IDEBE PHYSICS - FORM FOUR

CLASSICAL NOTES – 2020

TOPICS:

1. Waves
2. Electromagnetism
3. Radioactivity
4. Thermionic emission
5. Electronics
6. Elementary astronomy
7. Geophysics

FIRST EDITION

TOPIC–1 WAVES

Wave: Is a progressive disturbance propagated from a point in a medium (matter) on space without the movement of the points themselves.

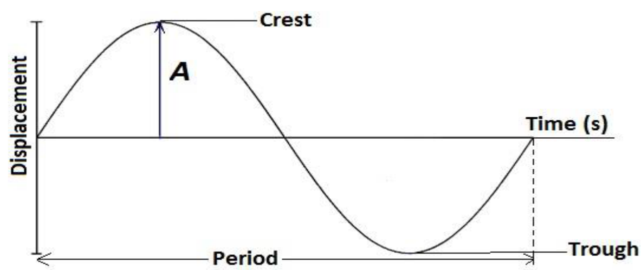
OR **Is a periodic disturbance that transfers energy from one point to another**
For example, **light**, **sound** and **water** waves

Terms Used

1. **Period:** Is the time taken by the wave to repeat itself.
   OR Is the time taken for the wave to complete one cycle.
   It is represented by letter T. Its SI unit is **second (s)**

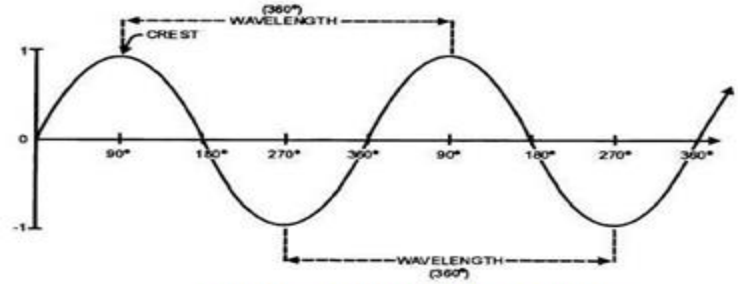
2. **Amplitude:** Is the maximum displacement of the wave from the equilibrium position.
   It is represented by letter **A**. Its SI unit is **meter (m).**
3. **Crest:** Is the point of maximum positive displacement of the wave from the equilibrium position

4. **Trough:** Is the point of maximum negative displacement of the wave from the equilibrium position



5. **Wavelength**: Is the distance between two successive or adjacent crest troughs.

   OR Is the distance travelled by the wave to complete one cycle
   It represented by letter **Lambda (λ)**



Wave length of a wave

6. **Frequency:** Is the number of crests or troughs that pass a given point per unit time.
   OR Is the number of cycles per unit time.
   It is represented by letter **f**. Its SI unit is **hertz (Hz).**
   1hertz (Hz) = 1per second (s^{-1})
   Then $f = \frac{1}{T}$, where T is a periodic time
7. **Wave velocity: Is** the speed at which the wave moves through a medium
   OR Is the displacement of the wave per unit time.
   It is represented by letter **v**

Mathematically

$$speed\ (V) = \frac{wavelength}{time} = \frac{\lambda}{T} = \lambda \times \frac{1}{T} = \lambda \times f$$

Therefore: $v = \lambda f$

Examples:

1. Sound waves have a frequency of 16 kHz. What is the periodic time for the waves?

Soln:

Given: $f = 16kHz = 16\ 000Hz$

From: $f = \frac{1}{T}$ $\rightarrow T = \frac{I}{f} = \frac{1}{16000} = 0.0000625\ s$

2. A radio station transmits waves at a frequency of 95.6 MHz. What is the wavelength of the waves transmitted? (c = 3.0 x 10^8 m/s)

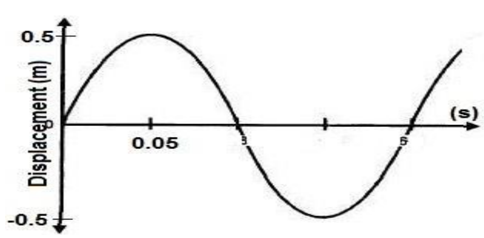
Soln:

Given: $f = 95.6MHz = 95.6\ x\ 10^6\ Hz$, **c = 3.0 x** 10^8 m/s

From: $v = \lambda f$ $\rightarrow \lambda = \frac{v}{f} = \frac{3.0\ x 10^8}{95.6\ x\ 10^6} = 3.14\ m$

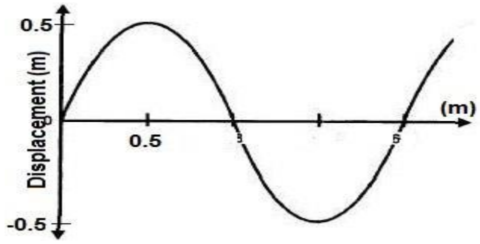
Class Activity – 1:1

1. From the diagram below, determine the amplitude, period and frequency of the wave

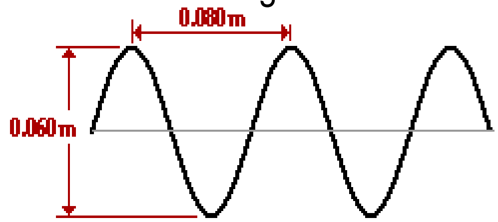


ANS: Amplitude, A = 0.5m Period, T = 0.2 Frequency = 5Hz

2. From the diagram below, determine the wavelength and velocity of the wave, frequency of the wave is 5Hz (**ANS V = 10m/s)**



3. What is the amplitude and wave length of the wave in the diagram below?



ANS: A = 0.03m, Wavelength = 0.08 m

4. A periodic and repeating disturbance in a lake creates waves which emanate outward from its source to produce circular wave patterns. If the frequency of the source is 2.00 Hz and the wave speed is 5.00m/s then the distance between adjacent wave crests is ___ meter.(**ANS: Wavelength = 10 m)**
5. **Ca**lculate the wavelength of red light in air if the frequency of red light is 4.3 x 10^{14} Hz, C = 3.0 X 10^{8} (**ANS: 6.98 x 10^{-7}m)**
6. A pendulum makes exactly 40 vibrations in 20.0 s. Its period is **(ANS: 0.5 s)**
7. If the frequency of a wave is doubled and if the speed remains constant, its wavelength is ___ **(ANS: halved**.)
8. A wave whose speed in a snake is 4.4 m/s enters a second snakey. The wavelength changes from 2.0 m to 3.0 m. The wave in the second snakey travels at approximately ____. **(ANS: 6.6 m/s.)**
9. A 2.0-meter long rope is hanging vertically from the ceiling and attached to a vibrator. A single pulse is observed to travel to the end of the rope in 0.50 s. What frequency should be used by the vibrator to maintain three whole waves in the rope? **(ANS: 6.0 Hz)**
10. Transverse stationary waves are set up in a long string using a suitable vibrator of frequency 60 Hz. The average distance between successive nodal points is measured to be 50 cm .Calculate the velocity of transverse waves in the string **ANS: V = 60 M/S**
11. The distance between successive crests of water ripples in a ripple tank experiment is 3.2 cm and their wave speed is 26 cm/s. Determine the wavelength ,Frequency and period of the ripples **ANS: f = 8.125 Hz, λ=3.2cm T=0.123 Hz**

Types of waves

- **Electromagnetic wave**
- **Mechanical wave**

Electromagnetic Wave:
- Is the type of wave which does not require a medium to transfer energy.

Mechanical Wave:
- Is the type of waves in which a medium is required to transfer energy.

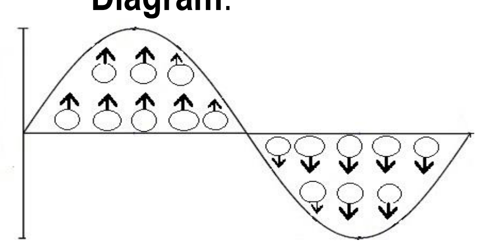
Difference between Mechanical and Electromagnetic Waves

Mechanical waves	Electromagnetic waves
❖ Are disturbances which are transported through a medium due to particle to particle interaction	❖ Are disturbances made up of electric and magnetic fields
❖ Requires a material medium to transfer energy	❖ Do not requires materials medium to transfer energy
❖ Cannot travel through vacuum	❖ Can travel through vacuum
❖ Examples are water waves, sound waves etc	❖ Examples are X – rays, Visible light etc

Types of Wave motion
- ➢ Transverse wave
- ➢ Longitudinal wave

Transverse Wave
- **I**s the mechanical wave in which particles of the medium vibrate in a direction perpendicular to the direction of movement of the wave.
- For example, water wave
- This wave enables a duck in a lake floating in the same position as the wave passes (**This is due to the vertical displacement of water waves ie transversely**)

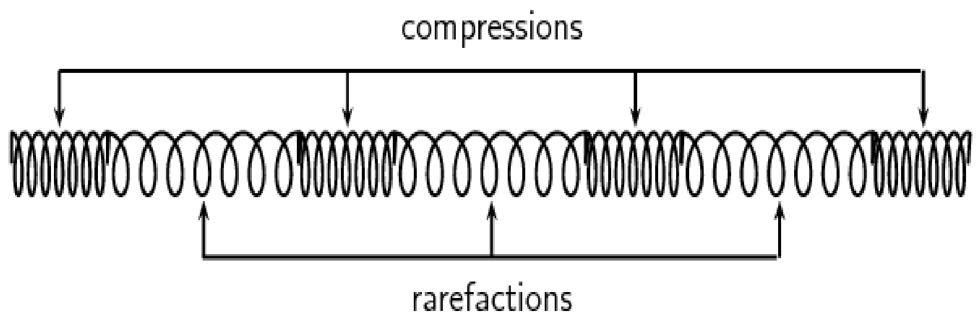
Diagram:



- This vibration of medium cause a boat on the ocean moves up and down while the waves themselves move toward the shore

Longitudinal Wave

- Is the mechanical wave in which particles of the medium vibrate in a direction parallel to the direction of movement of the wave.
- For example, sound wave
- It consists of **compressions** and **rarefactions**
- **Compression:** Is a region in a longitudinal wave where the particles are closest together
- R**arefactions**: Is a region in a longitudinal wave where the particles are furthest apart



Differences between Transverse wave and Longitudinal waves

Transverse wave	**Longitudinal wave**
Particles of the medium vibrate perpendicular to the direction in which the wave advances	The particles of the medium vibrate in the same direction in which the wave advance
It is formed of crests and troughs	It is formed of a series of compressions and rarefactions
It can propagate only in solids and at the surface of liquids	It can propagate in all types of media (solid, liquid and gas)
There is no pressure variations	The pressure and density are maximum at compressions and minimum at rarefactions
Examples are: • Ripples produced on the surface of water when stone is dropped into it • Waves produced in a rope fixed at one end when the free end is moved up and down rapidly • Waves in the stretched strings • Earthquake S waves	Examples are: • Sound waves travel through air • Waves in a coil (helical) spring • Vibrations of air column in organ pipes • Earthquake P waves

Properties of Waves

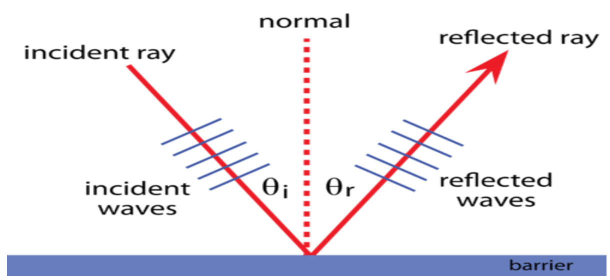
- Reflection of waves
- Refraction of waves
- Interference of waves
- Diffraction of waves

Reflection of Waves

- Is the abrupt change in the direction of propagation of a wave that strikes the boundary between two different medium.

See the figure below

Reflection of Mechanical Waves



Laws of reflection of waves

1st."*The angle of incidence is equal to the angle of reflection*"

2nd. "*The incident direction of propagation, the reflected direction of propagation and the normal all lie in the same plane*"

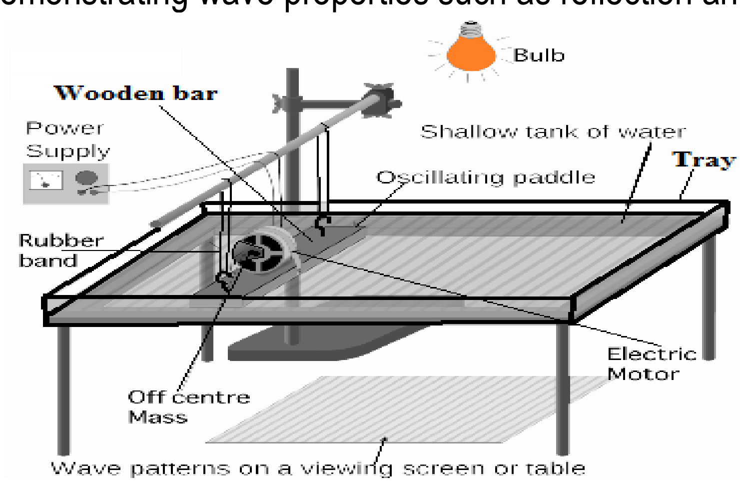
Applications of Reflection of Waves

- ❖ Is used in the designing of plane mirrors
- ❖ Reflection of waves(sound waves) used in measuring distances
- ❖ Sonar system rely on the reflection of sound waves to assist ships in navigating, communicating and detecting other vessels
- ❖ In geology, it is important in the study of seismic waves

N.B SONAR = Sound Navigation and Ranging

Ripple Tank Experiment

- **Ripple tank** Is a shallow glass tank of water used in schools and colleges to demonstrate the basic properties of waves.
- It is useful in demonstrating wave properties such as reflection and refraction.



A ripple tank

Main Parts of Ripple Tank

(a) Shallow tank of water

- Shallow tank of water is the source of waves in which an oscillating paddle generates parallel water waves

(b) Motor

- The rotating armature (axle) of an electric motor makes the wooden (metal bar) to vibrate on water surface and generating ripples

(c) Oscillating paddle

- Oscillating paddle is the one in which transform mechanical energy generated by motor by off centre mass to wave energy in a Shallow tank of water

(d) Lamp (Bulb/ filament)

- Bulb or filament which is used to illuminate the water surface to see the water waves onto the white board or white sheet below the ripple tank

(e) Paper sheet

- Paper sheet used to display shadow of the wave pattern placed under the tank

(f) Various obstacles

- Various obstacles is paced in the tray to observe properties of waves e.g. reflection, refraction, interference and diffraction. Example, **laying glass**, **rectangular barrier**, **curved barrier** (concave and convex barrier) etc

(g) Stroboscope

- The stroboscope enables the observer to see the waves as stationary

(h) Laying glass

- Laying glass used to vary the depth (tray thickness) of the water. This allows observing waves travelling from one to another medium

(i) Metal bar

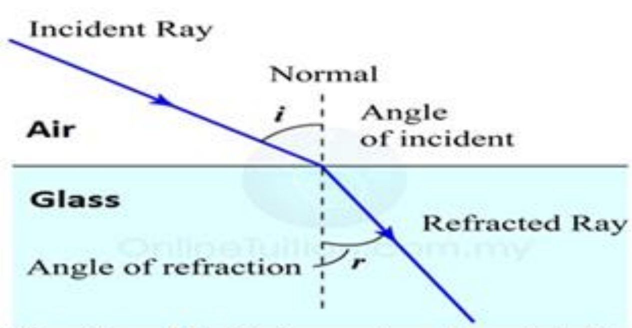
- A metal bar (wooden bar) is screwed to the electric motor and suspended above the ripple tank with rubber (elastic) bands and touching the water surface

(j) Power supply

- Power supply for electric motor

Refraction of Waves

- Is the change in direction of waves as they pass from one media to another due to change in speed and wave length
- It obeys **Snell's law: ie**



Refraction of light at an air - glass interface

- The speed of waves depends on the medium i.e velocity of the waves decrease with decrease in wavelength. $\boldsymbol{v} \propto \boldsymbol{\lambda}$

  That is: $\boldsymbol{v} = \boldsymbol{k\lambda} \quad \rightarrow \frac{v}{\lambda} = \frac{v_1}{\lambda_1} \qquad \rightarrow \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$

  But the ratio $\frac{v_1}{v_2}$, is the refractive index of the second medium relative to the first medium

N.B

- The length of water waves in **shallow water** is usually **shorter than in deep water**
- When wave is refracted into a less medium, the speed of wave increases and vice versa
- When wave is refracted into a less medium**, the wave length of wave increases and vice versa**

Applications of Refraction of Waves

- ✓ It is used in optical instruments which focus or spread light. For Example, microscopes and telescopes
- ✓ It is used in dispersion of light waves
- ✓ It is used to determine the eye's refractive error

Individual task

1. During the day sound from distant sources are not very clear unlike during the night

ANS: During the day sound waves are refracted upwards from the hot earth, while at night, sound waves are refracted downwards, hence are much louder.

2. Give reason why the amplitude of the wave does not change as it crosses the boundary

ANS: Because there is no **LOSS** of energy therefore amplitude does not change

Interference of Waves

- Is a phenomenon in which two waves superpose to form a resultant wave of greater, lower, or the same amplitude

OR

- Is the pattern formed when two or more waves overlap in medium

Types of Interference

- ❖ Constructive **Interference**
- ❖ Destructive **Interference**

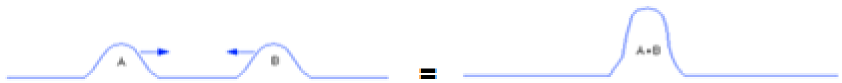
Principle of Superposition

It states that

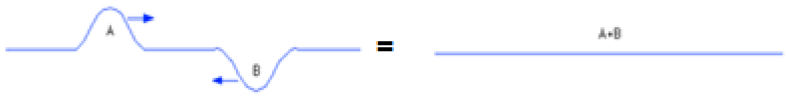
"***The resultant displacement at any points is equal to the sum of the displacements of different waves at the point***"

NB:

- When two different crests meet at the same point in the same direction results a greater amplitude than individual, this refers as **constructive interference**



- When crest and trough meet at the same point in the opposite direction results smaller amplitude than individual, this refers as **destructive interference**



N.B

- ✓ **Soft sound** occurs in regions where sound waves interfere destructively
- ✓ **Loud sound** occurs where sound waves interfere constructively
- ✓ **Node**: Is a point on a stationary wave where particles have zero displacement
- ✓ **Antinode**: Is a point on a stationary wave where particles have maximum displacement

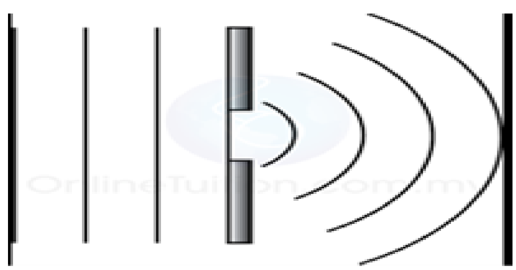
Applications of Interference of wave

- **Creation of hologram**. holograph is a photograph of an interference pattern which is able to produce a three dimensional image when suitably illuminated
- **Noise reduction system**. For example, earphones capture environment sound which destructed by second computer sound
- **Concert halls and auditoriums** designed to reduce the amount of destructive interference by introducing sound absorber

Diffraction of Waves

Diffraction: Is the change in the direction of waves as they pass through an opening or around a barrier in their pass

OR **Is the spreading of waves around obstacles**



Diffraction of waves

NB:

- ✓ It is possible to hear sound round obstacles but not possible to see light. **This is because sound waves have longer wavelengths therefore are more readily diffracted unlike light waves , which have very short wavelengths therefore not readily diffracted**
- ✓ Diffraction of wave is greater when the wave length and width of the gap is the same
- ✓ We hear someone sound even she/he behind the building due to diffraction of wave sound

Factors affecting diffraction

- The wavelength (**the shorter wavelength, the greater the of angle of diffraction**)
- The size of the opening gap **(the size of gap** $\propto \frac{1}{diffraction\ of\ wave}$**)**

Applications of diffraction of Waves

- It is used in determining the crystal structure of materials
- It is used in measuring the coefficient of thermal expansion, crystalline size and thick of thickness of thin films
- It is used in determining the types and phases present in a specimen where the spacing of obstacles (atoms) is between 1 and 3nm

Sound Waves

- **Sound wave is a longitudinal wave that produced by vibrating object.**
- For example, **turning fork**

Propagation of Sound Wave

- Sound travels by vibration of particles to transfer energy to the next particles until the sound reaches another point

Qn: Why solid materials transfer sound faster than liquid/gas

Answer: **The molecules/particles of solid materials are packed together**

Sources of Sound Wave

- Almost everything ranging from **people**, **animals**, **plants** and **machines**

Factors affecting speed of sound in air

- **Temperature**

  $V \propto T$, e.g, $V_{da} = V_a + 0.6\ T_c$ (V_{da} = velocity of sound in dry air**)**
- **Direction of Wind**
  - In the same direction : $V \propto W$
  - In opposite direction: $V \propto \frac{1}{W}$
- **Humidity**

  $$V \propto \frac{1}{H}$$
- **Density of Air**

  $$V \propto \frac{1}{\rho}$$

Audibility Range

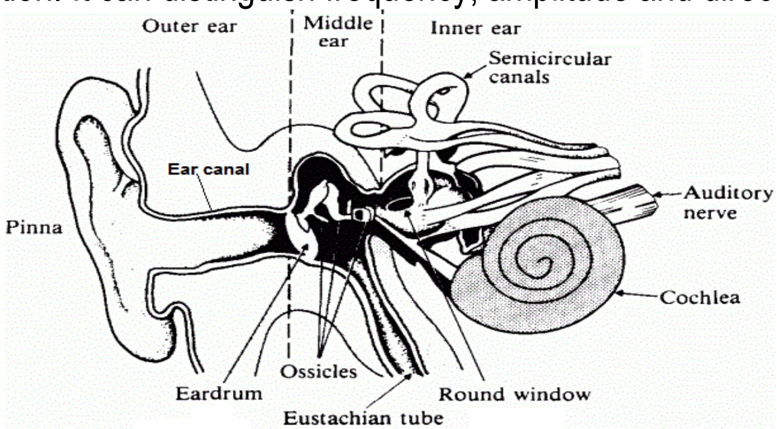
- Audibility range is the range of frequency detected by human ear

NB:

- The human ear is most sensitive to sound with a frequency around **3000Hz**
- Sound below 20Hz is called infrasonic Sound
- Sound above 20000Hz is called **ultrasonic sound**
- Dogs, cat, bat and dolphins detect ultrasonic sound
- Bats can fly in the dark without hitting anything because they are guided by ultrasonic waves produced by them
- Human ear can distinguish two simultaneous sound if their frequencies differ by at least **7Hz**

The Human Ear

- Human ear is the human organ responsible for conversion of sound energy to mechanical energy to nerve impulse that transfers to the brain for interpretation. It can distinguish frequency, amplitude and direction.



