = \frac{F}{A}$$

are used to raise a load of 600N by the application of an effort of 200N, if the radii of the

Where F = force of the bigger drum

f = force of the smaller drum

A = area of t he bigger drum

a = area of the smaller drum

Activity 1

1. A wheel and axle are used to raise a load of 600N by the application of an effort of 200N, if the radii of the wheel and axle are 0.5cm and 0.1cm respectively, what is the efficiency of the machine?

Solution

$$V.R = \frac{R}{r} = \frac{0.5}{0.1} = 5$$

$$M.A = \frac{L}{E} = \frac{600}{200} = 3$$

$$Eff = \frac{M.A}{V.R} \times 100 = 60\%$$

SUMMARY

So far, we have learnt how to

1. State the common types of machine
2. State the need for the use of machines
3. Explain the terms by which operating principles of the machine are based on
4. State the instances where machines are used
5. Explain the levers and the pulley system

INTERACTIVE ASSESSMENT QUESTIONS

1. A simple machine designed to rotate about a fixed point called

   A Pulley
   B Screw
   C Lever
   D An inclined plane
   E Hydraulic press

2. A wheel and axle are used to raise a load of 600N by the application of an effort of 200N, if the radii of the wheel and axle are 0.5cm and 0.1cm respectively, what is the efficiency of the machine?

A 50%
B 45%
C 60%
D 30%
E 25%

3. The velocity ratio of the pulley system is determined by the number of

A Pulleys
B Load
C Effort
D Mechanical advantage
E Efficiency

4. Wheelbarrow belongs to what order of lever

A Second-order
B First-order
C Third-order
D A and B
E A, B, and C

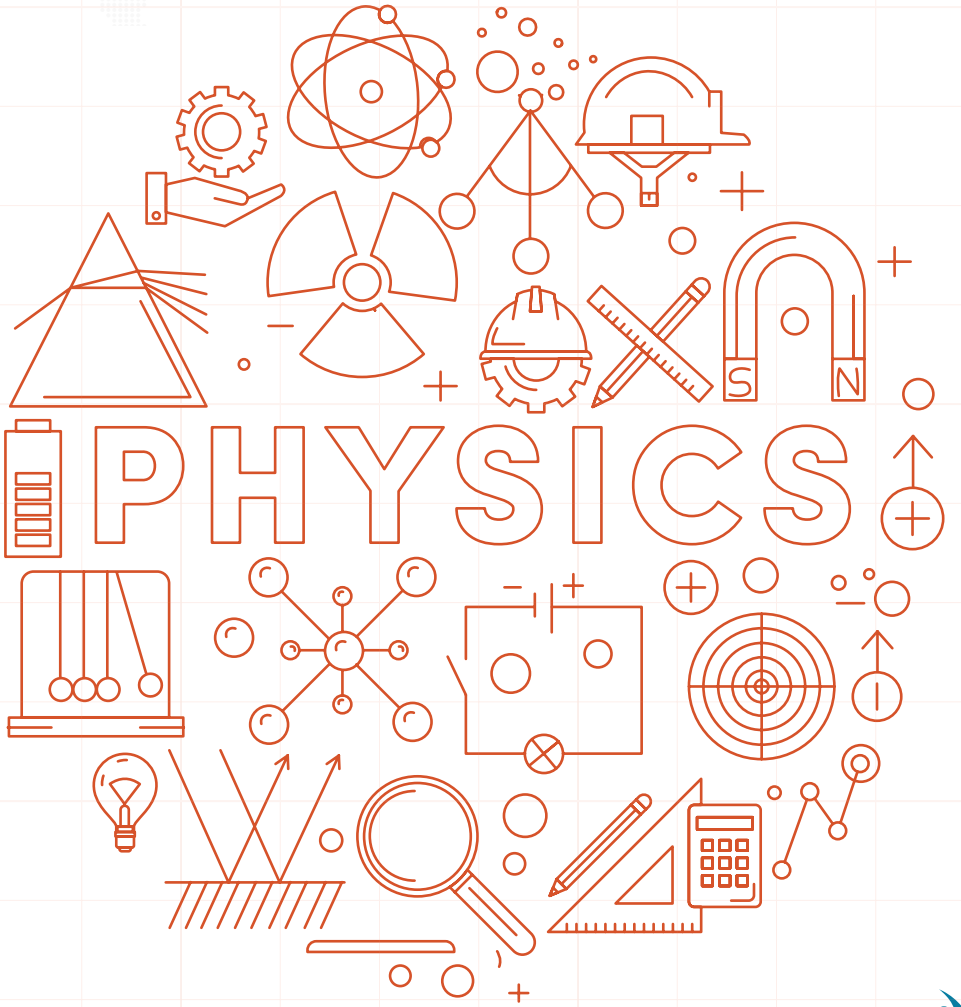
5. The efficiency of a machine is always

A Load per effort
B Effort per load
C Output force per input force
D Mechanical advantage per velocity ratio
E Distance moved by effort per distance moved by the load

REPAIR AND MAINTENANCE OF THE SIMPLE MACHINES

PERFORMANCE OBJECTIVES

1. State the need to identify faults in machines and get them repaired
2. State the need for regular maintenance of machines
3. Identify and follow a maintenance schedule for a machine



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INTRODUCTION TO MAINTENANCE

Machines and other service facilities are subject to wearing and failure due to their use and exposure to environmental conditions. If this process of deterioration is not properly checked, it can render them unserviceable. It is necessary to attend to them from time to time, to repair and repositioned them to enhance their lives economically.

Maintenance can be defined as a combination of actions carried out to repair, replace, service and modify the components in a machine so that it will continue to operate at a specified availability for a specified period.

Maintenance is more important especially in the case of machines due to their non-uniform pattern of wear and tear which depends on a large number of factors

Every machine is thoroughly checked, tested, and inspected by the manufacturers before selling them, and even by the purchaser before it is put to use. When it is used, it will be subjected to wear and tear and proper attention should be given to protect the machine and its components from undue wear and thus protect them from failures.

Proper attention means cleaning, lubrication, timely inspection, and systematic repair. Maintenance of a machine means efforts directed towards the up-keep and the repair of the machine.

A major part of the is basically on men, maintenance and materials in the industry. Every machine would require repairs even if it is best designed, the repair must be done at such a time when it has the least disruptions.

Checking of the machine is generally done when it is not in use, so that the defect, if any, can be immediately and easily corrected without causing any extensive damage to the plant.

In this case, we can say that maintenance is responsible for the smooth and efficient working of a machine and helps in improving its productivity. It also helps in keeping the machines in a state of maximum efficiency with the economy.

With the high importance of maintenance of plants and equipment, maintenance management is concerned with the direction and organization of resources to control

the availability and performance of plants to some specified level.

The maintenance management is therefore a restorative function to ensure availability and efficiency of the existing plant, equipment, and buildings at an optimum level.