Parts of human Ear

It consists of three basic parts include

- **outer ear**
- **Middle ear**
- **Inner ear**

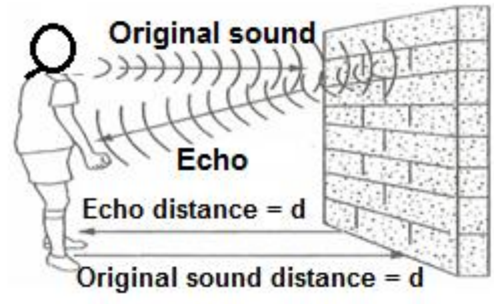
Mechanism of Hearing

- Earflap collect sound waves, which pass through the ear canal to hit drum which results vibrations of interconnected bones where vibrate cochlea fluid through (oval window) results vibrations of hair cells which transform mechanical energy to electrical impulses, which transmitted to the brain where they are decoded and interpreted as sound

N.B **Hearing**: Is the process by which the ear transforms sound vibrations in the external environment into nerve impulses that are conveyed to the brain where they are interpreted as sounds

Echo

- **Echo is a reflected sound which is heard distinctly from the original sound**
- Since sound waves go and bounce back its distance becomes 2d.



- Hence speed (v) of sound associated with echo is calculated by, **v =** $\frac{2d}{t}$

NB: Always echo reaches the ear more than 0.1s

From: **v =** $\frac{2d}{t}$

Then: **2d = v x t = 0.1 x 340, d = 17m**

- **Therefore:** An obstacle must be at least 17 m away for a distinct echo to be heard

The accoustics of buildings

- Is the science of controlling the quality and amount of sound inside a building
- It is used to allow for pleasant sound in a concert hall and to reduce echoes and noise within an office building
- When a hall has many people, most of the sound (including echoes) is absorbed by clothes and skins of the audience, thus echoes do not occur (noise reduced)
- It also concerns suppressing sound coming from outside the building such as apartments

Reverberation

- Are the multiple reflections of sound produced when it travels in an enclosed room

Reverberation time

- Is the time required for the sound to decay in a closed space or cavity

Examples

1. An echo sounder produces a pulse and an echo is received from the sea – bed after 0.4 seconds. If the speed of sound in water is 1500 m/s, calculate the depth of the sea –bed

   Soln:

   Given: v = 1500 m/s, total time = 0.4 s

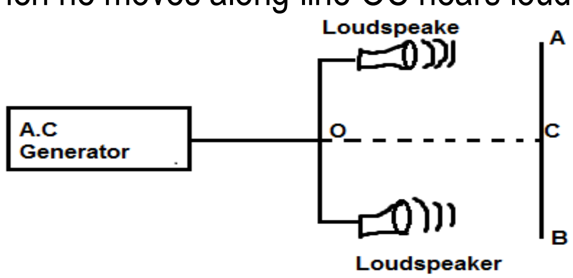
   From: $v = \frac{2s}{t} \rightarrow \boldsymbol{s = \frac{vt}{2} = \frac{1500 \, x \, 0.4}{2} = 300 \, m}$

2. In determining the depth of an ocean an echo sounder produces ultrasonic sound. Give reasons why ultra sound is preferred for this purpose

ANS: (a) Ultra sound penetrates deepest (b) Ultra sound is reflected easily by tiny grains of sand

Class Activity – 1:2

1. A gun was fired and the echo from a cliff was heard 8s later. How far was the gun from the cliff? (**ANS: d= 1400m)**
2. (a) Define an echo
   (b) Name any two factors that affect the speed of sound in air
   (c) Explain briefly why sound produced in hall with many people is heard more clearly than when the hall has few people?
   (d) A person standing 99m from the foot of mountains claps his hands and hears an echo 0.6 second later. Calculate the speed of the sound in the air (**AN: V = 330m/s)**
   ANS (c) When a hall has many people, most of the sound (including echoes) is absorbed by clothes and skins of the audience, thus echoes do not occur
3. It is possible to hear sound round obstacles but not possible to see light. Give reason
4. Two sets of transverse waves arrive at the same time. Under what conditions do they:
   (i) Cancel out (**ANS: trough from one arrive at the same time as crest from the other)**
   (ii) Produce a larger wave (**ANS: A crest from one arrive at the same time as a crest from the other (constructive interference))**
5. **A** fathometer produces sound in a ship and receives two echoes where there is a raised sea bed one after 2.5 seconds and the other after 3.0 seconds. Find the height of the raised sea bed (Take V in water = 1460 m/s) (**ANS: h_1-h_2 = 365 m**)
6. **A** girl standing 200 m from the foot of a high wall claps her hands and the echo reaches her 1.16 seconds later. Calculate the velocity of sound in air using this observation **(ANS: V = 344.8 m/s)**
7. From the figure below, give reason why, an observer moving along the line AB hears loud sound at same point and soft sound at other points. How is the sound along the line OC? (when he moves along line OC hears loud sound only)



8. A person stands 100 m from the foot of a tall building claps his hands and hears an echo 0.588 seconds later .Calculate the velocity of sound in air (**ANS: 340 m/s)**
9. The velocity of sound in air is 330 m/s, Find the wavelength in water of sound wave of frequency 660 Hz if the velocity of sound in water is 1. 32 km/s
10. A source of sound produces waves of wavelength 0.8 m in air. The same source of sound produces waves of wavelength 4.0 m in air. If the velocity of sound in air is 332 ms^{-1} , find the velocity of sound in water **(ANS: v = 332 m/s)**
11. How far does sound travel in air when a turning fork of frequency 250 Hz completes 50 vibrations? The speed of sound in air is 340 m/s. **(ANS: $\lambda = 1.36\ m$)**
12. A bat emits ultrasonic sound of frequency 100 kHz in air. If this sound meets a water surface, what is the wavelength of (i) the reflected sound (ii) the transmitted

sound? If the speed of sound in air = 340m m/s and in water = 1486 m/s (**ANS: (i) $\lambda = 3.4$ x 10^{-3} m (ii) $\lambda =$ 1.486 x 10^{-3} m)**

13. If the frequency of radio waves is 600 kHz, find the wavelength of the waves. The speed of radio waves = 3 x 10^8 m/s. (ANS: $\lambda = 500\ m$)

14. A stone is dropped into a well 19.6 m deep and the impact of sound is heard after 2.056 seconds. Find the velocity of sound in air **(ANS: v = 350 m/s)**

15. A personal with deep voice singing a note of frequency 200Hz is producing sound waves whose velocity is 330m/s. find the sound's wave length. (**ANS: λ = 1.65m)**

16. A hospital uses an ultrasonic scanner to locate tumours in a tissue. What is the wavelength of sound in a tissue in which the speed of sound is 1.7 kms^{-1}? The operating frequency of the scanner is 4.2 MHz. (ANS: $\lambda = 0.405\ m$)

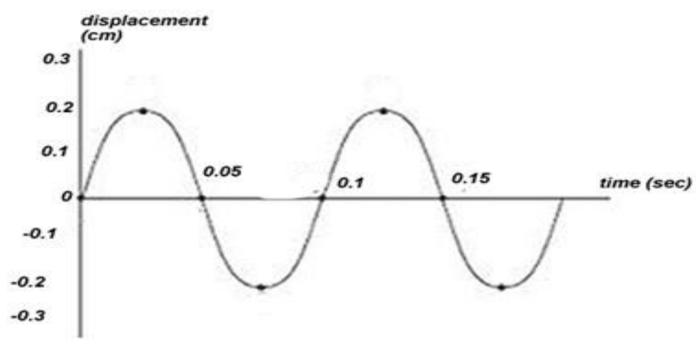
17. Calculate the velocity of the wave whose wavelength is 1. 7 x10^{-2}m and frequency 2x10^{14}Hz (**ANS: 3.4 1x10^{12}m/s)**

18. Find the wavelength of sound wave whose frequency is 550Hz and speed is 330m/s (**ANS: The wavelength is 0. 6m) NB:** The higher the frequency of a wave, the shorter the wavelength and the lower is the frequency on the wave, the longer is the wavelength.

19. The radio waves have a velocity of about 3.0 x10^8m/s and the wavelength of 1500m. Calculate the frequency of these waves? (**ANS: f =** 2. 0 x 10^5 Hz)

20. Consider the figure below illustrates part of a wave traveling across the water at a particular place, Calculate;

(a) The frequency of the wave **(ANS: f = 10 Hz)**
(b) The wavelength of the wave (**ANS: λ = 0.1 m)**
(c) The amplitude of the wave **(ANS: A = 0.2 m)**
(d) The velocity **(ANS: v = 2m/s)**



21. The wavelength of signals from a radio transmitter is 1500m and the frequency is the 200 KHz. To what speed does the radio wave travel?.What is the wavelength of a transmitter operating at 1000 KHz**? (ANS: V = 3 x 10^8 m/s, λ= 3. 0 x 10^2m)**

22. A certain wave has a periodic time of 0.04 second and travels at 30 x 10^7 m/s Find its wavelength. (**ANS: λ = 1.2 x 10^7 m)**

23. A signal is sent to the seabed from the bottom of a ship. The signal comes back in one – fifth of a second .How deep is the water?

24. The commercial Programme of radio Tanzania is broadcast on wavelengths of 1500m and 247 m. The frequency of the 1500 m wave is 200 kHz. What is
(a) The velocity of the wave? (b) The frequency of the 247 m wave?

25. Sound travels 1.7 Km in 5 seconds .The time between a flash of lightning and the thunder is 10 s. How far away is the storm?

26. Explain how bats can fly in the dark without hitting anything

Uses of Echo

- Used to find depth of ocean (lakes)
- Looking at babies in the womb (pre – natal scanning) by Ultrasound
- To detect the submarines
- To detect large groups of fish
- To detect the wrecked ships
- To detect the dangerous rocks

Musical sounds and noise

- **All** sounds which produce sensation of hearing may be roughly dived into two classes namely (i) musical sounds (ii) noise

(a) Musical sound

- Is a pleasant, continuous and uniform sound produced by regular and periodic vibrations

OR

- Is a sound produced by continuous and regular vibrations
- Example sound produced by turning fork, flute and piano

(b) Noise

- Is an unpleasant ,discontinuous and non–uniform sound produced by irregular succession of disturbances

OR

- Is the random and non-structured sound musical scale that not appealing to the human ear
- Example is sound produced by a falling brick, the clapping of two wooden blocks

NB:

- Tone (Musical note) is a sound of regular frequency

Properties of Musical Sounds

- These are loudness, pitch and timbre (quality)

Loudness

- **Loudness is the intensity of the sound as perceived by the human ear.**
- The large the amplitude, the louder the sound

Pitch

- **Is the degree of highness or lowness of a tone**.
- The higher the frequency, the higher the pith produced.

Timbre

- **Timbre is the quality of sound produced by an instrument**.
- For example, different instruments produce different sound

N.B:

- **The** difference between sounds are caused by intensity, pitch and tone
- **For example a violin** sounds different than a **flute** playing the same pitch. This is because they have a different tone or sound quality

Musical Instruments

- Musical instrument is a device constructed or modified for the purpose of making music

Categories of musical instruments

String Instrument

- Is the instrument which produces sound from stretched strings that are plunked, bowed or struck
- Example, guitar is plunked, violin is bowed and piano is struck

Percussion Instrument

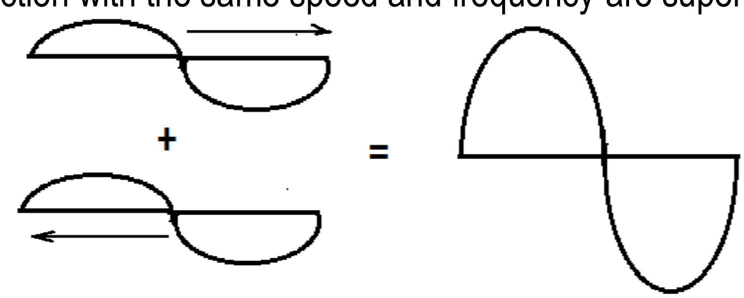
- Is the instrument which produces sound by struck with an implement, shaken, rubbed, scrapped or by any other action which sets the object into vibrations
- Example **drum**, **cymbals**, **tambourine**, **marimba** and **xylophone**.

Wind Instrument

- **Is the instrument which produces sound by blowing.**
- Example **recorders**, **flutes**, **vuvuzela** and **trumpets**

Stationary Waves

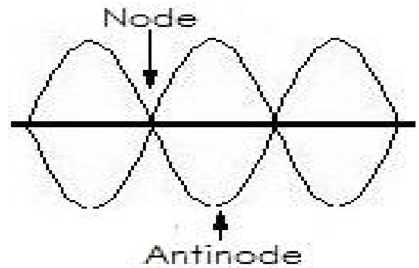
- A stationary wave is the wave which occurs when two waves are travelling in opposite direction with the same speed and frequency are superposed



Formation of stationary waves

NB:

- When adding together producing maximum displacement (amplitude) called **antinodes** and when cancel out producing zero displacement called **nodes**



- Distance between adjacent nodes or antinodes is equal to half wave length,
  i.e L = λ/2

Fundamental Frequency(note)

- Is the lowest frequency of a vibrating object

Fundamental note: Is the primary note of the harmonic series

Fundamental harmonic

A harmonic: Is a wave whose frequency is an integral (whole number) multiple of the fundamental frequency

OR

- Is a note whose frequency is a whole number that of the fundamental frequency

Overtone (Fundamental Overtone)

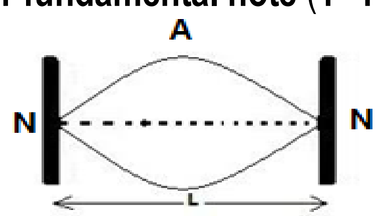
- Is any frequency higher than the fundamental frequency of a sound

NB:

- The fundamental note is equal to first harmonic
- The second harmonic is equal to first overtone
- Stationary wave in a string have certain fixed wavelength

Consider the diagrams below

For fundamental note (**1st harmonics**)

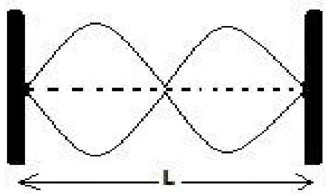


From: $L = \frac{\lambda}{2}$ → **λ = 2L**

From: V = λf → $v = 2Lf$ **Then**: $f = \frac{v}{2l}$

$$\therefore fundamental\ frequency, f_0 = \frac{v}{2l}$$

For 1st overtone (2nd harmonic)



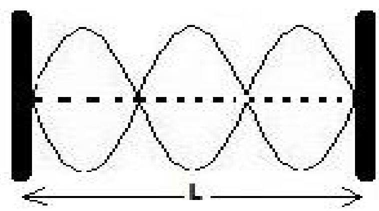
From: L = 2 × $\left(\frac{\lambda}{2}\right)$ → **λ =2** $\left(\frac{L}{2}\right)$

From: V = λ*f*

Then: $f_1 = \frac{v}{\lambda} = \frac{v}{l} = \frac{2}{2} \times \frac{v}{l} = 2 \times \frac{v}{2l} = 2f_0$

$\therefore 1^{st} overtone\ (2^{nd}\ harmonic),\ f_1 = 2f_0$

For 2nd overtone (3rd harmonic)



From: L = $3 \times \left(\frac{\lambda}{2}\right)$ $\rightarrow \lambda = \frac{2l}{3}$

From: V = λf

Then: $f_2 = \frac{v}{\lambda} = \frac{3v}{2l} = 3 \times \frac{v}{2l} = 3f_0$

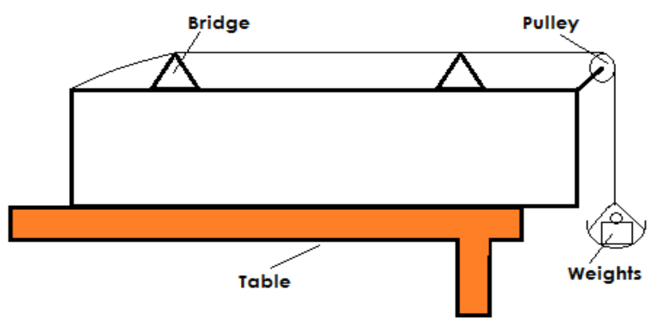
$\therefore 2^{nd}\ overtone\ (3^{rd}\ harmonic), f_2 = 3f_0$

Generally the n^{th} overtone of a stationary wave is given by

$$f_n = (n+1)f_0 \dots\dots\dots\dots (where\ n = 1, 2, 3 \dots\dots)$$

Sonometer

- Sonometer is an instrument used to study the properties of stationary wave
- It is an apparatus made of a hollow box having two holes



- It is used to study the relationship between the frequency of the sound produced by a plucked string, and the tension, length and mass per unit length of the string.
- **N.B:** Stringed musical instruments are provided with a hollow box **in order to amplify the sound made by the vibrations of the strings of the instrument.**

Factors affecting the frequency of a vibrating string

- **Length of wire, L**
- **Tension of the wire, T**
- **Mass per unit length, μ (diameter and density)**

Length (L) of stretched string (Wire)

- When the length of the string is changed, it will vibrate with a different frequency. The shorter strings have higher frequency and therefore higher pitch
- Example when a musician presses her finger on a string, she shortens its length .The more fingers she adds to the string ,the shorter she makes it and the higher the pitch will be
- Therefore: **The frequency of a stretched string is inversely proportional to its length (f ∝ $\frac{1}{L}$ …………..(i))**

  If $f \propto \frac{1}{l}$ $\rightarrow$ **then** $f = \frac{k}{l}$ $\rightarrow$ $fl = constant$

$$\therefore \; f_1 l_1 = f_2 l_2 \quad or \quad \frac{f_1}{f_2} = \frac{l_2}{l_1}$$

Tension (T) of the stretched string

- Tension refers to how tightly the string is stretched
- Tightening the string gives it a higher frequency while loosening it lowers the frequency
- Example when string players tighten or loosen their strings , they are altering the pitches (frequencies) to make them in tune
- Therefore**: The frequency of a vibrating string is directly proportional to the square root of the tension T (f ∝ $\sqrt{T}$………….. ii)**

  If $f \propto \sqrt{T}$ $\rightarrow$ **then** $f = k\sqrt{T}$ $\rightarrow$ $\frac{f}{\sqrt{T}} = constant$

$$\therefore \; \frac{f_1}{\sqrt{T_1}} = \frac{f_2}{\sqrt{T_2}} \quad OR \quad \frac{f_1}{f_2} = \sqrt{\frac{T_1}{T_2}}$$

Mass per Unit Length (μ) of a vibrating string

- This includes the thickness (diameter) and heaviness (density) of a sting
- Thus the thicker and heavier a string is, the lower is its frequency for a given length and tension and vice versa
- Example a thin string with a 10 mm diameter will have a frequency twice as high as one with a larger, 20 mm diameter
- Also the instruments often have strings made of different materials. The strings used for low pitches will be made of a more dense material than the strings used for high pitches
- Therefore: The frequency is inversely proportional to the square root of the mass per unit length, μ $\left(f \propto \sqrt{\frac{1}{\mu}} \ldots\ldots\ldots\ldots\ldots iii\right)$

If $f \propto \sqrt{\frac{1}{\mu}} \quad \rightarrow then \quad f\sqrt{\mu} = k \quad \rightarrow \quad f\sqrt{\mu} = constant$

$$\therefore \; f_1\sqrt{\mu_1} = f_2\sqrt{\mu_2} \quad or \quad \frac{f_1}{f_2} = \sqrt{\frac{\mu_2}{\mu_1}}$$

- **Also for a diameter and density** $\left(f \propto \frac{1}{D} \;\; and \;\; f \propto \sqrt{\frac{1}{\rho}}\right)$

Now combine the three equations

$f \propto \frac{1}{L}\sqrt{\frac{T}{\mu}}$ …………….. Remove proportionality constant

$$f = k\frac{1}{L}\sqrt{\frac{T}{\mu}}$$

Where: k = 1/2, (experimentally) **Then**: $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$

$$\therefore f = \frac{1}{2l}\sqrt{\frac{T}{\mu}} = \frac{1}{2l}\sqrt{\frac{Tl}{m}}$$

(fundamental frequency/first harmonic)

Since $\mu = \frac{m}{l}$ **(mass per unit length)**

From: $V = \lambda f \quad \rightarrow v = 2l\left(\frac{1}{2l}\sqrt{\frac{T}{\mu}}\right) = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{TL}{m}}$

Since $l = \frac{\lambda}{2} \quad \rightarrow \lambda = 2l$ (for fundamental frequency)

$$\therefore Velocity\ of\ sound\ , v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{TL}{m}}$$

Therefore for the n^th^ harmonic is given by

$$\boldsymbol{f_n = \frac{n}{2L}\sqrt{\frac{TL}{m}} = n\left(\frac{1}{2l}\sqrt{\frac{TL}{m}}\right)}$$

(*Whereby* $\boldsymbol{f_n}$ = frequency of n^{th} harmonic, n = 1,2,3,4 etc)

Example

1. The vibrating length of a stretched wire is altered at constant tension until the wire oscillates in unison with a turning fork of frequency 320 Hz. The length of the wire is again altered until it oscillates in unison with a fork of unknown frequency. If the two lengths are 90 cm and 6o cm, respectively , determine the unknown frequency

   Solution

   Given that: f_1 = 320 Hz, L_1 = 90 cm, L_2 = 60 cm, f_2 =?

   From: $\boldsymbol{f \propto \frac{1}{l}} \quad \rightarrow \boldsymbol{\frac{f_1}{f_2} = \frac{l_2}{l_1}}$

   $$\therefore \boldsymbol{f_2 = \frac{l_1 f_1}{l_2} = \frac{320\times 90}{60} = 480\ Hz}$$

Class Activity – 1:3

Use acceleration due to gravity, g = 10 m/s^2

1. A string has a length of 75cm and a mass of 8.2g, the tension in the string is 18N.Calculate the 1st harmonic and 3rd harmonic **(ANS: f_1 = 27Hz, f_3 = 81Hz)**
2. A string of length 1 m and mass 5 x 10^{-4} kg fixed at both ends is under a tension of 20 N. It is plucked at a point situated 25 cm from one end. What would be the frequency of vibrations of the string? **(ANS: f = 200 Hz)**
3. A wire of length 140 cm and mass 0.**52** x 10^{-3} kg is stretched by means of a load of 16 kg. Calculate the frequency of the fundamental note.**(ANS: f = 234 Hz)**
4. The vibration length of a stretched wire is altered at constant tension until the wire oscillates in unison with a turning fork of frequency 320 Hz. The length of a wire is again altered until it oscillates in unison with a fork of unknown frequency. If the two lengths are 90 cm and 65.5 cm, respectively, determine the unknown frequency (**ANS: $\boldsymbol{f2}$ = 440 Hz)**
5. **The** length of a sonometer wire between two fixed ends is 110 cm. Where should the two bridges be placed so as to divide the wire into three segments whose fundamental frequencies are in the ratio 1:2:3?

   (from: $\boldsymbol{f \propto \frac{1}{l}}$, $f_1L_1 = f_2L_2 = f_3L_3$, Thus L_1=60 cm,L_2 =30 cm and L_3 = 20 cm)

6. A 90 cm long wire of a sitar has a fundamental frequency of 256Hz. At what distance from the upper end should the wire be compressed so that a note of frequency 384 Hz is produced? **(ANS: L = 30 cm)**
7. A nylon string is stretched between supports 1.2 m apart. Given that the speed of sound in the string is 800 ms^{-1},find the frequency of the fundamental vibration and the first two overtones **(ANS: f_0 =333 Hz, f_1 = 666 Hz and f_3 = 1000 Hz)**
8. A Sonometer wire of length 40cm between two bridges produces a note of 512Hz when plucked at the midpoint. Calculate the length of the wire that would produce a note of 256Hz with the same tension (**ANS: L2 = 0.8m)**
9. A sonometer wire of length 40 cm between two bridges produces a note of 512 Hz when plucked at the mid point .Calculate the length of the wire that would produce a note of 256 Hz with the same tension
10. The frequency obtained in a plucked string is 500Hz when the tension is 3 N .calculate
    (i)The frequency when the tension is increased to 10 N (**ANS: 912.8 Hz)**
    (ii)The tension needed to produce a note of frequency 800 Hz (**ANS: T =7.7 N)**
11. A plucked string of length 30 cm has a mass per unit length of 0.5 kg/m .If the tension in the string is equal to 40 N ,Find :
    (a)The fundamental frequency (**ANS: f_0 = 14.9 Hz)**
    (b)The first overtone frequency (**ANS: f_1 = 29.8Hz)**
    (c)The second overtone frequency (**ANS: f_2 = 44.7 Hz)**
12. A plucked wire of 10 m long and radius of 7mm has a density of 500 kg/m^3. Calculate
    (i) The fundamental frequency **(ANS: f_0 = 0.5 Hz)**
    (ii) The first overtone frequency (**ANS: f_1 = 1.0 Hz)** needed to produce a tension of 8 N
13. A string has a length of 75cm and a mass 0f 8.2g. The tension in the string is 18N. Calculate the velocity of the sound wave in the string. (**ANS: V = 40.5m/s.)**
14. Given that the velocity of the sound wave emitted from a string is 50m/s the Length of the string is 40cm and the mass of the string is 0.0004kg calculate the tension of the string. (**ANS: T = 2.5N)**
15. A sonometer wire of length 50cm vibrate with frequency 384Hz. Calculate the length of the sonometer wire so that it vibrates with frequency of 512Hz.**(37.5 m)**
16. A sonometer wire of length 40cm between two bridges produces a note of frequency 512Hz when plucked at midpoint. Calculate the length of the wire that would produce a note of frequency 256Hz with the some tension.**(L = 80cm)**
17. The frequency obtained from a plucked string is 400Hz when the tension is 2 Newton. Calculate;
    a) The frequency when the tension is increased to 8N (**ANS: f= 800Hz)**
    b) The tension needs to produce a note of frequency 600Hz (**ANS: T = 4.5N)**
18. Given that the frequency obtained from a plucked string is 800Hz when the tension is 8N. Calculate;
    (a) The frequency when the tension is doubled **(ANS: f = 1131. 2 Hz)**
    b) The tension required when the frequency is halved **(T = 1.414 N)**

19. Under constant tension the note produced by a plucked string is 300Hz when the length is 0.9m;

a) At what length is the frequency 200Hz? **(ANS: L_2 = 1.35m)**

b) What frequency is produce at 0.3m (**ANS: f = 90Hz)**

20. A string fixed between two supports that are 60cm a part. The speed of a transverse wave in a string is 420m /s. Calculate the wavelength and the frequency for Fundamental note, Second overtone and Fifth overtone (**ANS: fo = 350 λ = 1.2 m, f_3 = 1050 λ = 0.4 m , f_5 = 2100 λ = 0.2m)**

21. A string is fixed two ends 50cm a part. The velocity of a wave in a string is 600m/s. Calculate;

(a) The first five over tone (**ANS: 1200Hz, 1800Hz, 2400Hz, 3000Hz, and 3600Hz).**

(b) The tenth overtones **(The tenth overtone is 6600Hz)**

NOTE: In stationary wave a string does note compose up to ten overtones, though mathematically is possible. In real practical of the sonometer by using turning, is possible for the second and third overtone.

22. Given that the refractive index of glass is 1.52. The wavelength of the radio waves in vacuum is 1.5 x 10^3m .Calculate the wavelength of the radio waves in glass.(**λ =986.8 m)**

23. A guitar wire fixed between two supports 60cm a part produced wave of frequency 500Hz. Calculate;

(a)The frequency of a wave when the length of the guitar wire is reduced to quarter

(b)The length of the guitar wire when the frequency of the wave produced is 2000Hz **(ANS: f = 2000Hz ,L = 150m)**

24. A string A is 2m long and has a linear mass density of 9 g/cm^3. String B has has a linear mass density of 18g/cm^3 .If the tension in both strings is the same ,how long must string B be for it to be raised to hear the next peak in intensity

25. What is the approximate distance of a thunderstorm when you note a 3 s delay between the flash of lighting and the sound of thunder? (**d** $\approx \mathbf{1000\ m} \approx \mathbf{1\ km}$**)**

26. How long does it take for a radio signal sent from the earth to reach the moon? The distance from the earth to the moon is 3.84 x 10^6 m

27. During a storm ,thunder is heard 7 s after the lightning is seen .If the temperature of the air is 28 ^{0}C ,how far away is the storm (C = 3 x 10^8 m/s)

28. In a resonance tube experiment ,the smallest value of L for which a peak in sound intensity occurs is 9.0 cm .How much must the tube be raised to hear the next peak in intensity

29. A helicopter is hovering at an altitude of 200 m above the surface of a lake. A speaker on the helicopter is sending out sound waves ,which are reflected from both the surface of the water and the bottom of the lake .If the difference in arrival times of the two echoes is measured to be 0.24 s, what is the depth of the lake ?(The atmospheric temperature is 20 ^{0} C) **(ANS: h** $\approx \mathbf{700\ m}$)

30. Matter expands when heated and contracts when cooled .Explain why a musician must re – tune a stringed instrument if its temperature changes

31. Explain why it is not advisable for soldiers to march across a bridge in rhythm.

32. Guitars have strings of varying thickness .Which of the strings (thickest or thinnest) produces the highest frequency of musical notes? Explain your answer .
33. A loud sound is made and the echo from a distant cliff is heard 8 s later .If the atmospheric temperature is 22^0 C, how far away is the cliff?

Forced Vibration and Resonance

Forced Vibration

- Is the vibration in a system as a result of impulse received from another system vibrating nearby

OR

- Is type of vibration in which a force is repeatedly applied to a mechanical system

RESONANCE

- **Is the tendency of a system to oscillate at maximum amplitude at certain frequencies from another system.**

OR

- Is a phenomenon that occurs when the frequency at which a force is periodically applied is equal or near equal to one of the natural frequencies of the system on which it acts

OR

- Is a large increase in amplitude of vibration in a body when it interacts with another vibrating body

OR

- Is the phenomena where by the response of the system that is set into forced vibration when the driving frequency is equal to the natural frequency of the responding system.

NB:

A resonance is said to occur when a body or system is set into vibration or oscillation at its own natural frequency as a result of impulses received from another system which is vibrating at the same frequency.

OR

A Resonance is said to occur when the amplitude of an object's oscillations are increased by the matching vibrations of another object

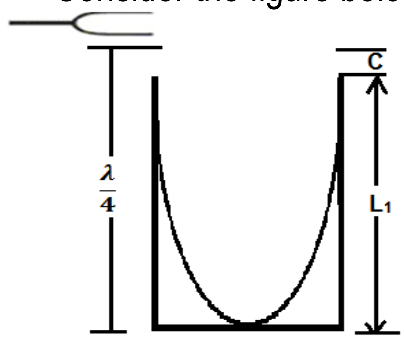
Example of Resonance

1. A group of troupes was marching towards the bridge the bridge collapsed even before it is approached.
2. **If a very loud sound is produced near the mouth of the glass bottle, the glass is likely to break.**
3. The buildings are likely to collapse following the occurrences of the earth quake
4. **Applied when turning the knob of a radio**. This occurs when changing the natural frequency of the receiver, it matches the transmission frequency of the radio station. When the two frequencies match ,energy transfer occurs and we listen to the selected channel

Resonance in a Closed Pipe

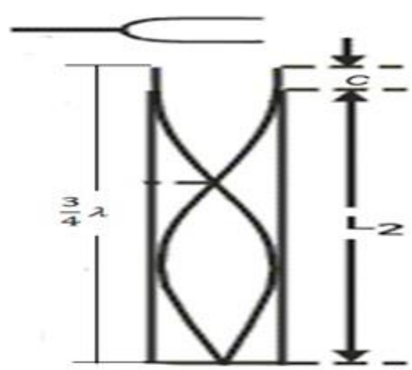
- When a turning fork is sounded at the top of a tube with one end open and the other closed, the air in the tube vibrate freely (resonates) at a certain length of a tube. The resonance is observed as a loud sound produced in the tube when the proper length obtained

Consider the figure below



Fundamental frequency (First harmonic)

- Considering the end correction, $l_1 + c = \frac{\lambda}{4}$ .... **(i)**
- For second harmonic or first overtone is produced when the length is increased to l_2



First overtone (Second harmonic)

- **Con**sidering the end correction, then $l_2 + c = \frac{3\lambda}{4}$ .... **(ii)**

Now, consider the two equations

$$l_1 + c = \frac{\lambda}{4} \quad \rightarrow c = \frac{\lambda}{4} - l_1 \quad \text{................ (iii)}$$

$$l_2 + c = \frac{3\lambda}{4} \quad \rightarrow c = \frac{3\lambda}{4} - l_2 \quad \text{................ (iv)}$$

Compare the two equations ((iii) and (iv))

$$\frac{\lambda}{4} - l_1 = \frac{3\lambda}{4} - l_2 \quad \rightarrow l_2 - l_1 = \frac{3\lambda}{4} - \frac{\lambda}{4} \quad \rightarrow l_2 - l_1 = \frac{\lambda}{2}$$

$$\therefore waveleth, \lambda = 2\,(l_2 - l_1)$$

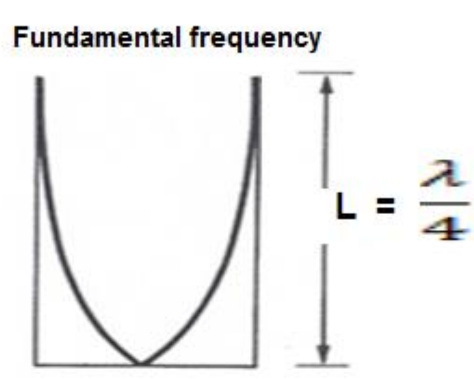
$$\therefore V = \lambda f = 2\,(l_2 - l_1)f$$

Whereby: **V** is the speed of sound in air column and f is frequency of sound in air

Class Assignment – 2:3

1. A turning fork of frequency 512 Hz is sounded at the mouth of a tube closed at one end with a movable piston. It is found that resonance occurs when the column of air is 18cm long and again when the column is 51cm long. Find wave length and velocity of sound in air **(ANS: λ = 0.66m and V_A = 338m/s)**
2. In a closed pipe, the first resonance is at 23cm and second at 73cm. determines the wave length of the sound and the end correction of pipe **(ANS: c = 0.002 m, $\lambda = 1.0$ m)**
3. A resonance tube produces a loud sound for the first time when the length of the air column is 17 cm and a loud sound at the second time when the length of the air column is 51 cm .The turning fork frequency used is 500 Hz .Determine the speed of the air in the tube (**ANS: V = 340 m/s)**
4. The first resonance in the tube of resonance occurs when the length of the air column is 20 cm. What are the lengths of air column in the second resonance and third resonance respectively **(ANS: 60 cm and 100 cm respectively)**
5. **(a)** Identify three characteristics of sound which distinguish one note from another. Hence state the physical factors which correspondingly define the mentioned characteristics
   (b) A resonance tube whose one end is closed and other open, resonance to a note of frequency 560Hz when the length of the air column is 15cm. determine the wave length of this sound in air. What is the shortest length of the air column which resonates in similar conditions to a note of frequency 1000 Hz (ANS: a. frequency, Loudness (amplitude) and Quality of music note (Timbre) .b **L_2 = 0.0504m**)
6. A turning fork of frequency 250Hz is used to produce resonance in an opened pipe. Given that the velocity of sound in air is 350m/s. find the length of tube which gives
   (a) First resonance (b) Third resonance (**ANS: L = 1.4m)**
7. The length of a closed pipe is 160mm. calculate the wavelength and the frequency of (i) The first overtone (ii) The third harmonic **(λ = 0.213, $f_2 \approx 1500$,Hz, f_3 = 2500Hz)**
8. A pipe closed at one end has a length of 100 cm. If the velocity of sound in air of the pipe is 340m/s. Calculate the frequency of;
   (a) The fundamental **(f_0 = 85 Hz)** (b) The first overtone **(f_1 = 255 Hz)**

Resonance in a closed Pipe (without end correction, c)

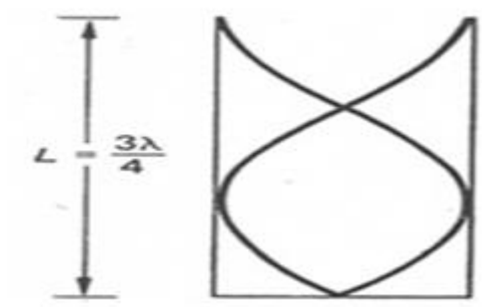


- From: $v = \lambda f \quad \rightarrow f = \frac{v}{\lambda}$

  But $l = \frac{\lambda}{4} \quad \rightarrow \lambda = 4l$

$$\therefore \boldsymbol{fundamental\ frequency}, \ \boldsymbol{f_0 = \frac{v}{4l}}$$

For the 1st overtone (2nd harmonic)



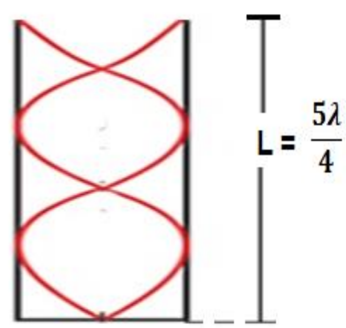
- From: $v = \lambda f \quad \rightarrow f = \frac{v}{\lambda}$

  But $l = \frac{3\lambda}{4} \quad \rightarrow \lambda = \frac{4l}{3}$

$$\boldsymbol{f_1 = \frac{\frac{v}{4l}}{3} = \frac{3v}{4l} = 3 \times \frac{v}{4l} \quad , but\ f_0 = \frac{v}{4l}}$$

$$\therefore \boldsymbol{the\ first\ overtone, f_1 = 3f_0}$$

For the 2nd overtone (3rd harmonic)



- From: $\boldsymbol{v = \lambda f} \quad \rightarrow \boldsymbol{f = \frac{v}{\lambda}}$

  But $\boldsymbol{l = \frac{5\lambda}{4}} \quad \rightarrow \boldsymbol{\lambda = \frac{4l}{5}}$

$$\boldsymbol{f_2 = \frac{\frac{v}{4l}}{5} = \frac{5v}{4l} = 5 \times \frac{v}{4l} \quad , but\ f_0 = \frac{v}{4l}}$$

$\therefore$ *the second overtone*, $f_2 = 5f_0$

Generally the n^{th} *overtone in a closed pipe is given by* ;

$$f_n = (2n+1)f_0 \ldots\ldots\ldots\ldots\ldots \text{where } n = 1,2,3,4 \text{ etc}$$

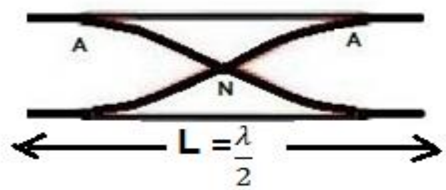
Since the resonance tube (closed at one end) produces odd harmonics then the equation of the length of tube **(length of air column**) is given by

$$L = \frac{n\lambda}{4} \qquad \rightarrow n = 1, 3, 5, 7 \ldots..$$

Resonance in Opened Pipe

Consider the diagram below

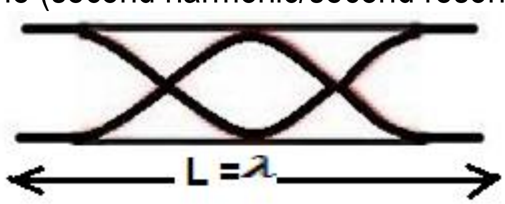
Fundamental note (First resonance)



- From: $v = \lambda f \qquad \rightarrow f = \frac{v}{\lambda}$, **But** $l = \frac{\lambda}{2} \qquad \rightarrow \lambda = 2l$

$\therefore$ *Fundamental frequency*, $f_0 = \frac{v}{2l}$

For the first overtone (second harmonic/second resonance)



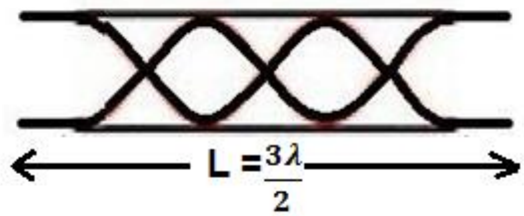
From: $v = \lambda f \qquad \rightarrow f = \frac{v}{\lambda}$

But $\quad l = \lambda$

$$f_1 = \frac{V}{\lambda} = \frac{V}{L} = \frac{2}{2} \times \frac{v}{l} = 2 \times \frac{v}{2l} = 2f_0, \ \text{since } f_0 = \frac{v}{2l}$$

$\therefore$ *First overtone*, $f_1 = 2f_0$

For the 2nd overtone (**T**hird harmonic/third resonance)



- From: $v = \lambda f \quad \rightarrow f = \frac{v}{\lambda}$

  But $\quad l = \frac{3\lambda}{2} \quad \rightarrow \lambda = \frac{2l}{3}$

  $then,\ f_2 = \frac{v}{\frac{2l}{3}} = 3 \times \frac{v}{2l}$

$\therefore$ *the Second overtone*, $f_2 = 3f_0,\ since\ f_0 = \frac{v}{2l}$

Generally the n^{th} *overtone of an open pipe is expressed as* $f_n = (n+1)f_0$

Whereby (n = 1,2,3,4…………)

- Since the resonance tube(opened at both ends) produces integral multiples of harmonics, then the equation of the length of tube (length of air column) at n^{th} **harmonic** is given by

$$L = \frac{n\lambda}{2} \quad \rightarrow n = 1, 2, 3, 4, \dots..$$

Example

1. A turning fork of frequency 256 Hz is sounded at the mouth of a tube closed at one end with a movable. It is found that resonance occurs when the column of air is 15 cm long and again when the column is 80 cm long. Determine the velocity of sound in air.
   Soln:
   Given: L_1 = 15 cm, L_2 = 80 cm, f = 256Hz, V = ?
   From: $V = \lambda f = 2\,(l_2 - l_1)f$

$\therefore V = \lambda f = 2\,(l_2 - l_1)f = 256\,x2(0.80 - 0.15) = 512\,x\,0.65 = 332.8\,m/s$

Class Activity – 1:4

1. The speed of sound waves in air is found to be 340m/s. Find;
   (a) The fundamental frequency (b) The frequency of the 3rd harmonic
   (c) The frequency of 9th harmonic (d) The frequency of 51st harmonic
   Given that the sound waves are probating in a closed pipe of length 700m.
   ANS: f_0 = 121.5Hz, f_3 = 850.5 Hz, f_9 = 2308.5 Hz, f_{51} = 12514.5 Hz

2. **In** a closed pipe, the first resonance is at 23 cm and second at 73 cm. Determine the wavelength of the sound and the end correction of the pipe. **(ANS:** $\lambda = 1\ m, c = 2\ cm$)
3. A pipe closed at one end has a length of 10cm. If the velocity of sound in the air of the pipe is 340m/s. Calculate the frequency of;
   (a) The fundamental (b) 1st overtone (**ANS:** f_0 **= 850 Hz,** f_1 **= 2550 Hz)**
4. A pipe closed at one and has a length of 2.46m. Find the frequency of the fundamental and the first two overtones. Take 343m/s as the speed of sound in air. (**ANS:** f_0 **= 34.85Hz, f1 = 104.55 Hz, f2 =174.25 Hz)**
5. When a tuning fork of 512Hz is sounded at the top of the measuring cylinder which contains water. The first resonances are observed when the length of the air column (the distance from the mouth to the level of the water is 50 cm) and the second resonance is observed when the length of the air column (the distance from the mouth to the level of water) is 80 cm; using these observations. Calculate the velocity of water in air.(**ANS: v = 307 .2m/s)**

Beats

- A beat is a rise or fall in loudness of sound when two sources of sound of nearly equal frequencies produce sound together.
- The Beat frequency (number of beats):
- Is the difference between the two frequencies of sound

That is $B_f = f_1 - f_2$ **or** $f_2 - f_1$

Example

1. A 256Hz turning fork produces sound at the same time with a 249Hz turning fork. What is the beat frequency? **(ANS: Bf = 7Hz)**
2. What is the beat frequency when a 262 Hz and 266 Hz turning forks are sounded together? (ANS: B_F = 4 Hz)

Electromagnetic Waves

- Are a self – propagating transverse wave of oscillating electric and magnetic fields
- **OR: Are the waves which are propagated through space or matter by the vibration of an electric field and magnetic field at right angles to one another**
- Self propagating means a change in electric field produces a change in magnetic field and vice versa
- Examples are **Radio waves ,Microwaves, Infrared radiation, Visible light , Ultraviolet rays , X–rays, Gamma rays**

NB:

- It is produced when electrically charged particles oscillate or change energy
- The greater the energy change, the higher the frequency of the resulting wave
- Electric field and magnetic field of an electromagnetic wave are perpendicular to each other

Properties of Electromagnetic Waves

- They do not require material medium to travel through
- They undergoes reflection, refraction, interference and diffraction
- They travel at the speed of light (**i.e $C = 3 \times 10^8$ m/s in vacuum**)
- They carry no electric charge
- They transfer energy in form of oscillating electric and magnetic fields
- They obey the wave equation, **$C = f\lambda$**

Electromagnetic Spectrum

- **Is** a continuous band of all electromagnetic waves arranged in order of increasing or decreasing frequencies or wavelength change.
- It is divided into seven regions or bands

Tables of Electromagnetic Spectrum

Wavelength (m)	Region (band)	Frequency (Hz)
$>10^{-1}$	Radio waves	$>3 \times 10^9$
$10^{-1} – 10^{-4}$	Micro waves	3×10^9 - 3×10^{12}
$10^{-4} – 10^{-7}$	Infrared	3×10^{12} - 4.3×10^{14}
$7 \times 10^{-7} – 4 \times 10^{-7}$	Visible light	4.3×10^{14} - 7.5×10^{14}
$4 \times 10^{-7} – 10^{-9}$	Ultraviolet light	7.5×10^{14} - 3×10^{17}
$10^{-9} – 10^{-11}$	X-rays	3×10^{17} - 3×10^{19}
$<10^{-11}$	Gamma rays	$>3 \times 10^{19}$

Electromagnetic Spectrum Observation

- ✓ **It is continuous**: means each band merges into next and there is no gap between their frequencies
- ✓ **Some Wave length overlap**: in some cases there is an overlap of wave length so we have to name according to source not to the wave length, for Example, **X-rays** and **Gamma rays**

Sources, Detectors, and uses of EMW

Radiation	Source	Detector	Uses
Gamma rays	• Radioactive substance	• Photographic plate • Geiger muller tube	• in medicine to locate internal body organs • sterilize surgical equipment • To detect flaws in metals
X –rays	• x –rays tubes	• fluorescent screens • photographic film	• Detect fractured bones and dislocations • Treatment of cancer • Study of crystal structure
Ultra violet	• the sun • sparks	• photographic films • photocells	• Detect forgeries e.g bank notes

	• mercury vapor lamp	• paper smeared with vaseline	• Source of vitamin D • To kill bacteria in water
Visible light	• The sun • Luminous objects	• The eye • Photocells • Photographic films	• Ordinary photography • Enables the eye to see • Photosynthesis
Infra red	• The sun • Fires • Hot bodies	• Thermometer with blackened bulbs • Thermopile • Bolometer	• Infrared photography • Drying substances • locate overheating in electric system • Used in remote control, night vision device, fibre-optic telecommunication and security system • Are used for welding plastics, drying prints, etc
Microwaves	• Magnetrons in microwave oven	• Solid state diodes	• For cooking in microwaves ovens • Satellite communication • **Radar** communication
Radio waves	• Oscillating electric circuits • Objects in space e.g planets,stars etc	• Aerials • Diodes • Earphones in electric circuits	• Used for broadcasting of information by radio and television channels • Used by astronomers to collect and study radio waves from distant stars and galaxies.