Machine and equipment maintenance plays an important role in production management because breakdown creates problems such as:

1. Loss of productive time
2. Need for sub-contracting work
3. Re-scheduling of production
4. Temporary work shortage, as during break down workers may not have work for them.

Types of Maintenance

1. Breakdown maintenance.
2. Preventive maintenance.

Break Down Maintenance

Breakdown maintenance is a maintenance activity conducted on any machine which has stopped functioning owing to shear or crushing or buckling or elongation or swelling or any other form of failure of any critical component of the said machine to enable the same to function as before by resorting to necessary replacement of the same and or more number of components by new ones or use old ones and/ or re-conditioning of the same within the minimum period considering the scope of work, available facilities, and skill.

Breakdown of a machine can occur due to the following two reasons:

(i) Due to unpredictable failure of components which cannot be prevented.

(ii) Due to gradual wear and tear of the parts, which can be eliminated to a large extent by regular inspections, known as preventive maintenance. From experience, it can be decided that, when a part should be replaced, so that breakdown can be avoided.

In breakdown maintenance, defects are corrected only when the machine could not

perform its function any longer, and the production department is forced to call on the maintenance engineer for repairs. After repairing the defect, the maintenance engineers do not attend to the machine again until another failure occurs.

In this type of maintenance, repair shall have to be done on failure, thus it may disrupt the whole production if it is performing important work. This method is expensive also due to the increase of depreciation cost, payment to idle operators, overtime to the maintenance staff for doing the emergency repairs.

Preventive Maintenance:

Preventive Maintenance is defined as a maintenance activity done on any machine as per laid down schedule or frequency by making necessary or need-based replacement and/or reconditioning of component(s) within the pre-fixed period of the said work to reduce and avert breakdown(s).

Preventive maintenance is sometimes termed as planned maintenance or scheduled maintenance or systematic plant maintenance. It is an extremely important function for the reduction of maintenance cost and to keep the good operational condition of equipment and hence increases the reliability.

Preventive maintenance aims to locate the sources of trouble and to remove them before the breakdown occurs. It is based on the prevention is better than cure. Scheduled maintenance is always economical than unscheduled maintenance.

The best safeguard against costly breakdown is to inspect, checkup, and lubricate the machine as frequently as possible. To take full use of the equipment and to maintain it in reliable condition, necessary measures should be taken to prevent overloading, dampness, negligence, and misuse of machines.

Frequent inspection should be decided based on the importance of the machine wear and tear of the machine and its delicacy. This periodic inspection or checking helps to find out the reasons leading to breakdown and to rectify them when they are in minor stages.

The repair can be done when one wants to do it when it has the least effect on the

production schedule. Further, this repair requires lesser time as compared to that of breakdown repair, and thus downtime is reduced by doing preventive maintenance.

Preventive maintenance has the following main objectives:

1. To keep the machine in proper condition to maintain the quality of the product.
2. By minimizing the wear and tear, preserve the value of the plant.
3. To obtain maximum availability of the plant by avoiding breakdown and by reducing the shutdown periods to a minimum.
4. To ensure the safety of the workers
5. To achieve all the above objectives with the most economical combination.
6. To keep the plant at the maximum production efficiency

Procedure for Maintenance:

Maintenance should be done considering all the above mention factors. Daily maintenance is done by the operators. Before starting the work of their shift, cleaning, oiling and greasing should be done by the operators. The purpose manufacturers used to issue maintenance instructions for their machines, should be strictly followed.

Preventive maintenance of the machine depends largely on the operators, as far as possible, one operator should be allocated to each machine, and when the same machine is used in more than one shift, one operator for each machine for each shift be allotted.

This system has following advantages:

i. It is easy to pin-point operators with bad operating habits. To remove these habits training can be arranged or disciplinary actions can be taken as the case may be.
ii. The machine will remain in good condition.
iii. An operator gets used to the sound and working of his machine and notices any change immediately, which helps in investigation and rectification of the defect then and there. If operators are changed frequently, immediate check-ups and timely repair cannot be possible.

Periodic maintenance is generally conducted by the maintenance crew members,

specially trained for this purpose. The period should be decided based on experience. Apart from this, operating instructions should carefully be followed by the operators.

In case any abnormal sound or behaviour is noticed in the machine, he should immediately bring this to the notice of the maintenance crew, so that the defect can be corrected immediately.

SUMMARY

So far, we have learnt how to

1. State the need to identify faults in machines and get them repaired
2. State the need for regular maintenance of machines
3. Identify and follow a maintenance schedule for a machine

INTERACTIVE ASSESSMENT QUESTIONS

1. Maintenance can be defined as

   A Components in a machine so that it will continue to operate at a specified availability for a specified period.

   B A combination of actions carried out to repair, replace, service, and modify the components in a machine so that it will continue to operate at a specified availability for a specified period.

   C A specified availability for a specified period

   D Activity conducted on any machine which has stopped functioning owing to shear or crushing

   E Subject to wearing and failure due to their use and exposure to environmental conditions

2. Breakdown maintenance is a maintenance activity

A Conducted on any machine which has stopped functioning owing to shear or crushing or buckling or elongation or swelling

B On any machine which has stopped functioning owing to shear

C The machine depends largely on the operators, as far as possible, one operator be allocated each machine, and when the same machine is used

D in more than one shift

Maintenance should be done considering all the above mention factors.

E Daily maintenance is done by the operators

To keep the machine in proper condition to maintain the quality of the product

3. A maintenance activity is done on any machine as per laid down schedule or frequency by making necessary or need-based replacement and/or reconditioning of component(s) within the pre-fixed period of the said work to reduce and avert breakdown.

A Break down

B Preventive

C Proactive

D Reactive

E Proaction

4. A maintenance activity conducted on any machine which has stopped functioning owing to shear

A Break down

B Preventive

C Proactive

D Reactive

E Proaction

5. Breakdown of a machine can occur due to the

A To keep the machine in proper condition to maintain the quality of the product.

B To ensure the safety of the workers

C To obtain maximum availability of the plant by avoiding breakdown and by reducing the shutdown periods to a minimum.