N.B: RADAR = Radio **D**etection **A**nd **R**anging

Example

1. What is the wavelength of radio waves of frequency 95.6MHz**?(c = 3.0 x 10^8 m/s)**

Soln:

From: $v(c) = f\lambda$

$$\therefore \lambda = \frac{v}{f} = \frac{3\ x\ 10^8}{95.6\ x10^6} = 3.14\ m$$

Class Assignment – 1

1. (a) Explain why radio waves are similar to light waves but not sound waves
   (b) A radio station transmits a signal of wave 1500m. Calculate the frequency of this signal (**ANS: f = 200 KHz)**
2. Light of frequency 4.6 × 10^{14}Hz travels at a speed of 1.24 × 10^8ms^{-1} in diamond. Calculate the refractive index of diamond for this color of light. (**ANS: μ = 2.42)**
3. (a) What is diffraction of wave?
   (b) Illustrate how plane water wave fronts are diffracted on passing through a narrow gap

(c)(i) Is it possible for light to be diffracted on passing through an open window?
(ii) Give an explanation on your answer above

4. (a) What is the fundamental frequency of a vibrating string?
(b) Sonometer consists of a taut steel wire fixed between two bridges 100cm apart. Defining the first harmonic, second harmonic, third harmonic and fourth harmonic, explain how overtones can be obtained

5. How an echo differs from the reverberation?

- **ANS:** Echo occurs when long distances are considered **WHILE** reverberation is when short distances are considered.
- Echo is due to the reflection of sound wave by obstacles or end points like wall etc. **BUT** Reverberation is due to the collection of reflection sounds from the surface which is enclosed completely

6. Sound travelling towards a cliff 700m away takes 4.2 seconds for an echo to be heard. Calculate the velocity of sound in air. **(ANS: V_a = 333.33m/s)**

7. A boy standing 100m from the foot of a high wall claps his hands and the echo reaches him 0.5 second later. Calculate the velocity of sound in air using this observation. **(ANS: V in air is 400m/s)**

8. A student standing between two vertical walls and 480m from the nearest wall, shouted. She heard the first echo after 3 seconds and the second after two second later use this information to calculate;
(i) Velocity of sound in air **(V_a =320m/s)** (ii) Distance between the two walls.**(d =1280 m)**

9. An old woman sitting in a gorge between two large cliffs gives a short sharp sound. She hears two echo, the first after 1 second and the next after 1.5sec. The speed of sound is 340m/s what is the distance between the two cliffs? **(ANS: d=425 m)**

10. A sonar signal (a high frequency sound wave) sent vertically downwards from the ship is refracted from the ocean floor and detected by a microphone on the keel. 0.4 sec after transmission. If the speed of sound in water is 1550m/s. What is the depth of the ocean in meters? **(ANS: The depth of the ocean is 300m)**

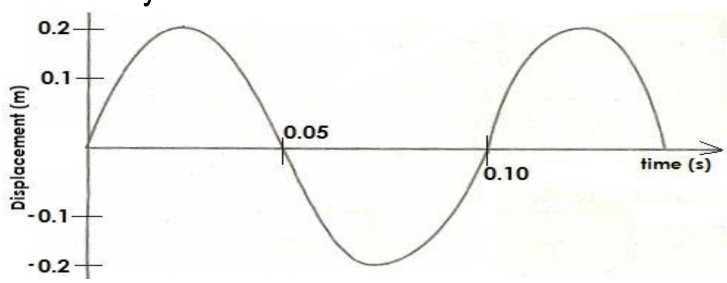
11. A man sees steam coming out from a factory whistle and 3 seconds later he hears the sound. The velocity of sound in air is 360m/s. Calculate the distance from the man to the factory. **ANS: d = 1080m**

12. (a) (i) Distinguish between longitudinal wave and transverse wave
(ii) Explain how beats are formed
(b) A light wave is refracted into an optically dense medium. What change will occurs in
(i) The frequency?
(ii) The speed?
(iii) The wavelength?
(c) (i) what is an echo
(ii) A sound is sent out from the ship and its reflection from the ocean floor returns one second later. Assuming that the velocity of sound in water is 1500m/s. how deep is the ocean? **(ANS: d= 750m)**

13. (a) (i) What is a sonometer?
(ii) Briefly explain when resonance is said to occur.

(b) Two boys are stand 200m apart on one side of a high vertical cliff at the same perpendicular distance from it. When one fires a gun, the other hears the sound 0.65 seconds after the flash and the second sound 0.25 second after the first sound. Calculate the perpendicular distance of the boys from the cliff

(c) A diagram below illustrates part of the displacement-time graph of a wave travel with velocity of 2m/s.



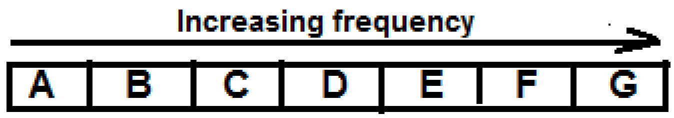
Calculate.

(i). The amplitude (ii). Frequency (iii). Wave length

(b) **ANS: d = 84.27m** (c) (i). **A = 0.2m** (ii) **f = 10Hz** (iii). **λ = 0.2m**

14. Which of the following has the shortest wavelength?
    (i) Radio waves (ii) X – rays (iii) Red light
15. A column of air 26.25 cm long in a closed tube resonates to a sounding tuning fork. If the velocity of sound in air is 33 600 cm/s, what is the frequency of the fork? (**ANS: f = 320 Hz)**
16. If the shortest length of the tube for resonance is 0.12 m and the next resonant length is 0.37 m, what is the frequency of vibrations? Take the speed of sound in air as 340 m/s. (**ANS: f = 680 Hz)**
17. Explain the following
    (a) Strings of different thickness are used on a stringed instrument such as a violin or a guitar
    (b) The same note played on a violin and a flute sound different
    (c) The strings of a stringed instrument are usually mounted on a hollow box of special shape
    (d) Matter expands when heated and contracts when cooled. Explain why a musician must retune a stringed instrument if its temperature changes
    (e) How does the size of the gap in the barrier affect the diffraction of waves?
18. The commercial program of Radio Annur is broadcast on wavelengths of 1500 m and 250 m. The frequency of the 1500 m wave is 200 kHz what is the frequency of 250 m wave?
19. Explain briefly how the concept of wave is applied in each of the following fields
    (i) Medicine (ii) Communication (iii) Scientific research
20. A light wave is refracted into an optical less dense medium. What change will occur in (i)The frequency (ii) The speed (iii)The wavelength
21. A solid is sent out from the ship and its reflection from the floor of the ocean returns half a second later. Assuming that the velocity of sound in water is 1500 m/s, how deep is the ocean?

22. Gamma rays bursters are objects in the universe that emit pulses of gamma rays with high energies. The frequency of the most energetic burst has been measured at around 3.x 10^{21} Hz.
(a) What is the wavelength of these gamma rays? (**ANS: λ =1.0 x 10^{-13} m)**
(b) What could be their period? (**ANS: T = 3.33 x 10^{-22} s)**
23. Differentiate between ultrasonic and infrasonic vibrations
24. An FM radio station broadcasts electromagnetic waves at a frequency of 150 MHz .The radio waves have a wavelength of 2.0 m. Calculate the speed of the radio waves (**ANS: v = 3 x10^8 m/s)**
25. The diagram below shows the electromagnetic spectrum. Region D represents visible light



(a) Which region contains radiation produced in nuclear reactors?
(b) Which region represents radiation capable of promoting the production of vitamin D in the skin?
(c) Which region is contains radiation used in radar system?
26. Explain why a duck remains floating at the same place as wave passes by the water in a lake
27. Two similar sonometer wires of the same material produces 2 beats per second. The length of one is 50 cm and that of the other is 50.1 cm. Calculate the frequencies of the two wires **(From: $f \propto \frac{1}{L}$. f_1 =1002 Hz, f_2 = 1000 Hz)**
28. Explain why it is not advisable for soldiers to march across a bridge in rhythm
29. A note of 100 vibrations per second is reflected back to an observer from a wall 34 meters away in 0.2 seconds. Calculate the speed of sound and the wavelength of tone
30. A note of frequency 100 is sounding. What is the frequency of a note (a) one octave higher (b) two octave higher?
31.

Topic – 2 Electromagnetism

Electromagnetism: Is the effect produced by the interaction of an electric current with a magnetic field

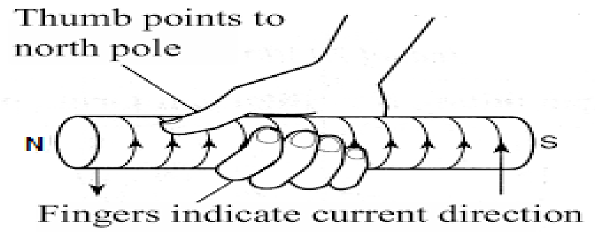
Direction of Current and magnetic field

- Is determined by applying two rules which are:-
  - (a) Right hand grip rule
  - (b) Maxwell's right hand screw rule

Right hand Grip Rule

- **For solenoid, the rule states that**

"When you wrap your right hand around a solenoid with your fingers pointing in the direction of conventional current, your thumb points in the direction of the magnetic north pole"

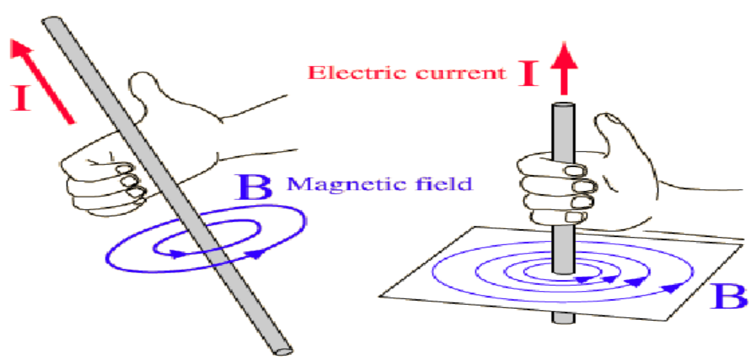


- **For conductor** ,the rule for conduct States that

"*Wrapping right hand around a conductor your fingers point in the direction of magnetic field and the thumb points in the direction of current*"

OR

"Imagine the wire carrying the current is gripped by the right hand with the thumb pointing in the direction of the conventional current (from positive to negative), the fingers will curl around the wire pointing in the direction of the magnetic field"

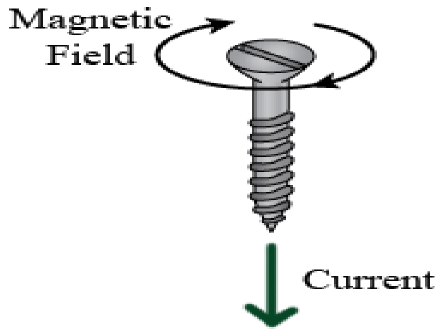


Maxwell's Right Hand Screw Rule

The rule states that:

"If a right-hand screw advances in the direction of the current, then the direction of rotation of the screw represents the direction of the magnetic field due to the current."

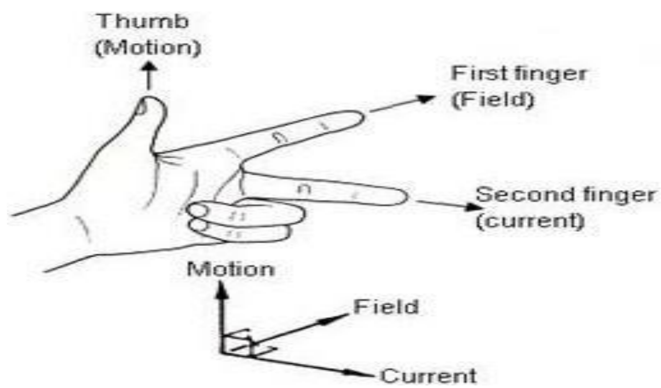
Diagram:



Fleming's Left Hand Rule

It describe the direction of force produced by conductor carrying current, which state that **"If you hold the index finger, the middle finger and the thumb of your left hand mutually perpendicular to each other so that the index finger points in the direction of the magnetic field and the middle finger points in the direction of current in the conductor, then the thumb will point in the direction of the force (motion) acting on the conductor."**

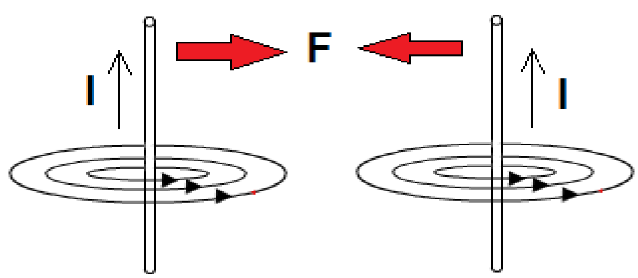
See the fig below:



Force in Parallel Conductors

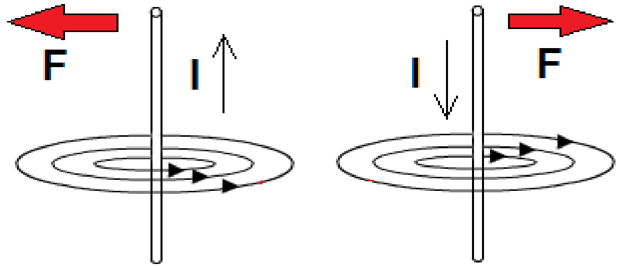
- When the current pass through a two conductors in the same direction the conductors are attracted to each other

Diagram:



- When the current pass through a two conductors in the opposite direction the conductors are repulsed to each other

See the fig below:



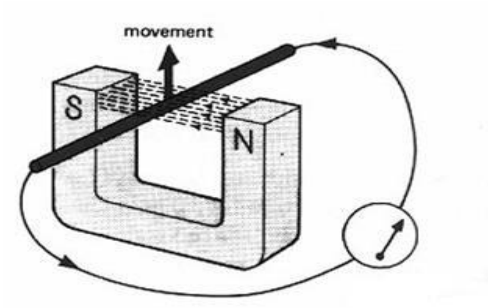
Electromagnetic Induction

- **Electromagnetic induction** is the production of electromotive force whenever there is change in the magnetic flux (**lines**) linking a conductor

OR

- **Electromagnetic induction** is the production of an electromotive force across a conductor when it is exposed to a varying magnetic field

See the fig below:



NB:

- An EMF is only induced in a conductor when there is relative motion between the conductor and the magnetic field
- EMF produced is called **induced electromotive force** and Current produced is called **induced current**
- The conductor should moves in perpendicular to magnetic field
- No current when conductor moves parallel to magnetic field

Laws of Electromagnetic Induction

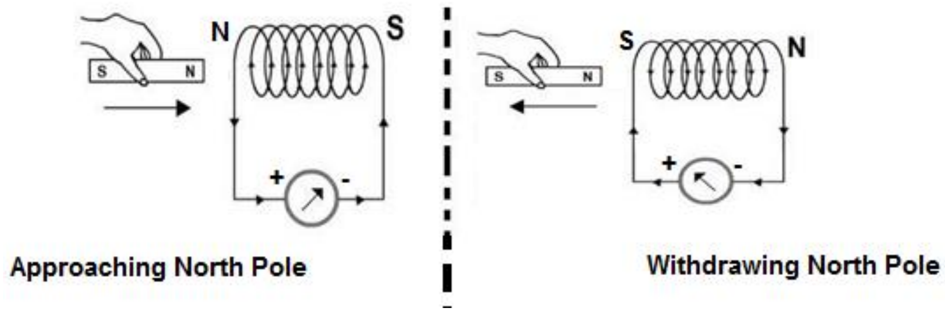
- ❖ Lenz's law
- ❖ Faraday's law

Lenz's Law

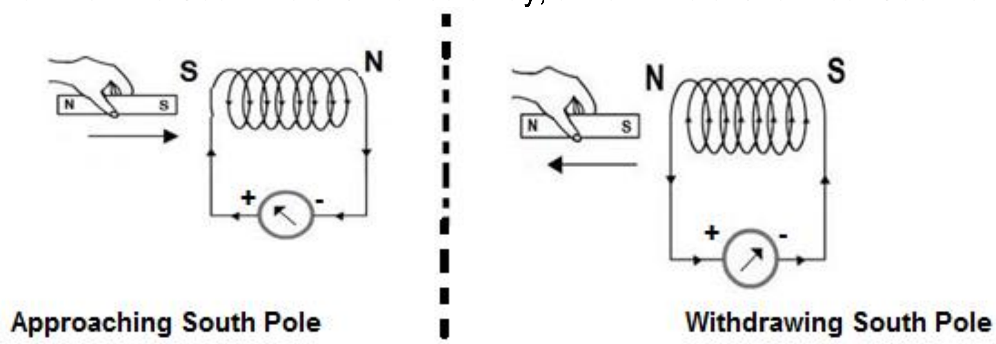
States that: **"the direction of the induced electromotive force is such that it tends to oppose the effect (change) producing it"**

- According to experiment of Lenz's law of electromagnetic induction, the following were observed

(a) When North Pole approaches to the end of the coil, the current in the coil flows such that a North Pole is formed at that end. When the North Pole is moved away, a South Pole is formed. See the fig below



(b) When South Pole is pushed towards the coil, a South Pole is formed at the end of the coil, and when the South Pole is moved away, a North Pole is formed. See the fig below



N.B

- When the N –Pole of a magnet is moving into a coil the magnetic flux **increases**, According to Faraday's law of electromagnetic induction, when there is a change in flux, an EMF and hence induced current is induced in the coil and this current will create its own magnetic field. Now according to Lenz's law ,this magnetic field created will oppose its own increase in through the coil
- When the N –Pole of a magnet is moving out of the coil the magnetic flux **decreases**, which induces an e.m.f in the coil. The resulting induced current must be in the direction to oppose this decrease in flux. The induced (secondary) magnetic field must be in the same direction as the primary field

Faraday's Law

It states that: **"The magnitude of induced electromotive force (EMF) is proportional to the rate of change of the magnetic flux linking the conductor"**

Factors affecting magnitude of Induced E.M.F

- The strength of magnetic field
- The rate of change of magnetic flux (speed)
- Cross section Area of the conductor
- Number of turns (N)

The Strength of magnetic field

- When strong magnet is used, it results strong magnetic field which produce high magnitude of induced e.m.f and vice versa

The rate of change of magnetic flux

- Increasing the speed results of the magnet high rate at which magnetic flux change in which produces high magnitude of induced e.m.f

Cross Section Area of the Conductor

- Increase in cross section area of the conductor results high magnitude of induced e.m.f **(e.m.f α A)**

Number of Turns (N)

- Increasing number of turns results high magnitude of induced e.m.f **(e.m.f α N)**

Self-Induction

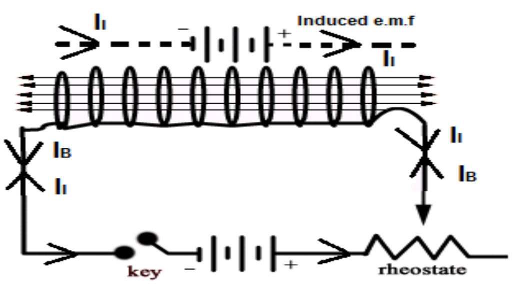
- Is the phenomenon in which a change in electric current in a coil produces an induced e.m.f in the coil itself

OR

- **Is the production of e.m.f in a conductor as a result of varying current in the same conductor/solenoid**

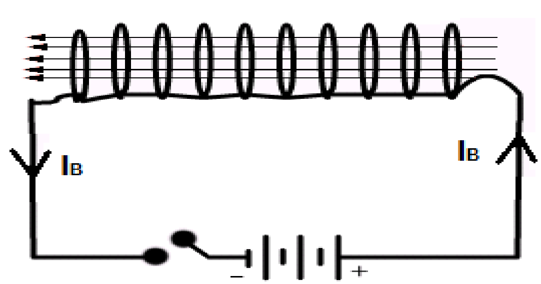
NB:

- If the original current is increasing, then the induced current is smaller than it would be
- If the original current is decreasing, then the induced current adds to it and the measured current is greater than it would be if no self – induced magnetic field was produced in the conductor
- Back e.m.f is the voltage induced in the coil due to variation of electric current flowing in the same coil



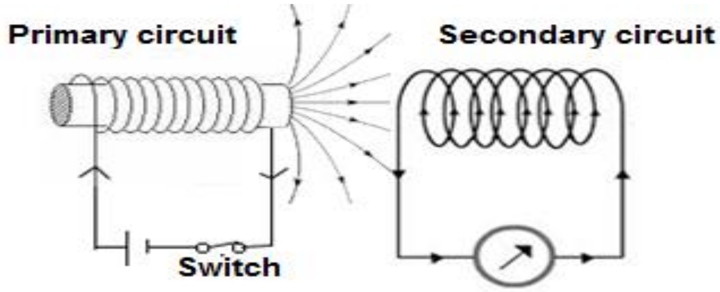
- In constant current no induced current

See the figure below:



Mutual Induction

- Is the production of e.m.f in one conductor or solenoid as a result of changing current in another conductor or solenoid



NB:

- The coil which varies current is **primary coil** while the coil with induced current is **secondary coil**

Mechanism

- Primary coil produces magnetic flux which change magnetic flux in secondary coil to produce electromotive force

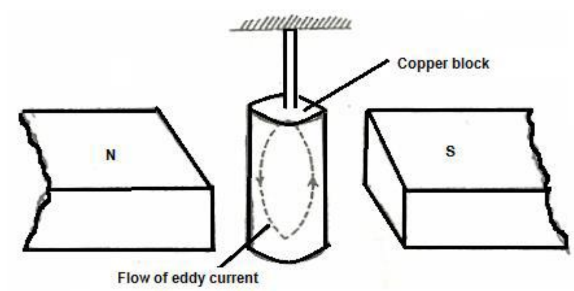
Application of Mutual Induction

- ✓ Is used in transformers
- ✓ Used in the ignition system
- ✓ Used in flash tubes in cameras and strobe light
- ✓ In wireless telegraphy
- ✓ Generators and motors

Eddy Current

- Are induced current loops circulating within a conductor

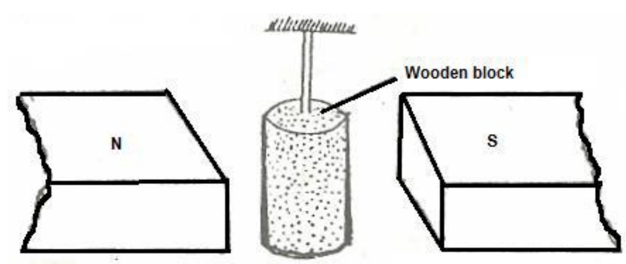
See the figure below:



Damping of Eddy Current

- Eddy current can be minimized by insulator materials which have high resistance in which eddy current cannot make loops circulation within a conductor

Diagram:



Methods used to minimize Eddy Current

Therefore Eddy current can be minimized by the following methods

- **Laminated core**: this is the reason to why all instruments use principle of electromagnetic induction are laminated like motor armature, dynamos armature, transformer coils are wrapped by insulator sheets
- **Magnetic material with high resistivity** e.g. ferrite

Advantages of Eddy Current

- Useful in heating metals
- Useful in electrical damping
- Crack detection
- Measurement of material thickness
- Measurement of coating thickness
- Measurement of conductivity

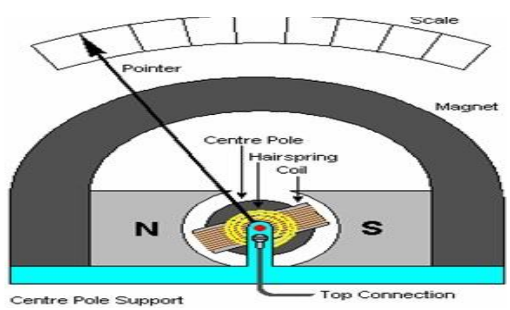
Disadvantages of eddy currents

- Complicate construction of cores of electromagnetic coils
- Causes heating in electrical components appliances
- They cause energy losses as heat e.g in transformers

APPLICATION OF ELECTROMAGNET

(a) **MOVING COIL GALVANOMETERS**

- A galvanometer is an instrument used to detect the presence of an electric current in a circuit.
- A moving coil galvanometer is the galvanometer where by the moving part is the coil.



- **Mode of Action**: The pointer rotates due to the force developed on the coil (**by Fleming's left hand rule**). When the current passes through the coil will be magnetized hence different poles will be formed.

Advantages

- The scale is uniform.

- Moving coil galvanometer is more accurate.
- The sensitivity of moving coil galvanometer is very high.
- A moving coil galvanometer can be converted into an ammeter and voltmeter.

Factors affecting the Sensitivity of the Galvanometer

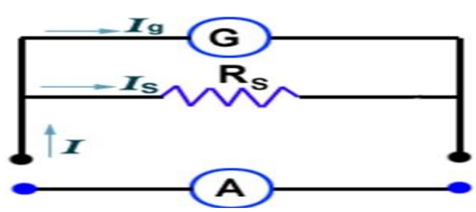
1. **The quantity of the current passing through the coil.** The bigger is the current the higher is the sensitivity and vice verse.
2. **The strength of a magnet**. The stronger the magnet, the higher is the sensitivity.
3. **The number of turns of the coil.** The bigger number of turns in the coil the greater the sensitivity.
4. **Cross sectional areas of the coil.** The bigger is the cross – sectional area of the coil, the higher is the sensitivity.

Conversion of Moving Coil Galvanometer into an Ammeter

- **Ammete**r Is an electrical device used to measure the quantity of an electric current in amperes.

How to convert:

- By replacement of the wires with low resistance.
- By connecting the resistor of low resistance called **SHUNT** parallel to the galvanometer



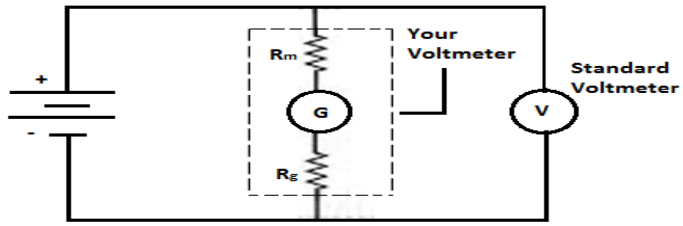
- If **$I = I_S + I_G$**
- Potential difference across the shunt is equal to the Potential difference across the galvanometer V_G., ie **$V_S = V_G$**
- Then: **$V_S = I_SR_S$ and $V_G = I_GR_G$** $\rightarrow$ **$I_SR_S = I_GR_G$** $\rightarrow$ **$R_S = \frac{IgRg}{I_S}$**, (Since: $I_S + I_G = I$)
- $\therefore$ **Shunt, R** is a small resistance which can be connected parallel to the galvanometer to give out ammeter reading ,ie **$R_S = \frac{IgRg}{I-Ig}$**

The Conversion of a Moving Coil Galvanometer into a Voltmeter

- A voltmeter is electronically device used to measure the potential difference.

How to convert:

- By replacement of the wire of high resistance.
- By replacing a resistor of high resistance known as **Multiplier** connected in series with the moving coil galvanometer.



Where: R_m = Resistance of multiplier
R_G = Resistance of the coil of galvanometer
V_m = Potential difference across multiplier
V_G = Across galvanometer
V = Total Potential difference of the full scale deflection

- **For series connection:** $V = V_m + V_G$ (**where I is constant**)
- **Then:** $V_m = IR$, $V_G = IR_G$

Thus: $V = IR_G + IR_m \rightarrow V = I(R_m + R_G) \rightarrow R_m = \frac{V}{I} - R_G \rightarrow R_m = \frac{V - IR_G}{I}$

- **Multiplier:** I s the large or high resistance which is connected in series with the galvanometer to give voltmeter reading , $R_m = \frac{V - IR_G}{I}$

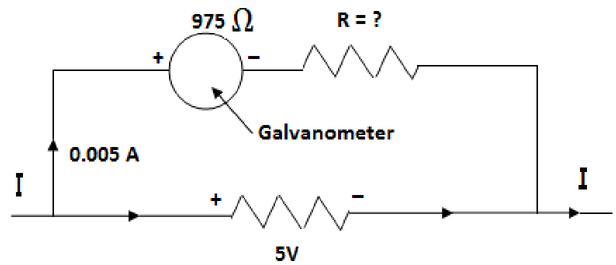
Individual task – 2:1

1. A moving coil galvanometer has a coil of resistance 25Ω and can carry a maximum of 15mA.

   (a) What is the value of the shunt required to enable the galvanometer to register 10A full scale deflection. (ANS: R_S **= 0.03Ω)**
   (b) What is the value of the multiplier required to enable the galvanometer to register 10V full scale deflection. How will be connected? (R_m **= 646.67Ω)**

2. A moving will galvanometer has a resistance of 20Ω and gives a full scale deflection when a current of 50mA passes through it. Calculate the value of the resistance which must be used so that the meter may measure the potential difference up to 100V.**(ANS: A multiplier of resistance 1980Ω must be connected in series with the galvanometer so that the meter may measure up to 100V)**

3. A moving coil galvanometer which gives a full scale deflection of 0.005A is converted to a voltmeter reading up to 5V using an external 975 Resistance what is the resistance of the galvanometer(**ANS: R_G = 25 Ω**)

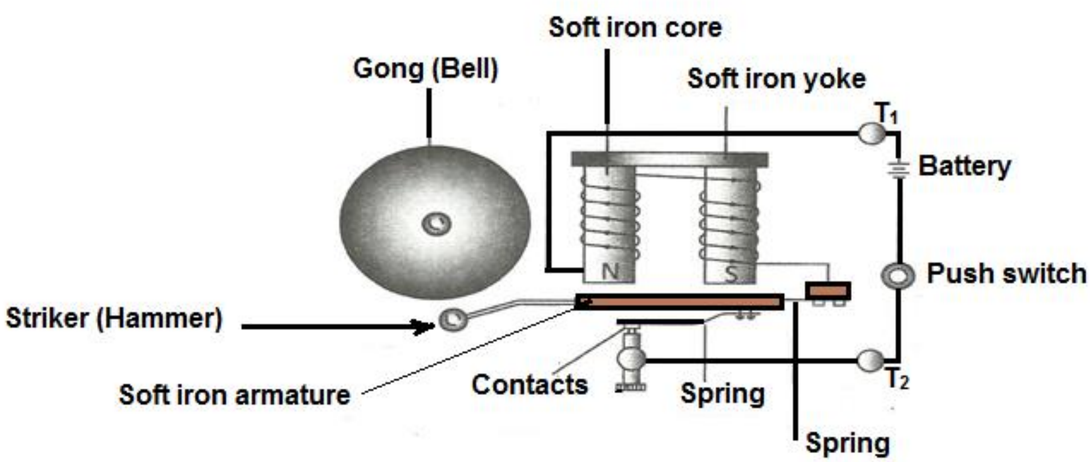


4. A galvanometer has a resistance of 50mA passes through it. Calculate the value of the resistance which must be used so that the meter may measures the current up to 2A **(ANS: A shunt of 0.5128 Ω must be connected to the galvanometer to give a reading of 2A.)**
5. A galvanometer coil has a resistance of 40**Ω** and the full scale deflection current 15mA. If it is to be converted so that it gives a full scale deflection current 1. 5A, then the required shunt will have a resistance of what size? (**ANS: Rs = 0.1Ω**)

(b) Electric Bell

- **Is a mechanical bell that functions by means of an electromagnet**
- It consists of a gong, an electromagnet , an iron strip and a contact screw

Consider the diagram below



Mechanism (working of an electric bell)

- When the switch is pressed and current flows through the circuit, the electromagnet is powered and generates a magnetic field that attracts the iron strip towards it
- The striker strikes the gong, when the striking arm strikes the gong, the contact is broken and current stops flowing through the circuit. This causes the electromagnet to lose its magnetic field.
- The connected spring arm returns the striker to its original rest position
- The contact is restored and current flows through the circuit
- The process is repeated from the beginning.

Individual task– 2:2

1. In the electric bell, explain what would happen if the armature is made of steel.

- **ANS:** If the armature is made of steel the hammer hits the gong and remains there/ the bell rings once this is because steel acquires permanent magnetism

2. Why is the core of the electromagnet of an electric bell made of soft iron and not steel?

- **ANS: Because iron gains and looses magnetisms easily.** It is only magnetized if there is a magnetic field around it and losses its magnetism immediately when the field is removed. It also requires very little energy to magnetize and demagnetize

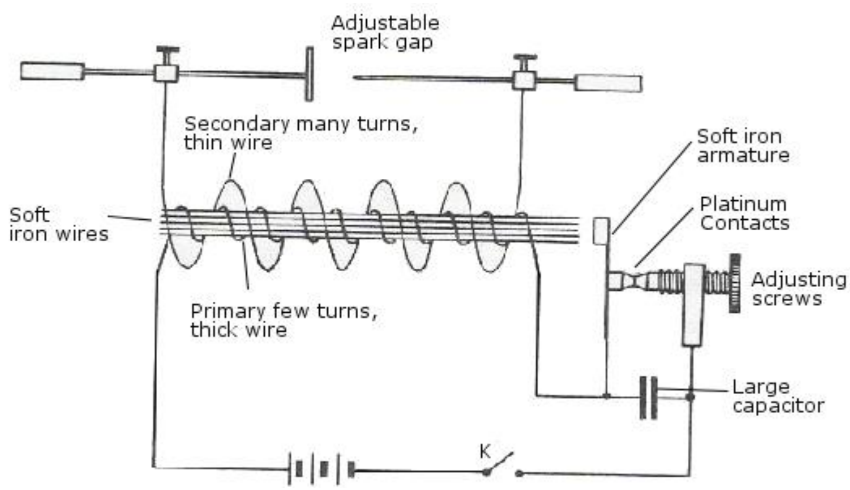
Reasons for steel:

(i) Steel forms a permanent magnet
(ii) Steel is not easily magnetized and demagnetized

Induction Coil (Spark coil)

- **I**s an electrical device consisting of two coils (primary and secondary coil) where secondary coil wound over primary coil on an iron core.
- **OR Induction coil** is a device for getting a high voltage from a low one.

The fig below:



Mechanism

- When switch is closed to complete the circuit, the primary coil produces magnetic fields which cause secondary coil to induce high voltage due to large number of turns,
- Induced magnetism on soft iron attracts iron hammer which open the circuit that incomplete the circuit by opening the gap in platinum contacts cause the soft iron to lose magnetism where spring pullback to platinum contacts to complete the circuit. This cycle of events is repeated automatically

Application of Induction Coil

- ❖ It is used commonly in ignition system of internal combustion engines
- ❖ It is used to trigger the flash tubes used in cameras and strobe lights
- ❖ It is also used in wireless telegraphy

Generators

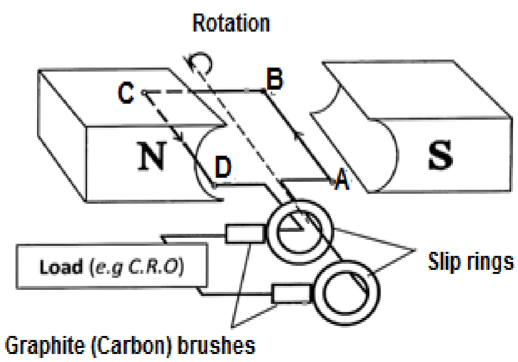
- **Generator :** Is a device which converts mechanical energy into electrical energy
- **OR:** Is the device which produces electricity on the basis of electromagnetic induction by the continuous motion of either a coil or a magnet
- **OR:** **Is a device consists of a coil rotating in an external magnetic field to produce electricity**

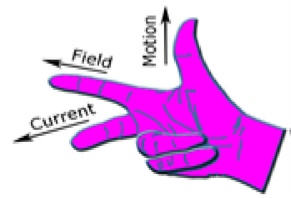
Types of Generators

- Alternating current generator (A.C Generator)
- Direct current generator (D.C Generator)

Alternating Current Generator (Alternator)

- **Is a device which converts mechanical energy into electrical energy**
- **OR** Is the device which produces electricity on the basis of electromagnetic induction by the continuous motion of either a coil or a magnet
- **OR** **Is a device which consists of a coil rotating in an external magnetic field to produce alternating current.**





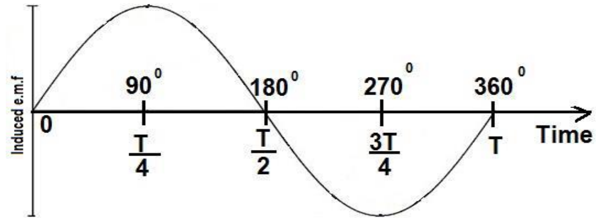
NB:

- The direction of motion, current and magnetic field can be shown by Fleming right hand rule which states that

"If three fingers of the right hand are held mutually perpendicular to each other, then the thumb points in the direction of motion, fore finger (index finger) points in the direction of the field and the middle finger points in the direction of the induced current"

Mechanism of Alternator (A.C Generator)

- Starting with the coil in the horizontal position, sides **AB** and **CD** are cutting the magnetic lines of force. Maximum **E.M.F** is therefore induced in the coil. Current flows from **A to B** and from **C to D**
- When the coil is in the vertical position, sides **AB** and **CD** are moving along the magnetic lines of force .The induced **E.M.F** drops to zero and current stops flowing
- During the second quarter rotation, the coils start cutting the lines of force and induced **E.M.F** increases from zero to a maximum value when the coil is in a horizontal position again. Current flows from **B** to **A** and from **D** to **C**, i.e is reversed
- This cycle of events is repeated automatically hence electricity is produced (See the fig below)

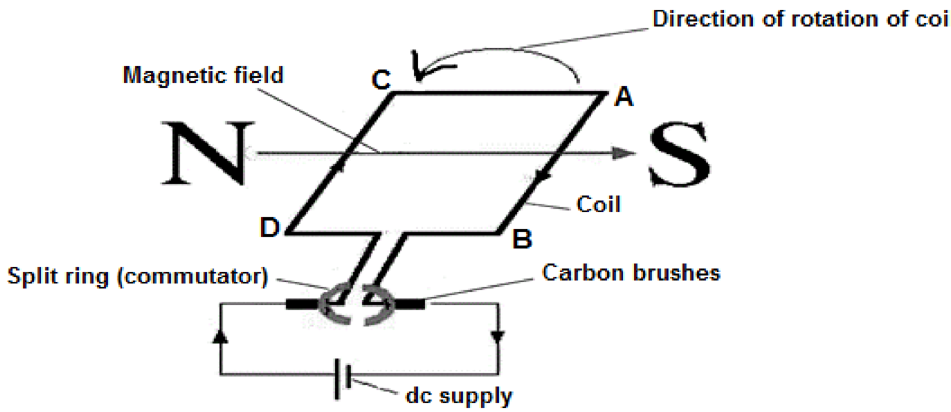


- The direction and magnitude of the induced e.m.f changes with time depending on the position of the coil

Direct Current Generator

- Is a device that consists a coil rotating in an external magnetic field to produce direct current

See the fig below:

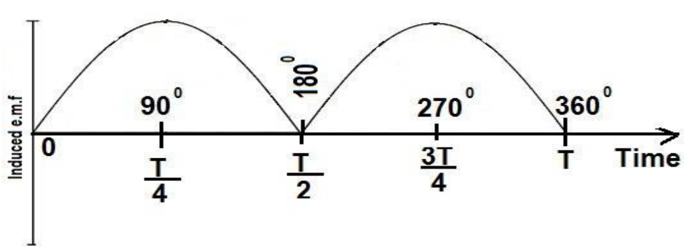


- In d.c generator the **Slip Rings** are replaced by a commutator in order **to prevent reverse of current.** Each half commutator is called **commutator segment** which is insulated from other half commutator

Mechanism of D.C Generator

- ✓ When the coil is vertical NO e.m.f is produced due to no cutting of the magnetic field on the coil
- ✓ When the armature rotates at 90^0 (parallel to magnetic field) the motion of coil is perpendicular to the magnetic field hence maximum e.m.f is induced
- ✓ When the coil is vertical (at 180^0) NO e.m.f produced due to no cutting of the magnetic field on the coil
- ✓ When the armature rotates after 180^0, starting from vertical position and the side of commutator segment interchange the loop which cause the loop of current remains in the same direction
- ✓ This cycle of events is repeated automatically hence electricity is produced

See the fig below



Advantage of alternator

1. Commutators are complex and costly to construct, therefore many d.c generators are being replaced with a.c generators by using rectifiers
   Rectifiers are devices that allow current flowing in one direction only.
2. Transformer works on a.c current only
   Helps in conservation of electric power during transmission by stepping up and down

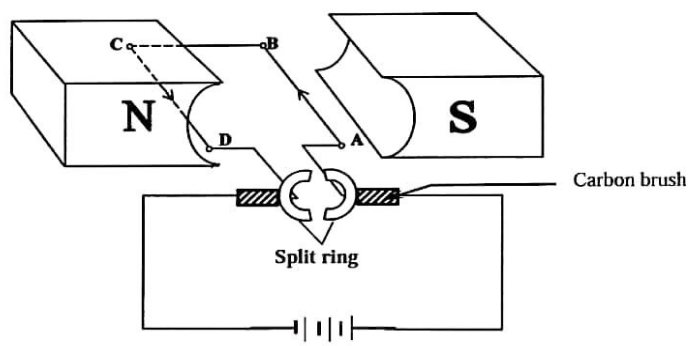
N.B:

- **In both a.c and d.c generators, the induced current can be increased by:**
  - **(a)** Using stronger magnet
  - **(b)** Increasing the number of turns of the coil
  - **(c)** Increasing the speed of rotation of the coil
  - **(d)** **Winding the coil on a soft iron core** so as to increase the magnetic flux trough the coil

Electric Motor

- Is an electrical device used to convert electrical energy to mechanical energy

Electric motor



Main parts of Electric motor

- **Carbon brushes**
- **Commutator split ring**
- **Magnetic field**
- **Rectangular coil of wire**

Rectangular coil of wire

- It is formed by winding several turns of wire on a soft iron core

Magnetic field

- Magnetic fields are formed by two unlike poles of permanent magnet

Commutator (split ring)

- It is formed by dividing copper ring into two equal halves. It is used to reverse direction of electric current flowing through the coil by changing the contact

Carbon brushes

- Connect power supply and rectangular coil

Mechanism of Electric motor

- ✓ When current is passed through the coil a force is created on side **AB** in the upward direction and on side **CD**, in the downward direction. These cause the coil to turn in the anticlockwise direction
- ✓ When the coil passes through the vertical position, no force acts on it, since the sides **AB** and **CD** are moving along the lines of force and are not cutting the lines. However , due to its momentum, the coil continues with its motion

Transformer

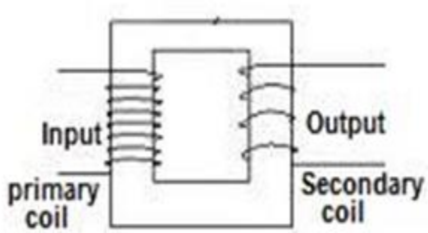
- Is a device that transfers an alternating current from one circuit to another by the principal of mutual induction either by increasing or decreasing the voltage

OR

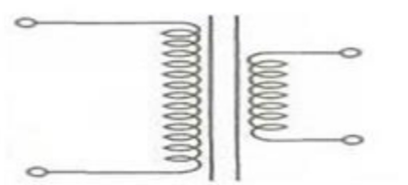
- Is a device that uses mutual induction between two coils to convert alternating voltage across one coil to a larger or smaller alternating voltage across the other coil

OR

- Is a static electrical device that transfers electrical energy between two or more circuits
- The coil connected to the source is called **primary coil** and the coil in which e.m.f is induced is called **secondary coil**



A transformer diagram


Its symbol

Types of Transformer

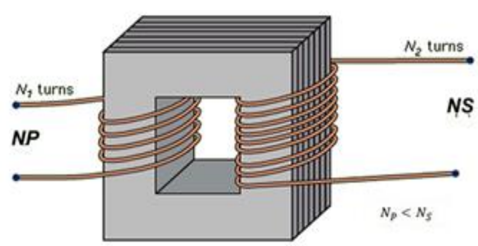
- Step up transformer
- Step down transformer

Step up Transformer

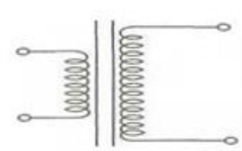
- Is the transformer that convert low alternating voltage from primary coil to high alternating voltage in secondary coil

OR

- Is a transformer that increases voltage from primary coil to secondary coil

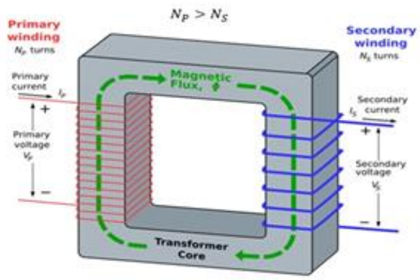


A step up transformer

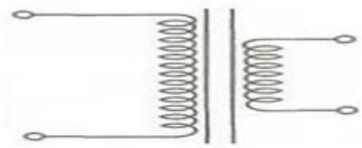

Its symbol

Step down Transformer

- Is the transformer that convert high alternating voltage from primary coil to low alternating voltage in secondary coil
- **OR** Is a transformer that decreases voltage from primary coil to secondary coil



A Step down transformer



Its symbol

Difference between Step – down and Step – up transformer

Step – down transformer	**Step – up transformer**
Decreases the output voltage	Increases the output voltage
Has many number of turn in primary coil	Has many number of turns in secondary coil
Primary voltage is higher than secondary voltage	Secondary voltage is higher than primary voltage
Current is high on the secondary winding.	Current is low on the secondary winding.
Secondary winding is made up of thick insulated copper wire	Primary winding is made up of thick insulated copper wire.
It is used in doorbell, voltage converter, etc	It is used in Power plant, X-rays machine, microwaves, etc.
Rating of output voltage 110v ,24v, 20v, 10v, etc.	Rating of output voltage is 11000 volts or above

Transformer Equation

- From the factors affecting the induced e.m.f (Faraday's law)

For primary coil

$\boldsymbol{N_P \propto V_P}$ $\quad\quad \rightarrow N_P = kV_P$

For secondary coil

$\boldsymbol{N_S \propto V_S}$ $\quad\quad \rightarrow N_S = kV_S$

Divide equation (i) to equation (ii)

$$\frac{N_P}{Ns} = \frac{K\,V_P}{K\,V_S}$$

$$\boxed{\therefore \frac{N_P}{Ns} = \frac{V_P}{V_S}}$$

Suppose no Power Loss (For ideal transformer)

$P_P = P_S$

But: P = IV

Then: I_P x V_P = I_S x V_S……………….. make $\frac{Vp}{Vs}$ the subject

$$\frac{Vp}{Vs} = \frac{Is}{Ip}$$

Therefore: $\frac{Vp}{Vs} = \frac{I_S}{I_P} = \frac{Np}{Ns}$

Where:

- **N_P** and **N_S** are the number of turns in primary coil and secondary coil respectively
- **V_P** and **V_S** are primary and secondary voltage respectively
- **I_P** and **I_S** are primary and secondary currents
- **P_P** and **P_S** are the power in primary coil and power in secondary coil

Transformer Efficiency

- Is the ratio power in secondary coils to power in primary coils expressed as a percentage
- Mathematically:

$$Efficiency = \frac{Power\ out\ put}{Power\ input} \times 100\% = \frac{Power\ in\ secondayry\ coil}{Power\ in\ primary\ coil} \times 100\% = \frac{Ps}{Pp} \times 100\%$$

- But: Ps = Is x Vs and Pp = Ip x Vp

$$\therefore Efficiency = \frac{P_S}{P_P} \times 100\% = \frac{I_S V_S}{I_P V_P} \text{ x } 100\%$$

Examples

1. A transformer with primary coil of 400 turns and secondary coil 200 turns is connected to 240 V ac mains. Calculate the secondary voltage.