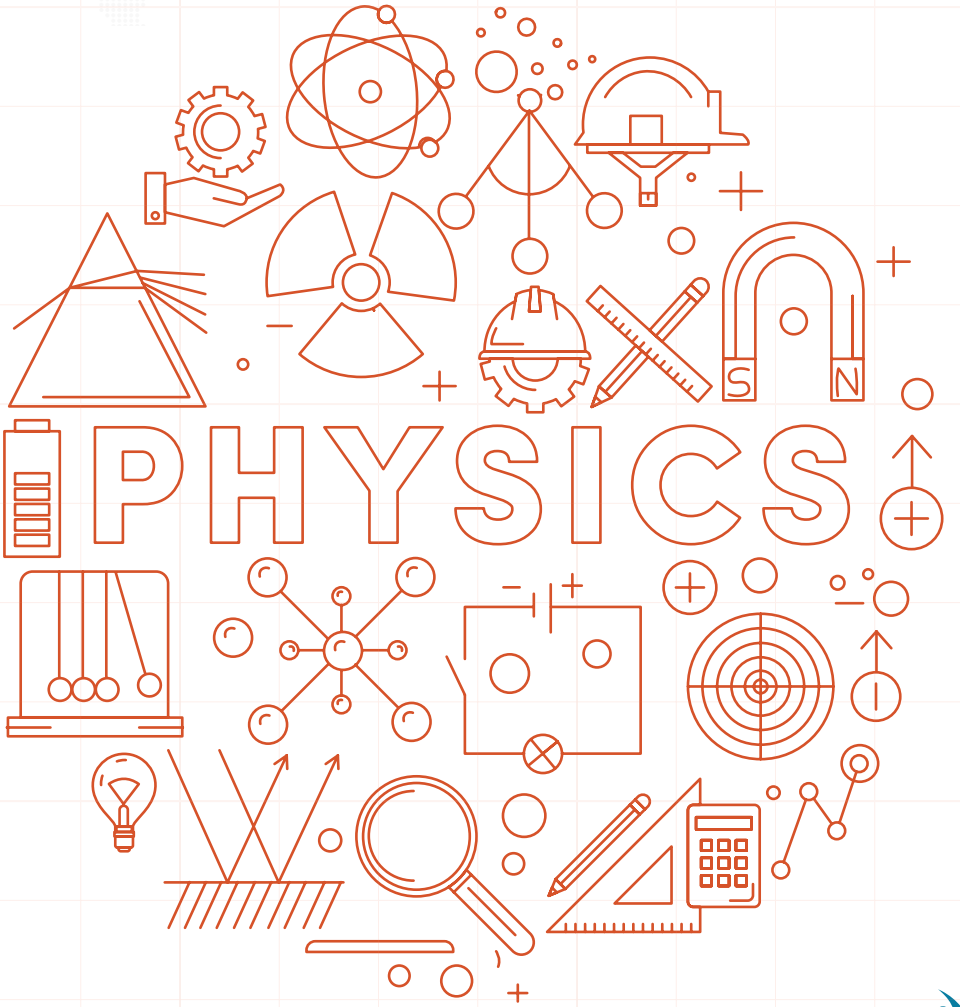
D By minimizing the wear and tear, preserve the value of the plant

E Unpredictable failure of components which cannot be prevented.

DAMS AND ENERGY PRODUCTION

PERFORMANCE OBJECTIVES

1. Identify dams for producing electricity in Nigeria
2. Describe how electricity is produced from a dam.



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HYDROELECTRIC POWER (DAMS)

What is a dam?

A dam is a man-made structure built across a river. Most dams are built to control river flow, improve navigation, and regulate flooding and some dams are built to produce hydroelectric power for consumers.

A hydroelectric dam is one of the major components of a hydroelectric facility. A dam is a large, man-made structure built to contain some body of water. In addition to construction to produce hydroelectric power. Dams are created to control river flow and regulate flooding. In some rivers, small-scale dams, often referred to as "weirs", are built to control and measure water flow.

How do dams make hydroelectric power?

Hydroelectric power is produced as water passes through a dam, and into a river below. The more water that passes through a dam, the more energy is produced. Once a dam is built, an artificial man-made lake is created behind the dam.

Electricity is produced by a device called a turbine. The turbine contains metal coils surrounded by magnets. When the magnets spin over the metal coils, electricity is produced. Turbines are located inside the dams and the falling water spins the magnets. Dams provide clean, pollution-free energy, but they are also harmful to the environment. Species that use rivers to survive are often hurt by dams.

Dams fall into the category of retaining structures, or structures that are built to create large standing bodies of water known as reservoirs. These reservoirs can be used for electrical generation or water supply. These structures are built on top of riverbeds and hold back water, raising the water level.

Dikes can be built along with the dam to increase the dam's effectiveness by preventing water from leaving the reservoir through secondary routes.

Dams can range from relatively small to a very large structure. The largest dam in the world is the Jinping dam on the Yalong river in China, standing at 305 meters tall.

Construction

The construction of a dam is difficult and labour intensive, before the construction begins, water is diverted or prevented from moving through the construction site. After the diversion, the foundation area is cleaned, excavated, and rock or sediments that will act as the foundation are repaired and deemed solid. This is done to ensure the rock or sediments won't shift or fail as a result of the load of the dam and reservoir. Supports known as rock bolts may be used to strengthen the foundation. Above the dam, rock bolts and netting may be used to prevent rocks from falling on the dam. Forms are then built along the edges of the dam, rebar is placed inside, and concrete is pumped in. This is done in sections, and the concrete is poured bit by bit in a block formation. Once enough of the dam is built, the reservoir is allowed to fill in a highly controlled manner. The dam is monitored during this process. Other structures that make the dam operational are then added.

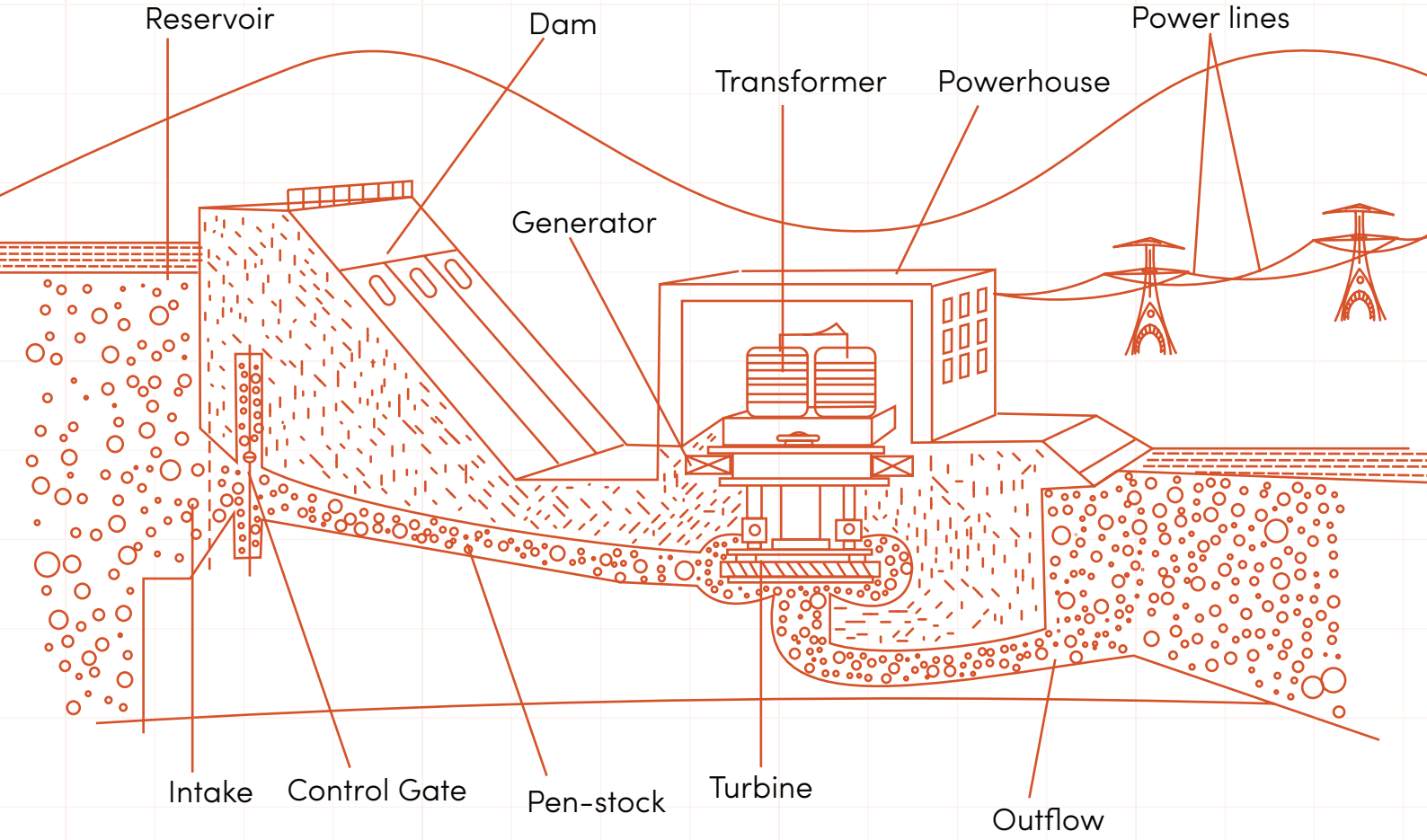


Fig. 5.23: The Hydroelectric Power Dam

Operation

Dams are just one component of a complete hydroelectric facility but are one major visible component in the system. The purpose of a hydroelectric dam is to provide a place to convert the potential and kinetic energy of water to electrical energy by using a turbine and generator. Dams act as the place where water is held back and released in a controlled manner through hydraulic turbines, enabling the mechanical energy of the water to be transformed into electrical energy.

Typical dams work to create a reservoir where water is stored at a given height. This height and the rate at which the water flows from the reservoir through the turbines determines how much electricity can be generated. This can be calculated by using the hydroelectric power equation.

$P_{th} = \rho qgh$

Where P_{th} = power theoretical available

ρ = density of the water

q = water flow (m^3/s)

g = gravity

h = falling height in meter

As the height of the dam increases, the amount of electricity generated increases as well. At the top of the dam is a gate that is used for blocking or allowing the release of water from the reservoir. This gate is opened or closed to meet electricity requirements. Between the top of the dam and the turbines are a series of channels known as penstocks that guide the water down and control the slope of the falling water to ensure maximum efficiency of the dam. Finally, turbines can be contained in the dam structure itself, and this is where the energy conversion takes place. After the water passes through the turbines, it is released in a tailrace at the bottom of the dam back into the river.

Locations of hydropower dams in Nigeria

i. Kanji dam in Niger state (the first and the largest dam in Nigeria)

ii. Shiroro dam in Kano state

SUMMARY

So far, we have learnt how to

1. Identify dams for producing electricity in Nigeria
2. Describe how electricity is produced from a dam.

INTERACTIVE ASSESSMENT QUESTIONS

1. The first and the biggest dam in Nigeria is

   A Shiroro dam
   B Benue dam
   C Niger dam
   D Kanji dam
   E Hadejia dam

2. In a hydropower dam, the device that produces electricity is

   A Turbine
   B Dynamo
   C Motor
   D Shaft
   E Reservoir

3. In any hydropower dam, living creatures cannot survive in it

   A True
   B False
   C Cannot be determine
   D Agreed
   E Strongly agreed

4. The electric voltage produced from the dam is always

A Step down
B Step up
C Minimized
D Maximized
E Unchanged

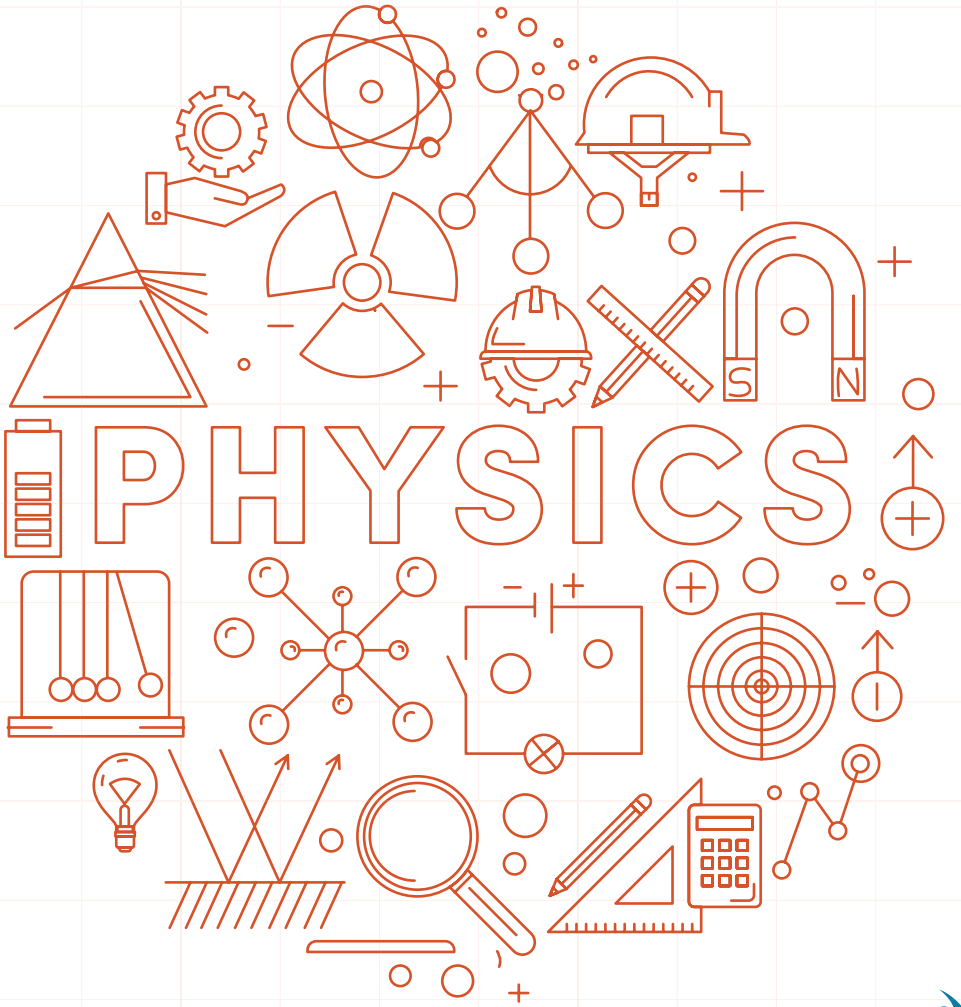
5. In hydro-power dam water is falling as a result of

A Gravity
B Force
C Pressure
D The density of the water
E Tension

ROCKETS AND SATELLITES

PERFORMANCE OBJECTIVES

1. State the components parts of rockets and satellites
2. State the functions of rockets and satellites
3. Explain Rocket Propulsion
4. Explain the component parts of satellites
5. State the uses of rockets and satellites



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ROCKETS AND SATELLITES

Rockets and Satellites are parts of technological advances of the modern world, both devices are always linked to one another.