   Soln:

   Given: N_P = 400, N_S = 200, V_P = 240 V, V_S =?

   From: $\frac{N_P}{Ns} = \frac{V_P}{V_S}$

$$\frac{400}{200} = \frac{240}{V_S} \quad \rightarrow V_S = 120\ V$$

2. A transformer with primary coil of 1200 turns and secondary coil 600 turns is connected to 240 V mains. If the primary current is 3.0A and secondary is 5.0A. What is its efficiency?

   Soln:

   Given: V_P = 240 V, N_P = 1200, N_S = 600, I_P = 3.0A, I_S = 5.0A

   Required: Efficiency=?

   From: $\frac{N_P}{Ns} = \frac{V_P}{V_S}$

$$\frac{1200}{600} = \frac{240}{V_S} \rightarrow V_S = 120\ V$$

$$Also\ \ Efficiency = \frac{Ps}{Pp} \times 100\% = \frac{I_S V_S}{I_P V_P}\ \text{x}\ 100\%$$

$$\therefore Efficiency = \frac{I_S V_S}{I_P V_P}\ \text{x}\ 100\% = \frac{120 \times 5}{240 \times 3}\ \text{x}\ 100\% = 83\%$$

Sources of energy/ Power loses in a Transformer

- There are four main causes of energy/ Power loss in a transformer. These are
  1. **Resistance of coils (Copper losses)**
- This is caused by high resistance of copper wire, which leads to energy loss in form of heat
- The copper losses can be minimized by using thick copper wires
  2. **Flux leakage**
- This leads to energy loss as a result of magnetic flux produced by the primary coils failing to link up with the secondary coils
- It can be minimized by winding the secondary coils over the primary coil
  3. **Hysteresis losses**
- This is the energy lost due to continuous magnetization and demagnetization of the core
- It can be minimized by the use of soft iron core which is easily magnetized and demagnetized
  4. **Eddy currents**
- Eddy currents circulating through the core produces a lot of heat
- It can be minimized by laminating the core

Transmission of electricity

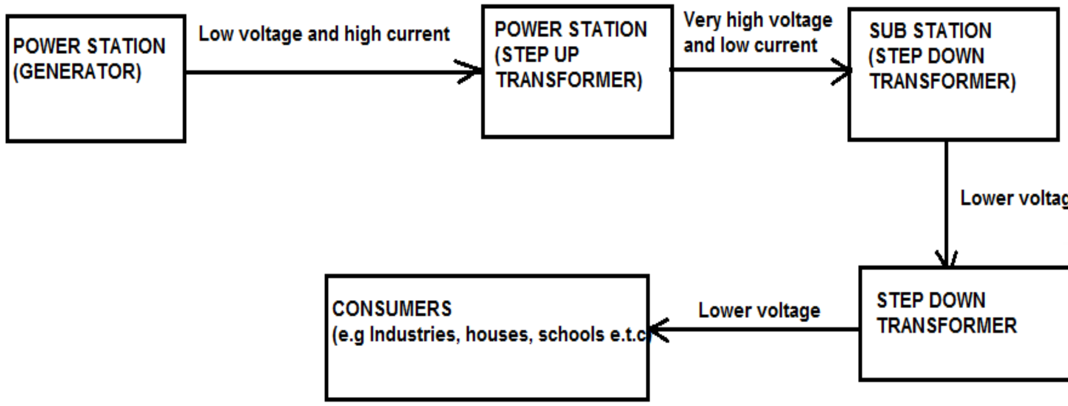
- Electricity generated at the power stations is usually at low voltage and high current.
- Before transmission, the voltage is first stepped up to very high voltages then transmitted over a network of transmission cables known as **the national grid system**
- **The national grid system** is a network of transmission cables connecting all power stations in a country to each other and to the consumers
- Advantage of the national grid system of transmission is that **"to ensure that the power is available to consumers even when one of the stations fails"**

N.B:

- The transmission of power over long distance is usually done at very high voltage and low current as opposed to low voltage and high current

Reason: **High voltage transmission of electricity minimizes power loss during the transmission**

Summary of steps involved during the transmission of electricity



Power loss during transmission

- **Power** loss during transmission , P is given by:

$$P = I^2R$$

Whereby: **P–Power lost during transmission, I–Current in the cables, R–Resistance of the cables**

Example

1. A power line from a power substation to a town some distance away, has a resistance of 0.10 ohms per kilometer. Determine the rate of energy loss in the transmission of power over 50 km at a current of 60 Amperes
   SOLN:
   Given: Total resistance over 50 km = 0.1 x 50 = 5Ω, I = 60 A
   From: $P = I^2R$
   $\therefore P = I^2 x\ R = 5x60\ x60 = 1800\ watts$

$Individual\ task$ **– 2:3**

(a) The resistance of a length of power transmitting cables is **10 Ω** and is used to transmit 11 kV at a current of 1.0A. Determine the power loss (**ANS:P = 10 W)**

(b) If this voltage is stepped up to a 160 kv by a transformer , determine the power loss (Assume the transformer is 100% efficient) (**ANS:P = 0.048 W)**

(c) **B**y what factor is the power loss reduced when the power is transmitted at 16 kV as opposed to 11 kV **(ANS: Power factor =** $\frac{Real\ power}{Apparent\ power} = \frac{10}{0.048} = 208.33\ times$)

Dangers of high voltage transmission

- Risk of electric shock due to the high voltage
- Risk of fire when the cables touch each other
- Strong electric fields set up by high voltages are harmful to animals and human beings

Precaution

- To minimize the dangers of high voltage transmission, the cables are **supported high above the ground**

Uses of transformer

- Transformers are used in power stations to step up voltage for transmission from the station to the area of consumption
  The stepping up reduces the current so that losses due to resistance in the transmitting wires are reduced
- The transformers are used to step down the voltage to the area of consumption as for as the value of voltage required for domestic use is connected.
- Electricity is transmitted from one part of the country to another part by grid system
- It can increase or decrease the value of capacitor, an inductor or resistance in an AC circuit. It can thus act as an impedance transferring device.
- It can be used to prevent DC from passing from one circuit to the other.
- It can isolate two circuits electrically.

Class activity – 2

1. A transformer is used to step down 240V mains supply to 12V for laboratory use. If the primary coil has 600 turns, determine the number of turns in the secondary coil **(ANS: Ns = 30 turns)**
2. A current of 0.6A is passed through a step up transformer with a primary coil of 200 turns. A current of 0.1A is obtained in the secondary coil. Determine the number of turns in the secondary coil and the voltage across if the primary coil is connected to 240V mains. (**ANS: Ns = 1200 turns, Vs = 1440V)**
3. A step up transformer has 10000 turns in the secondary coil and 100 turns through the primary coil. An a.c of 5A flow in the primary coil when connected to a 12V a.c supply, Calculate
   (a) The voltage across secondary coil **(ANS: Vs = 1200V)**
   (b) Current in secondary coil if transformer efficiency is 90% (**ANS: Is = 0.045A)**
4. With a secondary transformer output of 1,320 watts and a primary input of 1,800 watts, calculate the efficiency of the transformer**.** (***ANS:*** 73.33 %)
5. **How Does a Transformer Work?**

   Answer:

   - Transformer consists of two coils. If one coil is connected with ac voltage source then it will produce alternating flux in the core. Most of the flux is linked with second coil hence mutually induced emf will be produced in the second coil as per faraday's law of electromagnetic induction.

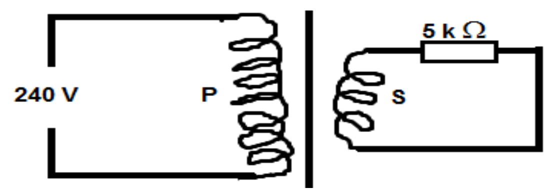
6. **Can DC be applied to Transformers?**
   ANS: NO
   - Because: Transformer works on Faraday's law of Electromagnetic Induction for which current in coil must change. If DC is applied current

will not change and transformer will not work. Practically winding resistance is very small. For DC, inductive reactance is zero and frequency is zero. Therefore impedance is low. Thus winding draws more current which may damage the winding.

7. What is the difference in energy transformation between a D.C motor and a D.C generator?
8. State five ways by which the electric motor can be made to rotate faster (**ANS:-**
   (i)By increasing the current flowing through the coils (ii) By using stronger magnets
   (iii) By using many number of turns of the wire
   (iv) By increasing the area of the coil in the magnetic field
   (v) By using many coils with more split ring parts in many planes
9. What is the main structural difference between the D.C generator and the A.C generator? (ANS: In the D.C generator a **split ring** (commutator) is used , while in an A.C generator, a set of **slip rings** are used)
10. A power line from a power substation to a town some distance away, has a resistance of 0.4 Ω per kilometer. Determine the current flowing through the power lines if the rate of energy loss in the transmission of power over 100 km is 100,000 W **(ANS: P = 50 A**)
11. What is meant by the national grid system?
12. What is the advantage of having a national grid in power transmission?
13. Why is the electricity transmitted at very high voltage and low current?
14. During the transmission of electricity over long distances, an alternating current is passed over alluminium cables at high voltages and low current.
   (a) Why is alternating current (a.c) used in preference to direct current (d.c)?
   ANS
   (i) Alternating current can be easily stepped up and down since transformers work only on a.c not on d.c
   (ii) Direct current requires thick overhead cables which will be expensive to buy and support
   (b)Why are alluminium cables preferred to copper for long distance transmission of electricity (**ANS:)**
   (i) Alluminium has lower density than copper.(It is lighter than copper, therefore easy to support. Use of copper wires will require very strong poles to support since copper wires are fairly heavy)
   (ii) Alluminium is a better conductor of electricity than copper
   (iii) Alluminium does not corrode easily, unlike copper
15. A transformer is used to step down 120V mains to 24volts, for kitchen use. If the primary coil has 400 turns, find the number of turns is the secondary coil (**N_S = 80)**
16. Explain why soft iron is better material to be used for the core than steel?
17. A step up transformer has 5000 turns in the secondary coil. And 500turns through the primary coil. An alternative current of 5A flows in the primary coil when connected to a 12V A.C supply.
   (a) Calculate the voltage across the secondary coil. (**ANS: V_S = 120V)**

(b) If the transformer has an efficiency of 90% what is the current in the secondary coil? (**I_S = 0.45A**)

18. A step down transformer is used to light a 12V, 24W lamp from 240 volts mains. The current through the primary coil is 125mA. What is the efficiency of the transformer? **(ANS: Eff = 80%)**
19. A transformer is used to step down 24V mains supplier to 12V for laboratory use, if the primary coil has 600turns. Find the number of turns in the secondary coil. (**N_s = 30 N**)
20. A current of 0.6A is passed through a step up transformer with a primary coil of 200 turns. A current of 0.1 A is obtained in the secondary coil. Find the number of turns in the secondary coil and the voltage across if the primary coil is connected to 240V mains (**ANS: N_S = 33 N, V_S = 39.6V)**
21. The figure below shows a step – down transformer connected to a 240 V mains socket. The primary coil P, has 4000 turns while the secondary coil, S, has 200 turns. The efficiency of the transformer is 60% and a current of 50 A flows through P. Calculate the current through S



22. A Transformer has 1000 turns in its primary coil, which is connected to a 250 V a.c supply. The secondary coil is connected to an ammeter via a 100 ohm resistor .Determine the number of turns in the secondary coil if the ammeter reads 1.5 A **(ANS: N_S = 600)**
23. A student is designed a transformer to supply a current of 10 A at a potential difference of 60 V to a motor from an a.c mains supply of 240 V. If the efficiency of the transformer is 80%. Calculate
    (a) The power supplied to the transformer **(ANS: P_{IN} = 750 W)**
    (b) The current in the primary coil **(ANS: I_P = 3.125 A)**
24. A low voltage outdoor lighting system uses a transformer to step down a 240 voltage house hold voltage to 24 voltages. The lighting system has 6 lamps with a total resistance of 10Ω
    (a) What is the current in the secondary coil of the transformer **(ANS:I =24 A)**
    (b) What is the current in the primary coil **(ANS: I = 2.4 A)**
25. The ratio of the number of in the secondary coil in a transformer to that in the primary coil is 16:1.If the current in the secondary circuit is 4.0A. What is the current in the primary circuit? (**ANS: I_S = 0.25A)**
26. Could a transformer be used to increase the voltage of a battery? Explain
27. Explain the function of the commutator in a DC electric generator
28. A transformer is used on a 240 V a.c supply to deliver 12 A at 120 V to a heating coil. If 20% of energy taken from the supply is dissipated in the transformer

(a) What is the current in the primary coil? (**ANS: I_P = 7.5 A**)

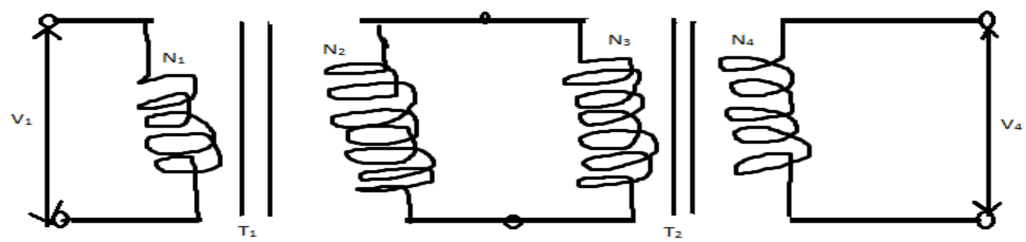
(b) Give three causes of 20% energy dissipation in the transformation above

29. Sketch the magnetic field patterns due to a current passing through:

(a) a long straight line (b) a circular coil

(c) a long solenoid. Indicate clearly the direction of current and magnetic field

30. Two transformers T_1 and T_2 are connected as shown in the figure below



Given that N_1 =10, N_2 = 200, N_3 =100, N_4 = 50 and V_1 =240 V, what is the value of V_4?

31. A laptop computer is plugged into the 230 V mains .The lap top is left on standby .Its power consumption from the mains is 3.2 W .The lap top's transformer changes the 230 V mains to 9.2 V which goes to the laptop .What is the current passing through the laptop?
32. Transformers are designed to use alternating current .Describe what change happens when a step – up transformer is used
33. What is meant by the national grid system?
34. Explain how transformers are used to improve the efficiency of power transmission in the national Grid.
35. A step – down transformer in a mobile phone charger converts 230 V mains into 5 V .The phone needs a current of 3 A when charging .What current is required from the mains?
36. Describe the structure and working of a simple d.c motor
37. A d.c generator has a resistance coil of 10 ohms and is connected to a bulb of resistance 100 ohms .Calculate the induced e.m.f if the current flowing in the bulb is 5 amps
38. A step – down transformer has a secondary winding of 100 turns and primary winding of 200 turns .If the output voltage is 150 V ,find the input voltage ,assuming the transformer is 100 % efficient
39. Describe the structure of a step – up transformer
40. A transformer with primary and secondary windings of 200 and 100 turns respectively is connected to 250 V mains .Calculate the secondary voltage if the transformer is 75 % efficient

Topic –3: Radioactivity

- **Radioactivity** is the process in which an unstable atomic nucleus loses energy by emitting radiation in the form of particles or electromagnetic wave.

OR **Radioactivity** is the spontaneous breaking up of unstable nuclei with the emission of one or more types of radiation

OR **Radioactivity** is the spontaneous disintegration of the nucleus of unstable elements with the emission of radiations

NB:

- Radioactivity is also called **radioactive decay**
- Disintegrated atom is called **parent nuclide**
- The new atom formed is called **Daughter nuclide**

Terms used

Matter

- Matter is anything that occupies space and has weight. Eg, **water**, **iron**, **meat**,etc

Element

- **Is** a pure substance that is made up of only one kind of atom and cannot be broken down into simpler parts by a chemical means.
- For example, helium (**H**), hydrogen (**He**), iron (**Fe**) etc

Atom

- Is the smallest particle of an element that has all the chemical characteristics of an element. For example, helium (**H**), hydrogen (**He**), iron (**Fe**) etc

Molecule

- Is a group of atoms. For example, water molecule (H_2O), hydrogen molecules (H_2)

Strong Force

- Is the force that hold protons and neutrons present in the nucleus oppose and overcome repulsion between protons

Binding Energy

- Is the energy that holds protons and neutrons present in the nucleus oppose and overcome repulsion between protons

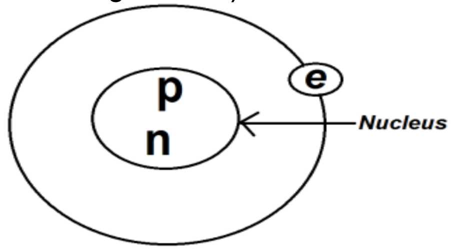
Nuclear Binding Energy

- I*s the energy required to split the nucleus of an atom into its components*

Structure of Atom

According to Rutherford atom

"*Atom has a structure like a small solar system, in which the planet is electron and the place* of the sun is taken by a small heavy positive charged particle called nucleus (Protons and Neutrons)" (see the fig. below)



- Therefore atoms are made up by subatomic (three types of) particles namely Protons(p), Neutrons(n) and Electrons(e)

Protons

- Proton is the positively charged particle of an atom.
- It is denoted by small letter **p**. its charge and its mass is $+1.6 \times 10^{-19}$ C and 1.6726×10^{-27} kg respectively

Neutrons

- Neutron is the neutral charged particle of an atom.
- It is denoted by small letter **n**. Its charge and its mass are **0** C and 1**.6749 x** 10^{-27} kg respectively

Electrons

- An electron is the negatively charged particle of an atom.
- It is denoted by small letter **e**. Its charge and mass are -1.6×10^{-19} C and 9.1094×10^{-31} kg respectively. The electron always revolve around the nucleus

Atomic Number

- *Atomic number is the number of protons present in a nucleus of a particular atom.*
- It is denoted by capital letter **Z**

Mass Number

- Mass number is the sum of protons and neutrons particles.
- Also is called atomic mass/weight. It is denoted by capital letter A
  Mathematically: **A = Z + N**
- In a given atom/elements (X) **mass number (A) located as Superscript** while **atomic number (Z) located as Subscript**. i.e $^{A}_{Z}X$

Isotopy

- Is the existence of atoms of the same element with the same atomic number but differ in atomic mass.
- Elements which can form isotopy are called **isotopic elements (isotopes)**

Isotopes

- **A**re the atoms of the same element having the same atomic number but different mass number

Isotopic Elements and their Isotopes

Elements	**Z**	**Isotopes**	**A**
Hydrogen	1	Hydrogen - 1 Deuterium Tritium	1 2 3
Carbon	6	Carbon - 12 Carbon - 13 Carbon - 14	12 13 14
Oxygen	8	Oxygen - 16 Oxygen - 17 Oxygen - 18	16 17 18
Chlorine	17	Chlorine - 35 Chlorine - 37	35 37
Uranium	92	Uranium - 234 Uranium - 235 Uranium - 238	234 235 238
lead	82	Lead - 202 Lead - 206 Lead - 207 Lead - 208	202 206 207 208

NB:

- The different isotopes always differ by one neutron (1 $^{0}_{1}n$)
- Isotopes of particular element/atom; the larger the mass number (A) the heaviest of element and vice versa

Isobars

- **I**sobar is the different elements having the same mass number but different atomic number.

Isotones

- Isotones are different elements having the same number of neutrons.

Example 1

3. One isotope of chlorine has the symbol $^{37}_{17}\boldsymbol{Cl}$
Calculate the number of neutrons in this isotope
Soln: from A = Z + N $\rightarrow 37 = 17 + N \quad \rightarrow 37 - 17 = 20$
$\therefore The\ number\ neutrons = 20$

Individual task – 3:1

1. Tin (Sn) has a total of twenty-five isotopes; the lightest is represented by the symbol $^{108}Sn_{50}$. Given that all twenty-five isotopes of tine exist, write down the symbol for the heaviest tin **isotopes** (**ANS:** $^{132}_{50}Sn$)

Stable Atom

- *Is the atom whereby its binding energy is strong enough to hold nucleus of an atom together*.
- **N.B: Stability of an atom decreases as the atomic number increases**

Unstable Atom

- **I***s the atom whereby its binding energy is not strong enough to hold nucleus of an atom together*.

Types of Radioactivity

- Natural radioactivity
- Artificial radioactivity

Natural Radioactivity

- **Is** the process in which an unstable atomic nucleus loses energy by emitting radiation in the form of particles or electromagnetic wave

OR

- Is the spontaneous disintegration of unstable atoms (nuclei).
- For example, unstable isotopes such that **carbon-14** and heavy elements such as **lead** and **uranium** etc

NB:

- ✓ In natural radioactivity the nucleus of the elements disintegrate on their own accord
- ✓ Materials exhibit radioactivity is called **radioactive material**
- ✓ In the periodic table all elements above lead exhibit natural radioactivity
- ✓ Examples of **radioactive material** are thorium (Th), uranium (U), Radon (Rn), Radium (Ra), Polonium (Po) etc

How Natural Radioactivity Occurs?