The Chinese were believed to have invented the first rocket which they used for war which was described as an "arrow of flying fore"

Components parts of Rockets

A rocket is an engine or instrument that produces great power, more power for its sizes than any other kind of engine, the components are:

1. The body tube - The hollow cylinder to which all other parts are attached.
2. The launch lug - The narrow tube fastened to the side of the body, guides the rocket and keep it vertical during lift-off.
3. The Fin - This is attached to the bottom part of the body tube which keeps the rocket straight during flight
4. Engine holder - The cabin for holding rocket engines
5. Rocket engine - The main part that is causing propulsion which contains solid fuels or propellant.
6. The nose cone - Forms the top of a model rocket, its tip has a rounded point that reduces the air resistance
7. The recovery devices - Are wired to return the rocket slowly to the ground after it has reached its highest point.
8. The launch system - Consists of a launchpad and an engine ignition system with a battery.

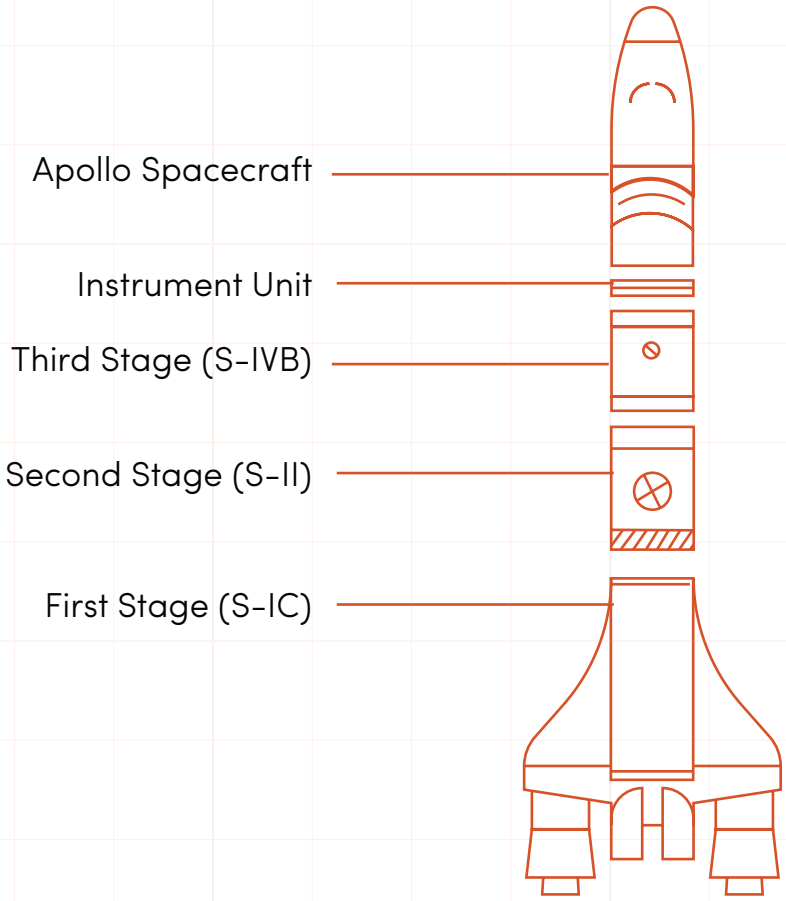


Fig. 5.24: Parts of a Multistage Rocket

Parts of a Multistage Rocket

The multistage rocket consists of two or more sections called stages, each stage has a rocket engine and propellant, the entire rocket itself consists of a rocket engine and nose-cone

A rocket traveling to space requires more than one engine, it requires a much larger amount of fuel to gain the required speed to escape from the earth's gravity.

A multistage rocket can reach higher speed because it becomes light when dropping the stage as it used up the fuel in it. The first rocket engine is called a booster which is used to launch the rocket, as it finished up the stage, it drops it and becomes lighter.

Launching a multistage rocket

The rocket is launched into space from a launchpad locket at a special site launch site

The rockets are prepared for launching in a step by step process called countdown timer, each step is scheduled for a specific time during countdown and it is launch when the countdown is zero

The first stage called the booster is fired to push the rocket into space or considerable height, before the other stages.

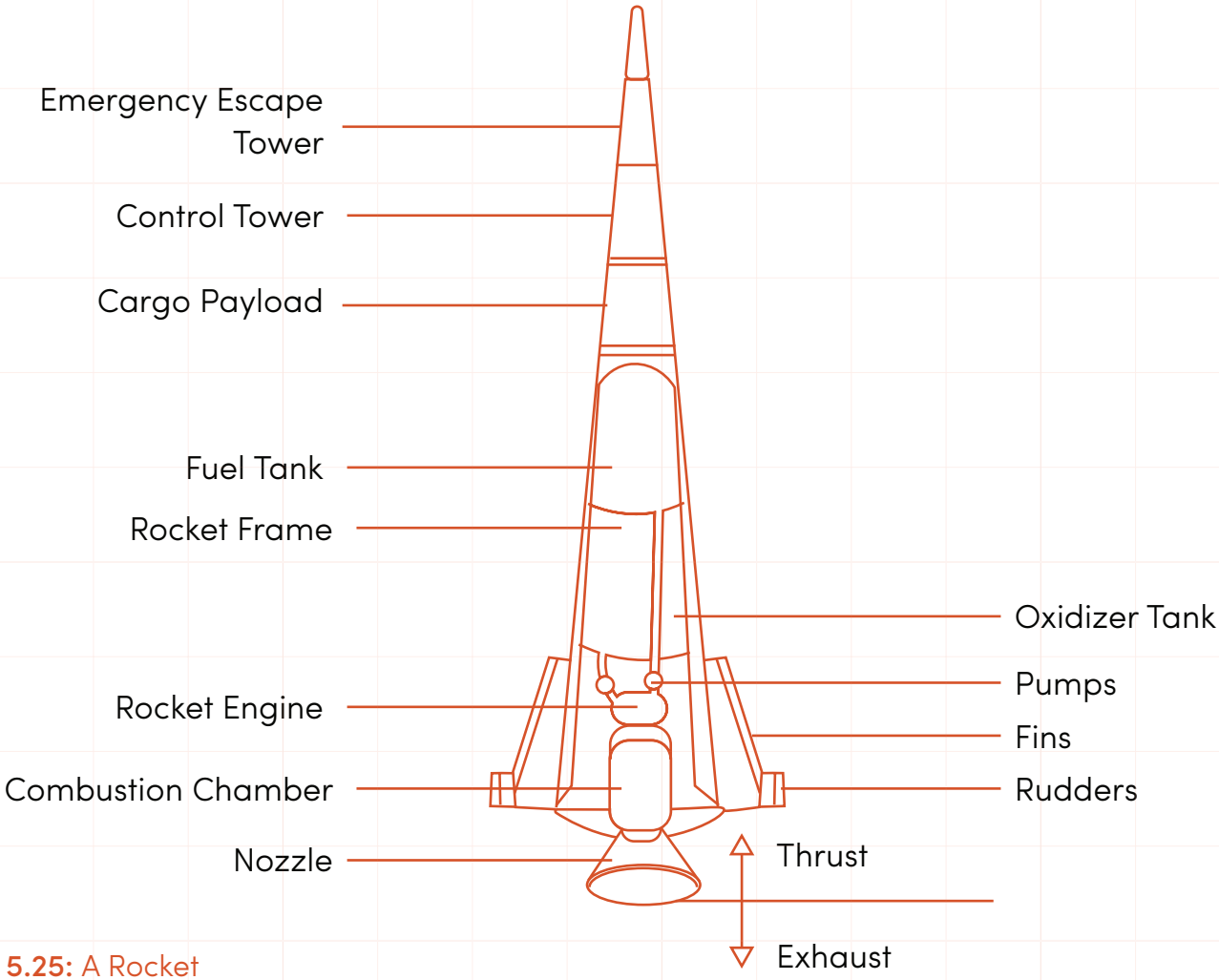


Fig. 5.25: A Rocket

Functions of rockets

1. It carries robotic probes to study other planets
2. It carries artificial satellites to be launched into space
3. It carries astronauts into space
4. With rocket space stations and laboratories are
5. In the nearest future, man will colonize other planets with the aid of rockets.
6. It serves as a vehicle for carrying bombs

Uses of Rocket

1. For high-speed transportation
2. Military use - Ballistic missiles
3. For scientific research and launching of telescopes
4. For the global village and space colonies
5. For space travel
6. For distress signals
7. For firework display

Rocket Propulsion

The force which moves a rocket comes from burning fuels, when the rocket fuel or propellant liquid hydrogen enters the engine, it mixed liquid oxygen in the right proportion and burns, during burning, the gas expands, and forced out from the opening which uses the newtons third law of motion (Action and Reaction are equal and opposite) Diagram

SATELLITES

A satellite is any object that orbits or moves around a planet, there are two types

1. **National satellite:** The natural bodies moving around a planet such as the Moons
2. **Artificial satellites:** The artificial bodies moving around planets

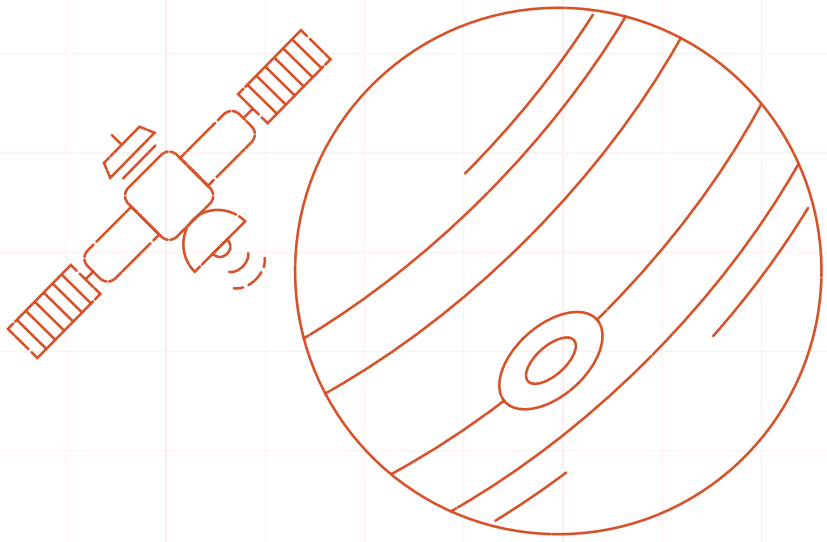


Fig. 5.26: A Satellite

Components parts of satellites

1. **Powerhouse:** The place where electricity is manufactured could be solar, and also the place where satellites are being controlled.
2. **Communication:** The communication control which can send signals to the ground control, has a long antennae radio signal
3. **Guidance:** Star trackers and gyroscope help satellites aligns themselves in the right direction
4. **Scientific instruments:** These are cameras, sensors, probes, etc.

Uses of satellites

1. For communication
2. For photography
3. For mapping
4. For geographic information system GIS
5. For geographic position system GPS
6. For the weather forecast
7. For astronomical satellites
8. For the defence industry

SUMMARY

So far, we have learnt how to

1. State the components parts of rockets and satellites
2. State the functions of rockets and satellites
3. Explain Rocket Propulsion
4. Explain the component parts of satellites
5. State the uses of rockets and satellites