- Natural radioactivity occurs when atomic nucleus has many number of protons in the nucleus, due to the law of charges, like charges repel therefore repulsion force is larger enough to overcome strong force (binding energy) resulting unstable atomic nucleus disintegrate (decay) into smaller nuclei (**daughter nuclide)** which are smaller and more stable than **parent nuclide**

Nuclear Radiation

- Is the energy or particles or electromagnetic waves emitted by unstable atom (radioactive element)

Types of Radiation
- Alpha (α) particle
- Beta (β) particle
- Gamma (γ) rays

Alpha Particle (α)
- Is the particle emitted by radioactive material which is equivalent to helium nucleus particle (^4_2He),i.e **α =** ^4_2He

Effect on Nucleus
- When a radioactive nucleus emits an alpha particle its atomic number decreases by two and mass number decreases by 4.
- The effect tend to form other element and the nuclear equation is given by:
  $$^A_ZX \rightarrow ^{A-4}_{Z-2}Y + ^4_2He$$
- **Whereby:**
  - ^A_ZX Is parent nuclide
  - $^{A-4}_{Z-2}Y$ Is daughter nuclide
  - The parent nuclide can give more than one daughter nuclide
- **Example 1:** Uranium-238 undergoes an alpha decay to produce thorium-234
  Solution: $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^4_2He$
- **Example 2:** Radium-222 undergoes an alpha decay to produce radon-218
  Solution: $^{222}_{88}Ra \rightarrow ^{218}_{86}Rn + ^4_2He$

Properties of Alpha Particles
- It is helium in nature
- It is a positively charged particle. it has relative charge of 2+
- It has very low penetrating power since it is the heaviest particle
- It can be stopped/shielding by a few cm of air, thin sheet of paper, skin, clothes etc
- It can cause some materials to fluorescence i.e. to give out light
- It affects/blackens photographic plate (film)
- It is a heaviest particle due to its biggest mass and charge
- It has very high ionizing power, since it is a heaviest particle
- It is emitted up to speed of 0.1of light
- It can be deflected by electric and magnetic field

Beta Particle (β)
- Is the particle emitted by radioactive material which is equivalent to electron ($^0_{-1}e$) (**β =**$^0_{-1}e$)

Effect on Nucleus

- When a radioactive nucleus emits beta particle its atomic number increases by one (1)and mass number remains constant.
- The effect tend to form other element and the nuclear equation is given as:

$$\boldsymbol{{}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e}$$

- **Example 1**: Carbon-14 undergoes beta decay to produce nitrogen-14

  Solution: ${}^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

- **Example 2**: Iodine-131 emits beta particles to produce xenon-131

  Solution: ${}^{131}_{53}I \rightarrow {}^{131}_{54}Xe + {}^{0}_{-1}e$

Properties of Beta Particles

- It is electron in nature
- It is a negatively charged particle. It has relative charge of -1
- It has high kinetic energy electrons
- It has moderate penetrating power due to its low mass
- It can be stopped by a few mm of metals like aluminium, Plastic, glass, light metals etc
- It has moderate ionizing power due to its low mass
- It is emitted up to speed of 0.9C where C = 3×10^8 m/s
- It affects/blackens photographic plate (film)
- It causes some materials to fluorescence i.e. to give out light
- It has smaller mass and charge than the alpha particle
- It can be deflected by either electric or magnetic field

N.B

- Beta particles have less ionizing powers compared to alpha particles. **This is because beta particles have smaller mass than alpha particles**

Gamma Rays (γ)

- Are electromagnetic waves with very short wavelengths and high frequencies
- It is released during emission of alpha or beta particle (γ). It is also called **gamma radiation**

Effect on Nucleus

- When a radioactive nucleus emits gamma rays its atomic number and mass number remain the same.
- The effect tend to form other element and the nuclear equation is given by:

  ${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + \gamma$

- Chemical reaction with alpha particle

  ${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He + \gamma$

- **Example 1:** Cobalt-60 by emitting a beta particle to produce nickel-60 and gamma rays

$$^{60}_{27}Co \rightarrow ^{60}_{28}Ni + ^{0}_{-1}e + \gamma$$

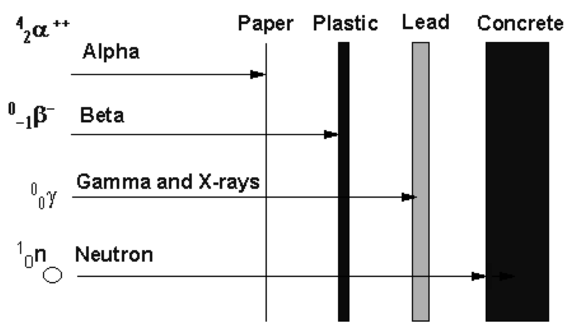
- **Example 2:** Iodine-131 emits beta particles to produce xenon-131 and gamma rays

$$^{131}_{53}I \rightarrow ^{131}_{54}Xe + ^{0}_{-1}e + \gamma$$

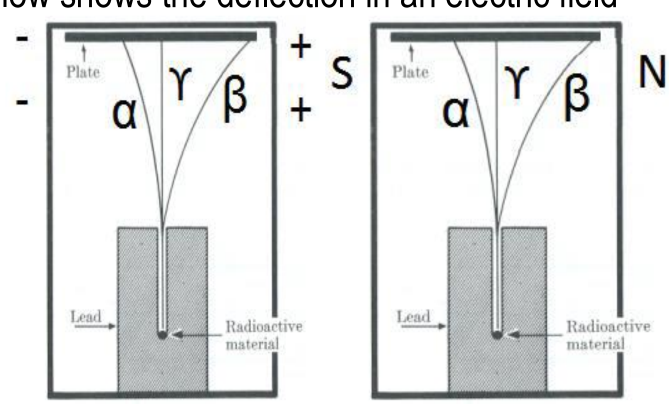
Properties of Gama Rays

- They are electromagnetic waves in nature
- They are neutral in charge i.e have zero relative charge
- They have very high frequency electromagnetic radiation
- They have very high penetrating power since they have no mass
- They can be stopped by a **thick layer of steel** or **concrete**, **dense metal**, but even a few cm of dense lead doesn't stop all of it
- They have lowest ionizing power since have no mass
- They have no mass since they are rays (radiations)
- They move with a speed of light i.e 3×10^8 m/s
- They affect/blacken photographic plate (film)
- They cause some material to fluorescence i.e. to give out light
- They cannot be deflected by electric field or magnetic field

- Consider the figure below showing the penetrating powers



- The figure below shows the deflection in an electric field



➢ Alpha particles deflected toward south pole, beta particles deflected toward north pole while gamma rays is not deflected

Individual task – 3:2

1. Uranium $^{238}_{92}U$ emits an alpha particle to become another element, as shown in the following equation $^{238}_{92}U \rightarrow {}^{A}_{Z}X + \ Alpha\ partice$. Determine the value of A and Z **(ANS: A = 234 , Z = 90)**
2. The element Thorium (Th) has atomic number 90 and mass number 234. The element decays by emitting a beta particle to form Protactinium (Pa). Write a nuclear equation for this decay **(ANS: $\boldsymbol{^{234}_{90}A \rightarrow {}^{234}_{91}Pa + {}^{0}_{-1}e}$)**
3. The following reaction is part of a radioactive series. Identify the reaction **x** and determine the values of **c** and **z**

   $\boldsymbol{^{210}_{83}A \xrightarrow{x} {}^{210}_{84}A \xrightarrow{\alpha} {}^{c}_{z}Q}$ (**ANS: x is beta particle, c = 206, z = 82)**
4. (ii) Define the terms isotope

   (ii) Uranium $^{238}_{92}U$ decayed to Polonium $\boldsymbol{^{222}_{84}Po}$ by α-particle emission at each stage via $^{234}_{x}Th$, $\boldsymbol{^{230}_{x}Ra}$ and $\boldsymbol{^{226}_{z}Rn}$. Following this stage $\boldsymbol{^{224}_{84}Po}$ decayed to $\boldsymbol{^{q}_{86}Rn}$ by β-particle only

   (a)Write balanced equation of the stage decay process from $^{238}_{92}U\ to\ \boldsymbol{^{226}_{z}Rn}$ and determine the value of **x, y, z and q**

   (b) Identify isotopes and isobars

   (**ANS Isotopes is Radon; $\boldsymbol{^{226}_{86}Rn}$ and $\boldsymbol{^{222}_{86}Rn}$, Isobars is $\boldsymbol{^{222}_{84}Po}$ and $\boldsymbol{^{222}_{86}Rn}$**)
5. A uranium nucleus, U-238 with atomic number 92, emits two α-particles and two β-particles and finally forms a thorium (Th) nucleus. Write the nuclear equation for this process **($\boldsymbol{^{238}_{92}U \rightarrow\ 2{}^{4}_{2}He \rightarrow\ 2{}_{-1}^{0}e \rightarrow {}^{234}_{90}Th}$)**

6. Radioactive uranium $^{238}_{92}U$ emits an α-particle to become thorium. Thorium emits a β-particle to become praseodymium which then emits another β-particle. What are the atomic number, mass number and number of final atom produced?
   (ANS: Uranium has atomic number 92 therefore the final product is uranium)

Application of Natural Radioactivity (Radio isotopes)

In hospital (medicine)

(a) Gamma rays from cobalt 60 are used to sterilize surgical equipment
(b) Radioactive sodium is used to monitor blood circulation
(c) Used to trace and treat maligned growth. E.g. **cancer** and **tumors**
(d) Used to measure correct patient dosages of radioactive pharmaceuticals
(e) Used in molecular biology and genetics research.
(f) Radioactive iodine 131 is used to monitor the function of thyroid gland

In industry

(a) Used to measure and control the thickness or density of metal and plastic sheets
(b) Used in preservation of food by killing microorganisms that cause spoilage

In agriculture

- **(a)** It is used to kill weeds
- **(b)** It is used to check cracking in pipes used for irrigation purpose
- **(c)** It is used to measure the moisture of materials stored in soils
- **(d)** It is used to measure amount of moisture content stored in grains and control pests

In transport

- **(a)** It is used to inspect passenger's luggage before boarding the plane
- **(b)** It is used to inspect airline luggage for hidden explosives

Science Field

- **(a)** It is important aid to biomedical researchers studying the cellular functions and bone formation in mammals
- **(b)** It is used in research in red blood cell survival studies
- **(c)** It is used to tell researchers whether oil wells are plugged by sand or not
- **(d)** It is used in biological research, agriculture, pollution control, and archeology
- **(e)** It is used to analyze electroplating solutions

Archaeological field.

- **(a)** It is used for carbon – dating to determine the age of ancient remains

Artificial Radioactivity

- Artificial radioactivity is the emission of radiation due to bombardment of small and stable nuclei by high energetic particles.
- It is also called **induced radioactivity or man – made radioactivity**
- In artificial radioactivity, the nucleus must be excited by injection of a neutron for radioactivity to start

How Artificial Radioactivity Occurs?

- Artificial radioactivity occurs when an atom is bombed with an accelerator or exposing it to slow moving neutrons in a nuclear reactor

Method of Inducing Radioactivity

- Neutron activation
- Photonuclear reaction

Neutron Activation

- Is the process whereby neutron radiation induces radioactivity in materials
- **Example:** Stable cobalt-59 undergo neutron radiation to emit cobalt-60

$$^{59}_{27}Co + {}^{1}_{0}n \rightarrow {}^{60}_{27}Co$$

Photonuclear Reaction

- Is the radioactivity induced by bombarding the target nucleus with high energy X-rays or gamma rays
- **Example:** In each of the nucleus reaction listen below what is the atomic number, mass number and a name of the particle produced?

  (i) Boron $^{10}_{5}B$ bombarded with a neutron gives lithium $^{7}_{3}Li$ particle
  (ii) Aluminium $^{27}_{13}Al$ bombarded by α-particle to give silicon $^{30}_{14}Si$ particle
  (iii) Sodium $^{23}_{11}Na$ is bombarded by α-particle to give aluminium $^{27}_{13}Al$ particle
  (iv) Chlorine $^{35}_{17}Cl$ is bombarded with proton gives Sulphur $^{35}_{16}S$ particle

ANS: (i) Particle is alpha (helium) (ii) Atom produced is proton
(iii) Atom produced is neutron (iv) Two electrons are produced

Application of Artificial Radioactivity

- ✓ Neutron activation is one of the most sensitive and accurate methods of **trace-element analysis**
- ✓ Neutron activation uses nuclear reactors for nuclear energy generation
- ✓ Neutron activation uses nuclear reactors for making nuclear bombs

Hazards/Effects of Nuclear Reaction

- Skin burning and Redding when exposed in radiation
- Death by killing human body cells
- Cancerous tumors
- Genetic mutation

Precaution to be taken from hazard

- Limiting the time of exposure
- Increase the distance from the source of radiation
- Using materials such water, concrete or lead to absorb the radiation
- Hold radioactive material by using mechanical tong
- Keep it out of the environment a material containing the radiation source

Types of Nuclear Reaction

- Nuclear fission
- Nuclear fusion

Nuclear Fission

- Is the process whereby unstable nucleus of an atom split into two or more smaller nuclei.
- **Example:** $^{238}_{92}U \rightarrow {}^{94}_{36}Kr + {}^{140}_{56}Ba + 2\ {}^{1}_{0}n$

NB:

- Nuclear fission of heavy element is a highly exothermic reaction that is why it is used as a source of energy in form of heat
- If neutron is bombarded with atom the decay will continue until stable atom form, since neutron decreases to finish. This chain is called **chain reaction**

Application of Nuclear Fission

- It is used in nuclear power plants to generate electricity
- It is used in making nuclear bombs

Nuclear Fusion

- Is the process whereby lighter nuclei joining together to form heavier nucleus.
- **Example:** Nuclear fusion of deuterium and tritium yield helium, neutron and heat energy

$$^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}H + {}^{1}_{0}n + \text{energy}$$

NB:

- Nuclear fusion of heavy element than iron or nickel is endothermic reaction
- Nuclear fusion of lighter element is exothermic reaction
- Nuclear fusion occur naturally in stars
- Nuclear fusion occur artificially in human enterprises

Application of Nuclear Fusion

- It is used in nuclear power plants to generate electricity
- It is used in making nuclear bombs. For example, hydrogen bomb

Carbon – 14 Dating

- Is the scientific method which is used to determine age of dead living and non-living organism

Half-life of Radioactive Nucleus (Decay)

- Half-life is the time required for one half of the nuclei present to decay.
- It is represented by the symbol ($t_{1/2}$)
- Each radioactive material has its own half-life

Activity

- **Is** the rate of disintegration of radioactive material with time

OR

- **A**ctivity is the number of atoms decayed per unit time
- Activity also is called count rate. SI unit of activity is count rate per second, (**c.p.s)**

Mathematically

$$\boldsymbol{Activity(A)} = \frac{\boldsymbol{number\ of\ atom\ decayed}\ (-\Delta N)}{\boldsymbol{time\ taken}(,\Delta t)} = -\frac{\Delta N}{\Delta t}$$

NB:

- Negative means as time goes the number of atoms decrease
- Activity is directly proportional to the original number of atoms presents

Mathematically

Activity (A) ∝ Original number of atoms presents (N)

$A \propto N$ – removing the proportionality constant

$A = kN$

But: $A = -\frac{\Delta N}{\Delta t}$

$$-\frac{\Delta N}{\Delta t} = kN = \lambda N \qquad (k = \lambda = \text{Proportionality/decay constant})$$

But: Decay constant, λ is given by

$$\lambda = \frac{ln2}{t1/2} \qquad \text{(Where by ln2 = 0.693)}$$

$$\therefore\ \lambda = \frac{0.693}{t1/2} \quad and \quad t_{\frac{1}{2}} = \frac{0.693}{\lambda}$$

- **Generally the final amount remaining after time t is given by**

$$\boldsymbol{N = \frac{N_O}{2^n} \quad or \quad N = N_O\, 2^{\left(-\frac{t}{t1/2}\right)} \quad \text{or} \quad N = N_O e^{-\lambda t}}$$

Where by N = Final mass/activity/Amount remaining after time t

N_O = Initial (Original) amount/fraction/activity/percentage

t = Total time taken/Time taken to decay

$t_{1/2}$ = Half life

λ = Decaying constant

$\boldsymbol{n = number\ of\ half-\ lives,\ n = \frac{t}{t_{\frac{1}{2}}}}$

The half life of a radioactive element can be calculated by using

1. **Linear method**

- This involves dividing the initial mass/ percentage /fraction by two after each half life
- In general, If No is the initial mass and $t_{1/2}$ the half life then:

$$N_O \xrightarrow{t_{1/2}} \frac{N_O}{2} \xrightarrow{t_{1/2}} \frac{N_O}{4} \xrightarrow{t_{1/2}} \frac{N_O}{8} \xrightarrow{t_{1/2}} \frac{N_O}{16}$$

Example: The count rate of a radioactive indium falls from 3200 counts per minute to 200 counts per minutes in 220 minutes. Determine the half – life of the radioactive isotope

Soln:

$$3200 \xrightarrow{t_{1/2}} 1600 \xrightarrow{t_{1/2}} 800 \xrightarrow{t_{1/2}} 400 \xrightarrow{t_{1/2}} 200$$

Total number of half lives = 4

Total time taken = 220 minutes

$$\therefore\ t_{1/2} = \frac{220}{4} = 55\ minutes$$

2. **Formula method**

- The formula used is:

$$\boxed{\frac{N}{N_O} = \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}} \quad OR \quad \frac{N}{N_O} = 2^n}$$

whereby: $n = \frac{-t}{t_{1/2}}$ $\quad (n\ is\ the\ number\ of\ half-lives)$

Example: If a radioactive isotope has a half –life of 2.5 hours, how long will it take for 256 grams of the isotope to decay to 32 grams?

Soln:

From: $\frac{N}{N_O} = \left(\frac{1}{2}\right)^{\frac{t}{t_{1/2}}}$

$$\frac{32}{256} = \left(\frac{1}{2}\right)^{\frac{t}{2.5}} \rightarrow \left(\frac{1}{2}\right)^{3} = \left(\frac{1}{2}\right)^{\frac{t}{2.5}}$$

$$by\ comparing\ exponents, \quad 3 = \frac{t}{2.5} \quad \rightarrow t = 3\ x 2.5 = 7.5\ hours$$

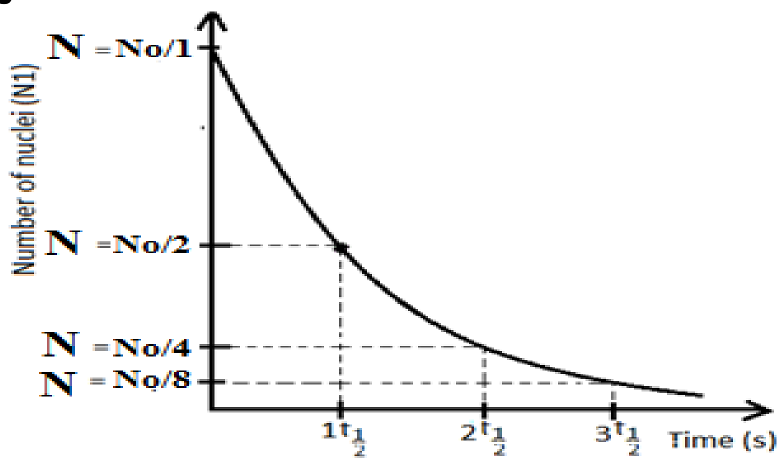
3. **Graphical method**

- This method involves plotting a decay curve, then using the curve to work out the half life

Radioactive Decay Curve

- Is the exponential curve drawn with number of atoms on the vertical axis and time for disintegration on the horizontal axis
  (Is a graph of either mass, count rate, activity, percentage e.t.c against time)

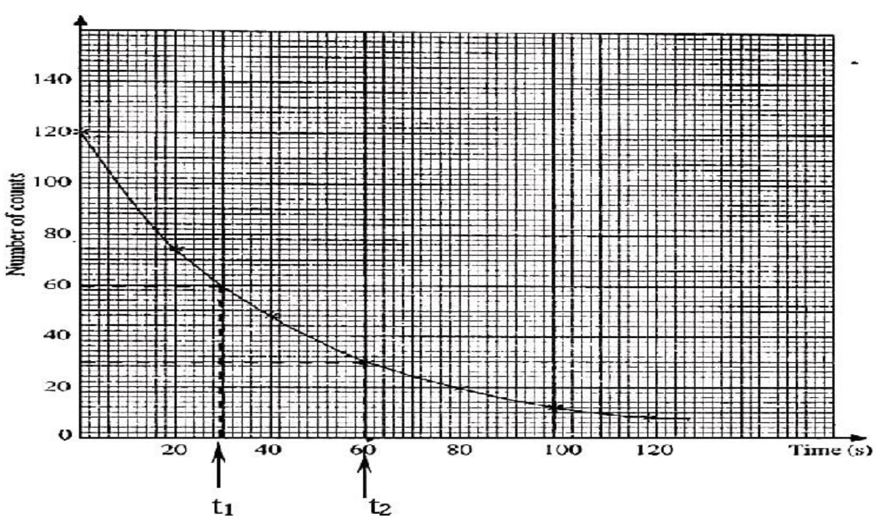
Consider the fig below



Whereby;

- **1T1/2** = First half life, **2T1/2** =Second half life and **3T1/2** =Third half life period

Example 1. From the figure below determine the half life



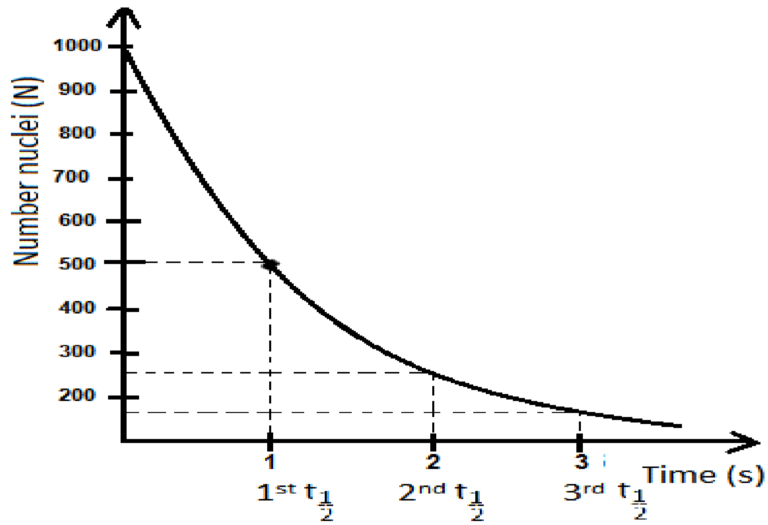
Half life, $t_{1/2} = (t_2 - t_1)$

$= 60 - 30$

$\underline{t_{1/2} = \textbf{30 seconds}}$

4. Isotope has a half-life of 1min and 1000 nuclei initially present, after 1min will decay to 500 nuclei, next 1min will decay to 250 nuclei, and next 1min will decay to 125 nuclei and so on

Graphically



NB:

- Half-life is the same for isotope
- Half-life is independent to physical state, temperature and pressure
- Radioactive isotope never decay to zero value

Individual task – 3:3

1. A sample of a radioactive contains 120 nuclei. Calculate the number of half-life it takes for the sample to decay so that there are only 15 nuclei left undecayed **(ANS: n =3)**
2. What is the half life of a radioactive material if its activity falls to 1/8 of its value in 3360 seconds
3. The half-life of iodine-131 is 8 days. A sample contains 800g of iodine-131. How much of the sample will remaining undecayed after 40 days (**ANS: 25 g)**
4. The half-life of iodine-131 is 8 days. A sample contains 16g of iodine-131
   (a) Draw a graph to represents
   (b) From the graph determine mass of the sample which will remain undecayed after 20 days
5. Archaeologist can determine the age of organic matter by measuring the proportion of carbon -14 present in a sample. Assuming that carbon -14 has a half –life of 5600 years ,Calculate the age of a piece of wood found to contain 1/8 as much carbon -14 as in a living material (**ANS: t = 16 800 yrs**)
6. Explain why long half –life of nuclear waste products presents a health hazard **(ANS: If the half –life is long/large, the activity remains at a very high level for a very long time resulting in a health hazard)**
7. A radioactive isotope **M** decays by emitting two alpha and beta particles to form $^{214}_{83}\boldsymbol{Y}$**.** What is the atomic number of **M**. After 224 days, 1/16 of mass of **M** remained. Determine the half life of **M**.**(ANS: Atomic number = 87, $t_{1/2}$ = 56 days)**