INTERACTIVE ASSESSMENT QUESTIONS

1. The hollow cylinder to which all other parts are attached

A The fin
B The body tube
C The cabin
D The tail
E The nose

2. The main part that is causing propulsion contains solid fuels or propellants

A The nose
B The tail
C The fin
D Rocket engine
E The cabin

3. An object that orbits or moves around a planet

A Rocket
B Saturn
C Satellite
D Orbit
E Sun

4. Rockets are the only flying machine that can escape from the earth's gravity

A False
B True
C Cannot say
D Undetermined
E Not agree

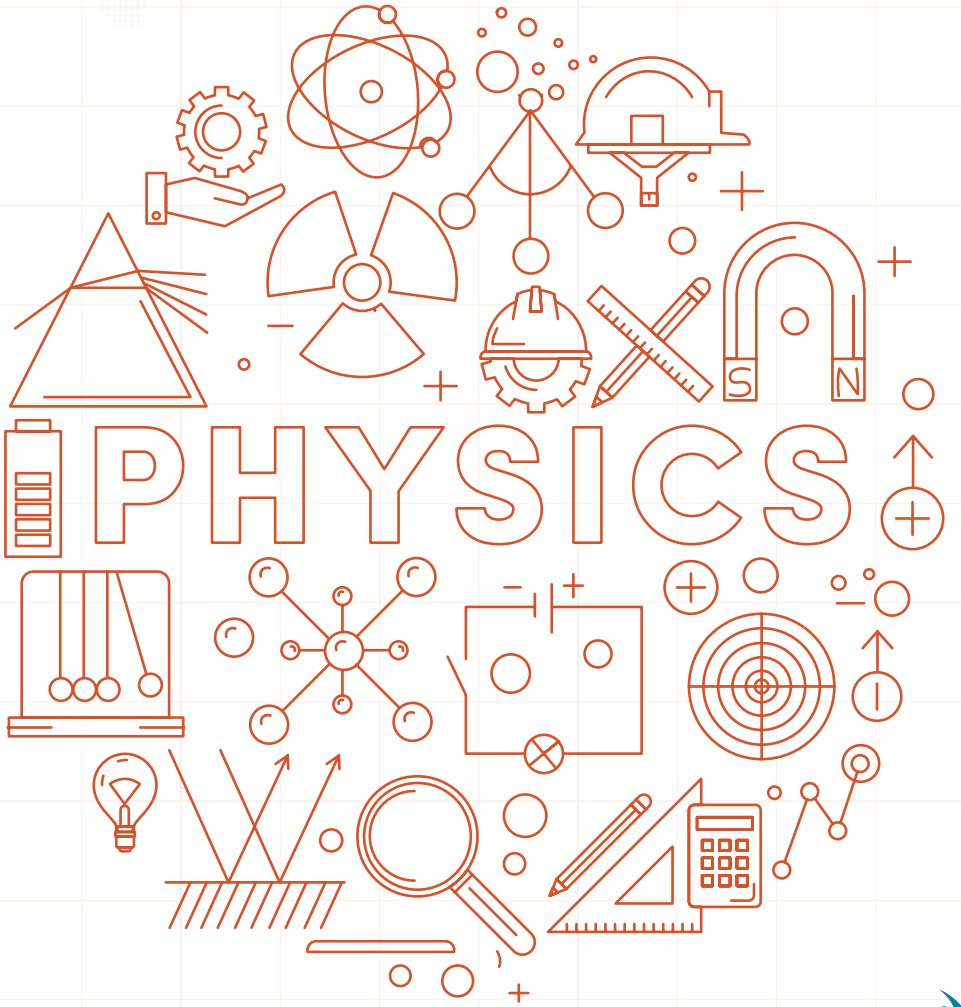
5. The fuels of rockets are

A Liquid hydrogen and gaseous oxygen
B Gaseous hydrogen and liquid oxygen
C Gaseous hydrogen and gaseous oxygen
D Solid hydrogen and liquid oxygen
E Liquid hydrogen and liquid oxygen

NIGERSAT 1

PERFORMANCE OBJECTIVES

1. State the features of NigerSat 1.
2. Describe its operations.
3. State its uses to Nigeria and neighbours.



NIGERIA SATELLITES

In 1999 April, National Space Research and Development Agency NASRDA with a mandate to organize all space science and technology-related activities to make a greater impact on Nigeria's space research.

NIGERSAT-1

Nigeria sat-1 is the Nigeria contribution to the international disaster monitoring constellation DMC project was launched on the 27th September 2003

The DMC is an international co-operation in space bringing together seven countries such as Algeria, China, Nigeria, Thailand, Turkey, Vietnam, and the UK. DMC consortium is forming the first-ever microsatellite constellation bringing remarkable Earth observation capabilities both nationally to the individual satellite owners and internationally to benefit worldwide humanitarian aid effort

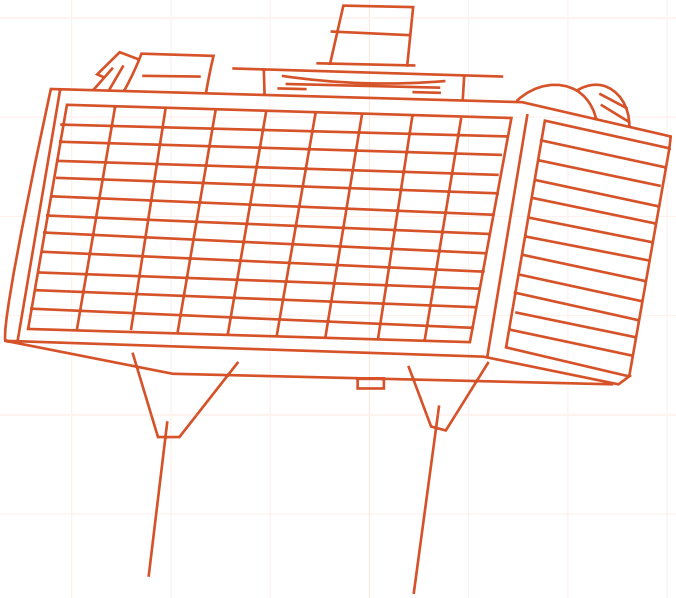


Fig. 5.27: The NIGER SAT-1

Features of Niger Sat-1

1. It weighs 100kg
2. It is an advanced technology microsatellite
3. It operates in low earth orbit
4. It is in constellation with six other satellites countries
5. It provides an opportunity to develop payload to solve a local problem

6. It provides capacity building in satellite technology for Nigeria engineers
7. It bridging the digital divide within and across Africa
8. The ground control station is located in Asokoro Abuja Nigeria.

Operation of NIGERSAT -1

It is for Earth's observation which means that the satellite will take photos of Nigeria's land on which it is focused and beam them back to the ground station for use in various areas of socio-economic development.

Uses of NIGERSAT-1

1. Its disaster management such as flooding, erosion, pollution, bush burning
2. For Agriculture such as pest control, disease control, mapping, afforestation
3. For water resources such as the location of dams, rivers.
4. For solid mineral exploration such as geological mapping, solid minerals exploitation
5. For ecosystem management
6. For demography such as mapping, land planning, boundary settlement
7. For transportation such as route mapping
8. For environment management
9. For defence and security
10. For health and public health delivery
11. For education and capacity building

SUMMARY

So far, we have learnt how to

1. State the features of NigerSat 1.
2. Describe its operations.
3. State its uses to Nigeria and neighbours.

INTERACTIVE ASSESSMENT QUESTIONS

1. NigerSat 1 was launched in the year

   A 26th September 2003
   B 24th September 2003
   C 25th September 2003
   D 27th September 2003
   E 29th September 2003

2. How many DMC consortium countries own the NigerSat 1

   A 5
   B 6
   C 8
   D 7
   E 9

3. The weight of NigerSat 1 is about

   A 120kg
   B 86kg
   C 100kg
   D 150kg
   E 93kg

4. The ground control station of NigerSat 1 is located in

   A Beijing China
   B Ankara Turkey
   C Asokoro Abuja Nigeria.
   D Manilla Philippine
   E London UK

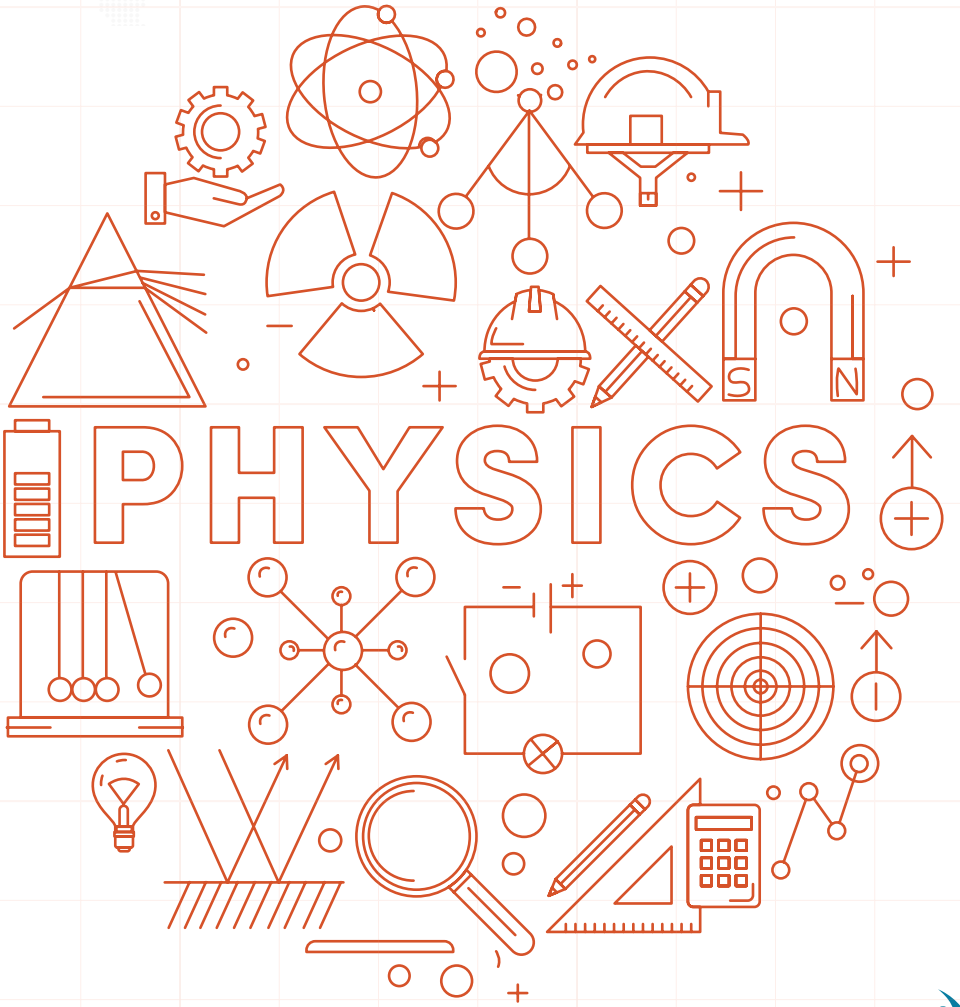
5. The agency in charge of NigerSat 1 is

A UK space agency
B ISRO
C NASA
D NASRDA
E China space agency

NIGCOMSAT-1

PERFORMANCE OBJECTIVES

1. State the features of NigComSat-1
2. Describe its operation
3. State its uses to Nigeria and its neighbours



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NIGERCOMSAT-1

Features

It is Nigeria Communication Satellite 1 which was launched on 13th May 2007. its purpose is for communication

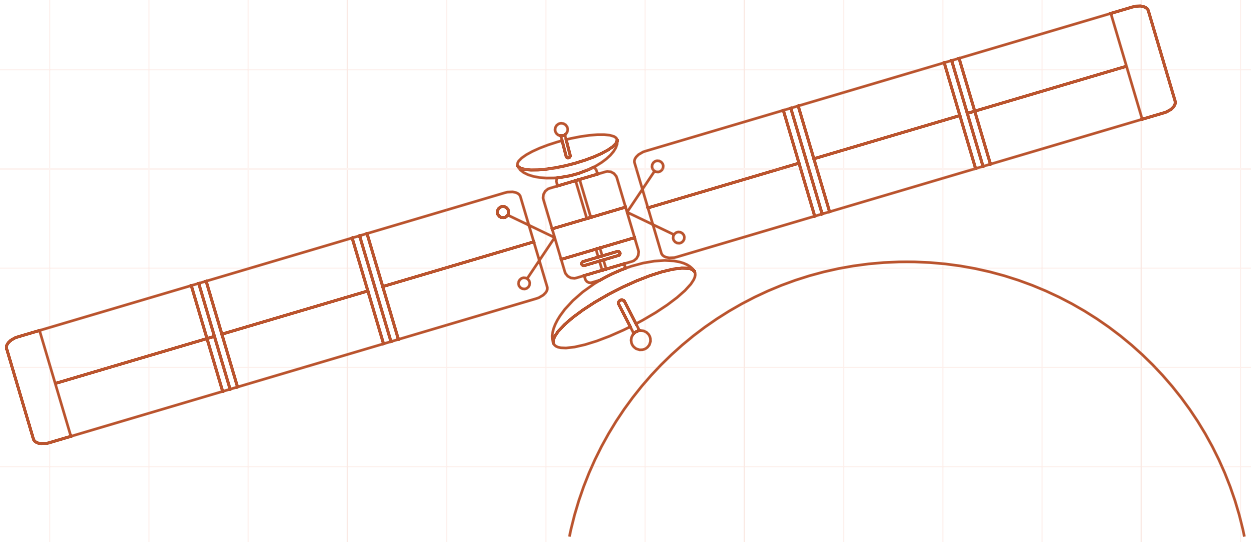

Fig. 5.28: NigComSat-1

NigComSat-1 is a Nigerian satellite ordered and built in China in 2004 and also the second satellite Nigeria government launched into space which is also the first communication satellite in Africa.

It was launched aboard a Chinese Long March 3B carrier rocket from Xichang launching center in China.

Operation of NigComSat-1

Based on the Chinese DFH-4 satellite bus and varieties of transponder

1. 4 C band
2. 14 Ku band
3. 8 Ka band
4. 2 L band

The satellite was design to provide coverage to many places in africa on C-band and Ku-band and to global navigation beam on L-band and ka-band transponders with spot beams over Nigeria and South Africa and Europe.

Uses of NigcomSAT-1

1. For telepresence - by present electronic means in order to render services, seminars, e- Government, e-Commerce
2. For broadcasting - which involves mainly television broadcast
3. For telecommunication- which involves the use of telephone, mobile phones.
4. For internet and multimedia - by exchange of information through the internet.

SUMMARY

So far, we have learnt how to

1. State the features of NigComSat-1
2. Describe its operation
3. State its uses to Nigeria and its neighbours

INTERACTIVE ASSESSMENT QUESTIONS

1. Nigeria Communication Satellite 1 which was launched

A	On 13th May 2006
B	On 13th May 2003
C	On 13th May 2005
D	On 13th May 2007
E	On 13th May 2008

2. The main purpose of NigComSat-1 is

A For research
B For military
C For surveying
D For communication
E For capacity building

3. The agency in charge of NigComSat-1 is

A NASA
B UK space agency
C China space agency
D ISRO
E NASRDA

4. The ground control station of NigComSat-1 1 is located in

A Beijing China
B London UK
C Ankara Turkey
D Abuja Nigeria
E Accra Ghana

5. The weight of NigComSat-1 is about

A 100kg
B 120kg
C 220kg
D 80kg
E 90kg

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