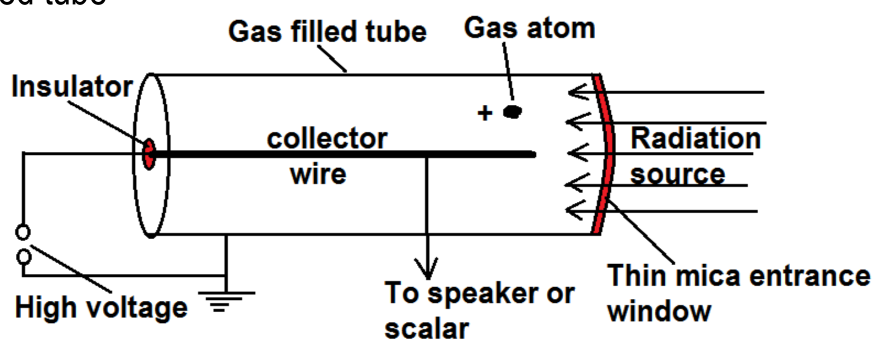
Detection of Nuclear Radiations

- Nuclear radiation is detected by its ability of ionizing the atom/molecules of gas passed through the detector, we have about many devices but the first-three are the common detectors includes

(a) Geiger Muller tube (GM tube)
(b) Spark counter
(c) Cloud chamber
(d) Photographic plate (film)
(e) Bubble chamber
(f) Gold leaf electroscope

Geiger Muller Tube

- Is a device which detects radiations by ionization of noble gas such as argon in a closed tube



Composition of Gm Tube

- ✓ Hollow tube consists of noble gas (argon) coated metallic film maintained at a high negative voltage relative to the collector
- ✓ Mica thin window at one end where radiation allowed passing through mica during detection
- ✓ A collector wire at the centre of tube

Mechanism of Gm Tube

- When radiation enters the tube, it causes electrons to be ejected from the gaseous atoms and are then accelerated toward the positively–charged collector wire
- Then an electron strikes the wire causing a brief pulse of electric current to be produced
- Finally the current can cause a ''click'' in a speaker or be counted by a scalar

Background radiation

- **Is** the natural radiation that is always present in the environment
- It comes from (sources) the earth's crust, the atmosphere, cosmic rays and radioisotopes

Background Count Rate

- Are the radiations present in the environment even when there is no apparent radioactive material around

OR Is the number of counts recorded by a radiation detector from background radiation

OR Is the evidence or effect on a detector of radiation caused by background radiation

Source of Background Count Rate

- Earth's radioactive impurities
- Residue of nuclear radiation present in G.M.T
- Cosmic rays escape from outer space through ozone layer

NB:

- A GM tube left well away from a radioactive source will still count some radioactive emissions (The background count).
- If the GM tube is placed close to a radioactive source, it will count the emissions from the source and the background count
- Background radiation count must be subtracted from the total count registered by a detector to obtain the actual /correct count of the source
- Example if the background was 5 Bq and the count recorded is 45 Bq, then the count from the source is **(45 – 5 = 40 Bq)**
- In calculations the Background count rate is treated as zero. i.e. not allowed (it is subtracted from recorded count rate)

Individual task – 3:4

1. The activity of a radioactive element when measured using the Geiger Muller tube was found to be 63 counts per minute. Given that the background radiation was 8 counts per minute, determine
   (a) The actual activity of the radioactive element **(Actual Activity = 63 – 8=55 c.p.m)**
   (b) The half –life of the element if the activity dropped from 128 counts/minute to 23 counts per minute in 6 hours (**ANS: t = 2hrs)**
2. In an experiment to determine the half –life of the radioactive element, the following data was obtained.

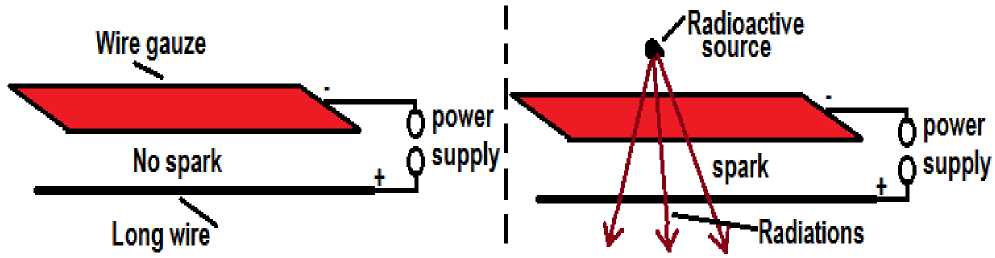
Activity (counts) per minute	52	44	34	28.5	24	19.0	17.5	15
Time (minutes)	0	0.5	1.0	1.5	2.0	2.5	3.0	3.5

   (a) Given that the background radiation is 10 counts per minute, Plot a decay curve for the element
   (b) Estimate from your graph, the half –life of the element **($t_{1/2}$ = 1.15 minutes)**
3. A Geiger Muller tube connected to rate meter is hold near a radioactive source, the corrected count rate(allowing for Background count rate is 400 c.p.s. 40 min the corrected count rate is 25c.p.s. What is the half-life of the source? **(ANS $t_{1/2}$ = 10 min)**
4. A rate meter records a background count rate of 2 c.p.s, when a radioactive source is held near the count rate is 162 c.p.s. if the half-life of the source is 5 min. what will the recorded count rate be 20 min? (**ANS N = 10 c.p.s)**

Spark Counter

- Spark counter is the device used to detect the presence of radiation based on their ability to ionize dry air molecules by producing sparks

Diagram



Composition of Spark Counter

- ➢ Piece of wire gauze
- ➢ Long wire
- ➢ Power supply with voltage below level required to cause a spark

Mechanism of Spark Counter

- When radiation pass through dry air cause dry air to ionize which increases conductivity of dry air allowing electrons to pass through them to form sparks

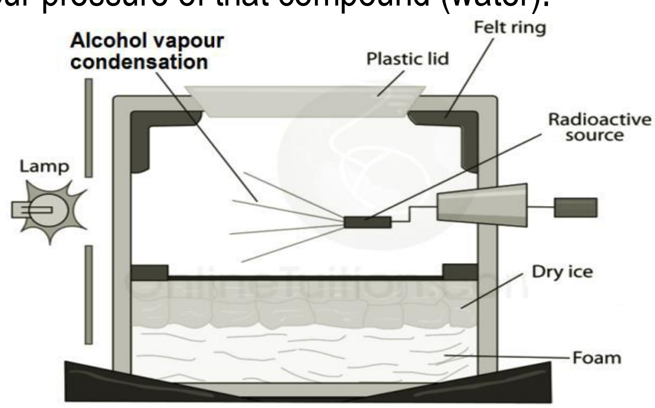
NB:

The number of sparks produced depends on the types of radiation emitted

- ✓ When Alpha (α) particles are emitted the largest number of sparks are produced due to highest ionization effect
- ✓ When Beta (β) particles are emitted the least number of sparks are produced due to moderate ionization effect
- ✓ When Gamma (γ) rays are emitted the few number of sparks are produced due to lowest ionization effect

Wilson Cloud Chamber

- Is a device used to detect presence of radiation by producing tracks of light
- It is sealed environment containing a supersaturated vapour of water, alcohol or any other compound that can be kept near its condensation point by regulating the temperature of the chamber. Supersaturated vapour of water refers to a vapour of a compound (water) that has a higher (partial) pressure than the vapour pressure of that compound (water).



Composition of Cloud Chamber

- ✓ **Felt ring soaked in alcohol**: to supply alcohol vapour to the chamber
- ✓ **Radioactive source**: produce radiation and cause ionization of vapour
- ✓ **Dry ice**: uses to cool the alcohol vapour until it is saturated
- ✓ **Alcohol vapor condensation**: to form liquid droplets around the ionized molecule
- ✓ **Lamp**: uses to light track which cause to view it clear
- ✓ **Foam**: support dry ice
- ✓ **Plastic lid**: the eyepiece

Mechanism of Cloud Chamber

- The air inside chamber is ionized by the radiation in its path.
- This leads to the formation of air ions
- Alcohol vapor condenses on these air ions forming droplets along the path ie forms some tracks
- These droplets/tracks are visible and so radiation is detected
- Each radiation forms a definite pattern. The radiation is identified by analyzing the nature of the pattern formed

Tracks formed by alpha particles   Tracks formed by beta particles   Tracks formed by gamma rays

Individual task – 3:5

A snap shot photograph of a cloud chamber shows 40 tracks well defined alpha particle track. A second snap shot taken 2 min later shows only 10 tracks. What is the half-life of the alpha source? **(ANS: $T_{1/2}$ = 1 min)**

Photographic Film

- Radiation exposes the film

Bubble Chamber

- It is similar to a cloud chamber but bubbles are formed in a liquid along the path of the radiation. It detect alpha and beta particles

Gold Leaf Electroscope

- Charged leaf of the electroscope collapses when a radioactive source is brought nearby. Then the air surrounding the leaves become ionized, the charge on the leaf can "leak" away

Advantage of diffusion cloud chamber detector over charged electroscope

- It can detect alpha, beta and gamma radiations unlike a charged electroscope which can only detect alpha particles

Difference between X-Rays and Gamma Rays

- x-rays are caused by energy transition in electron **while** gamma rays are caused by nuclear reaction within the nuclear
- metal (e.g. tungsten) used to produce x-rays not decaying **while** metal used to produce gamma rays decaying
- Wavelength of x-rays determined by nature of target and operating voltage **while** gamma rays depending on the nuclear for their wavelength
- X-rays are emitted by stable atoms of heavy nucleus **while** gamma rays formed nucleus of energetically unstable to became stable

Class Activity – 3

1. A patient suffering from cancer of thyroid glands is given a dose of radioactive iodine 131, with a half-life of 8 days, to combat diseases. He is temporarily radioactive and his nurse must be changed regularly to project them. If his radiation is initially 4 times the acceptable level, how long is it before the special nursing radiations can be dropped (**ANS : t = 16 days)**
2. The half life of iodine – 131 is 8 days .A sample contains 16 g of iodine – 131
   (a) Draw a graph to represent the decay of the sample
   (b) From the graph determine mass of the sample which will remain undecayed after 20 days **(ANS: (a) Draw graph (b) 3g)**
3. **A sample contains 800 g of** iodine – 131.How much of the sample will remain undecayed after 40 days ? (The half life of iodine – 131 is 8 days) **(ANS: 25 g)**
4. Isotope A has a half – life of 36 s and decays by emission of alpha particle to Isotope B . Isotope B has a half life of 18 s and decays by emission of beta particle to isotope C which is stable .A sample initially contains 120 mg of pure Isotope A. After 72 s :
   (a) What mass of Isotope A remains?
   (b) What mass of Isotope B has been produced?
   (c) Of the mass of Isotope B produced, how much remains?
   (d) What mass of Isotope C has been produced?
   (e) After which of the following times would there be less than 1 mg of isotope A remaining? **((a) 120 s (b) 160 s (c) 240 s (d) 280 s)**
5. The half life of Technetium 99m is 6h. If 12 mg of Technetium 99m is injected into a patient and starts to decay into Technetium 99m .Calculate the amount of Technetium 99m present in the patient after 24h ANS:
6. After 24 days, 2 mg of an original 128 mg sample remain .What is the half – life of the sample? (**ANS: 4 days)**
7. U – 238 has a half life of 4.46×10^9 years .How much U – 238 should be present in a sample 2.5×10^9 years old .If 2 g was present initially ? (**ANS: 1.36 g remain)**
8. How long will it take for a 40 g sample of **I–131** (Half – life = 8.04 days) to decay to 1/100 its original mass? (**ANS 53.4 days)**

9. If a radioactive element has a half – life of 40 minutes. Initial count rate was 1000 per minute , then how long will it take for count rate to drop to 125 per minutes?(**ANS:120min)**

10. A particular radioactive has a half-life of 2.0 hours. A sample gives a count rate of 2400 per second at 11:00 am. When will the count have dropped to approximately 300 per second in the same counting system?

11. 8 x 10^8 atoms of Radon were separated from Radium. The half life of Radon is 3.82 days. How many atoms will disintegrate after **7.64 days? (ANS: = 6 x 10^8 atoms)**

12. The half life of a radioactive element is 10 minute. Calculate how it takes for 90% of a given mass of the element to decay.(**ANS: Therefore, time = 33min)**

13. A radioactive material has a half life of 16 days. How long will it take for the count rate to fall from 160 counts /min to 20counts/min? (**ANS:** t= 48 min)

14. The half life of the Bismuth is 20min what fraction of a sample of this radioactive bismuth $^{214}_{83}Bi$ remain after 2 hours? (A**NS:** $\frac{N}{N0} = \frac{1}{64}$)

15. A radioactive nucleus is denoted by the symbol $^{288}_{92}Y$ write down the composition of the nucleus at the end of each of the following stages of disintegration.

(a) The emission of an alpha particle. (b) The further emission of a beta particle.

(**ANS (a.)** $^{288}_{92}Y \rightarrow {}^{284}_{90}X + {}^{4}_{2}H \quad (b) {}^{284}_{90}X \rightarrow {}^{284}_{90}M + {}^{0}_{-1}e, p = 91, n = 193$**)**

16. The count rate recorded by Geiger Muller tube and counter close to an alpha particle source is 400 per minute after allowing for the back ground count. If the half life of the source is 4 days.

(i)What will be the count rate 12 days later?

(ii) What should be determined over period of several minute rather than over a few second? (**ANS: C = 50 count/min,** This is because the rate of emission was so fast).

17. A rate meter record a background count rate of 2 counts per second when a radioactive source is held near the count rate is 162 counts per second. If the half life of the source is 5 minute what will be the recorded count rate be 20min later? (ANS: Therefore C = 10counts /sec, Hence the recorded count rate = 10 + 2 = 12 counts/sec)

18. A Geiger Muller tube connected to a rate meter is held near a radioactive source. The correct count rate allowing for background count is 400 counts per second. 40 min later the corrected count rate is 25 counter rates per second. What is the half life of the source? (**Half life = 10 minutes)**

19. The rate os disintegration of a radioactive substance is recorded after every 3 days ,as shown in the table below .Back ground radiation is 10 counts/day .Plot an appropriate graph and use it to determine the half – life of the substance .Show how you obtained your answer

Time(days)	0	3	6	9	12	15
Counts/day	123	95	66	47	34	25

20. The following symbol represents an isotpe of nickel: $^{60}_{28}Ni$

(i) What do the superscript and subscript represent?

(ii) How many protons and neutrons are there in the nickel isotope?

21. The half – life of Thorium – 234 is 24 days .Calculate the mass remaining unchanged of 0.64 g of the substance after

(a) 48 days (b) 72 days (c) 96 days

22. Chlorine exists in two forms – chlorine – 35 and chlorine – 37 .The atomic number of chlorine is 17

(a) What name is given to different forms of the same element ?

(b) Write down the number of protons and neutrons in each type of chlorine atom

23. Radon has a half – life of 91 h 12 min .How long will it take until only 1/8 0f a sample of radon remains unchanged ?

24. A radioisotope has a half – life of 8 hours. At 12 noon on 2 march a GM tube measures an activity of 2400 Bq.

(a) Calculate the activity at 4.00 am on 3 march

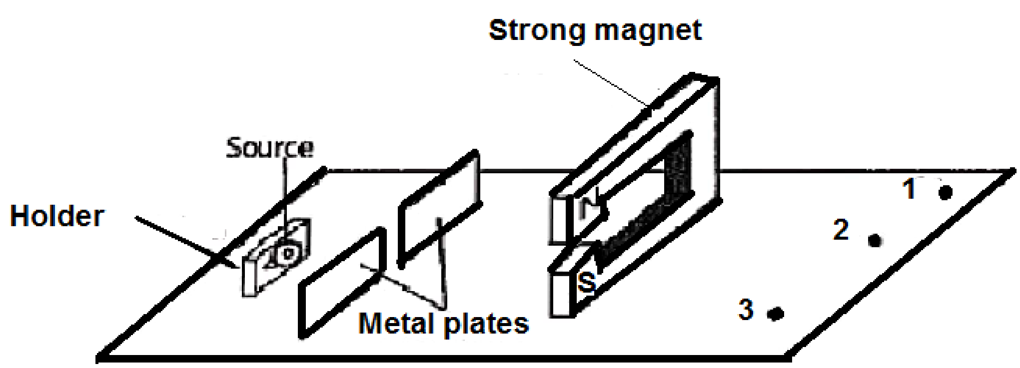
(b) Determine the time at which an activity of approximately 75 Bq will be measured

25. The limit of carbon dating is about 50 000 years. Explain why?

26. Archaeologists are analysing ancient bones from a human settlement. They discover that a sample of bone has one – sixteenth of the carbon – 14 of modern human bones. Determine the age of the setllement (Given that the half – life of acrbon – 14 is 5700 years)

27. A radioactive material has a half life of 2 minutes. Explain what that means . Determine how much of the material will be left after 8 minutes

28. A radioactive source is known to emit one type of radiation only, i.e $\propto, \beta\ or\ \gamma$. The source was placed in a holder as shown in the figure below , first without a magnet and then a magnet was introduced . A detector was placed at positions 1,2 and 3 and the count rates recorded in the table below



Table

	Counts per minute	
Detector position	Magnet not present	Magnet present
1	26	295
2	300	28
3	28	26

(e) What is the reason for placing the two metal plates in front of the source?
(f) What is the value of the background counts per minute? **(ANS: 27 c.p.m)**
(g) Define the background count

29.A radioactive element has an initial count rate of 1200 counts per minute measured by a scale and this falls to 150 counts per minutes in 15 hours
(a) Determine the half – life of the element **(ANS: Half life = 5 hours)**
(b) If the initial number of atoms in another sample of this element is 3.0 x 10^{20}, how many atoms will have decayed in 25 hours? **(ANS: 9.375 x 10^{18} atoms)**

30. Give any four uses of cathode ray oscilloscope(CRO)

31. State two ways in which X – rays differ from gamma rays

32. A radioactive nucleus is denoted by the symbol $^{284}_{90}X$ Write down the composition of the nucleus at the end of the following stages of disintegration
(i) Emission of an alpha ($\propto$)particle
(ii) Further emission of beta(β) particle
(iii) Further emission of a gamma (γ) radiation

33. A particular radioactive has a half – life of 2.0 hours. A sample gives a count of 2400 per second at 11:00 a.m. When will the count have dropped to approximately 300 per second in the same counting system? (ANS: will be 5:00 p.m)

34. Identify the type of radiation from the evidence supplied below:
(a) Absorbed in a few centimeters of air deflected by a magnetic field.
(b) Very penetrating rays, not deflected by a magnetic field, harmful to living things
(c) Mostly absorbed by a few millimeters of alluminium, deflected by a magnetic field
(d) Has a wavelength of several meters, an aerial is required for the transmission of these waves

35. Complete the following decay equation
(a) $^{3}_{1}H \rightarrow - + ^{0}_{-1}e$ (b) $^{14}_{6}C \rightarrow - + ^{0}_{-1}e$

36. Determine the superscripts and subscripts of the following
(a) $^{14}_{6}C$ (b) $^{238}_{92}C$ (c) $^{32}_{20}C$

37. s

Topic – 4 Thermionic Emission

- Thermionic emission: **is the discharge of electrons from the surfaces of heated materials.**

OR

- Thermionic emission is the process by which free electrons are emitted from the surface of a metal when external heat energy is applied
- **N.B** The rate of escaping (discharging) of electrons from a metal surface increases with the increase in temperature

How Thermionic Emissions Occur?

- Thermionic emission occurs when kinetic energy of electrons from the surface of the heated metal overcome the work function of the metal

Work Function

- Is the minimum kinetic energy needed by an electron for it to escape completely from the surface of the metal

OR

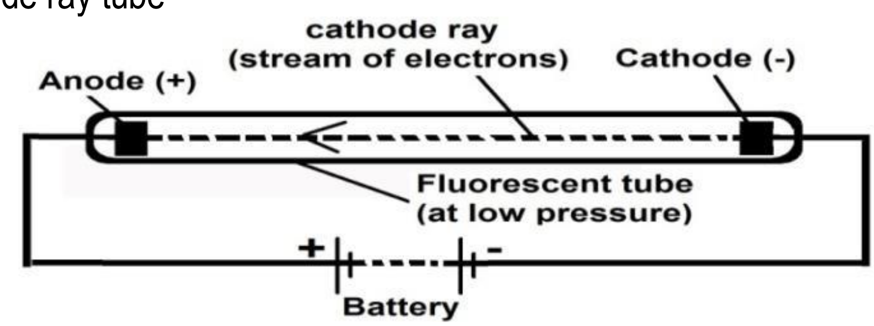
- Is the minimum energy needed to remove an electron from a solid to a point in the vacuum immediately outside the solid surface.

Types of Thermionic Emission

- Cathode rays
- X- rays

Cathode Rays

- Are fast moving electrons emitted from cathode moving to the anode in a cathode ray tube



Properties of Cathode Rays

- ❖ They travel in straight lines.
- ❖ They carry negative charges.
- ❖ They cause fluorescence (glow) when they strike materials.
- ❖ They have energy and momentum.
- ❖ They are deflected by electrical and magnetic fields (toward South Pole).
- ❖ Cathode rays can ionize gas atoms if the potential difference is large and the gas pressure is not high.

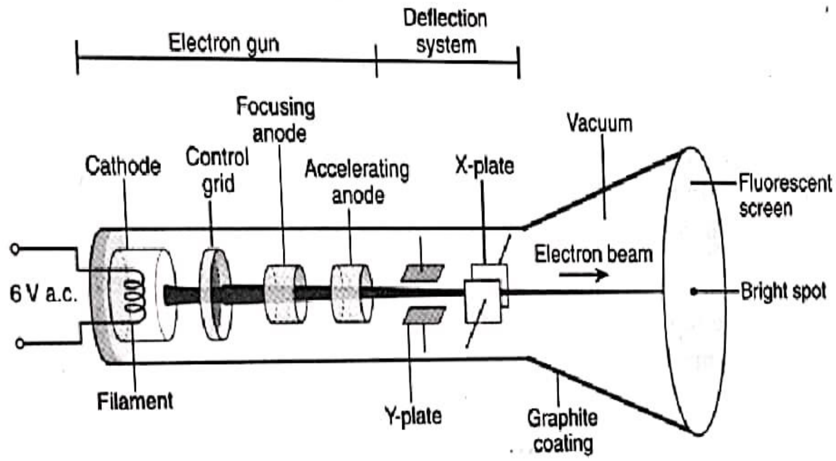
- ❖ They can penetrate thin sheets of paper or metal foils depending on their energy.
- ❖ They affect photographic plates.
- ❖ They produce X-rays when stopped suddenly

The Cathode-Ray Tube (CRT)

- Is an evacuated vacuum tube containing electron gun used to accelerate and deflect the electron beam(s) onto the phosphorescent screen to create the image

OR

- Is an electronic tube designed to display electrical data (see the fig. below)



Why Cathode-Ray Tube is evacuated?

- Cathode-Ray Tube is evacuated so as to minimize air or electric resistance in order to make electrons travel without colliding with other particles

OR **The tube is evacuated so as to prevent the electrons from losing their energy as a result of interacting with air particles before reaching the screen**

What would happen if CRT not vacuums?

- If gas is maintained in the tube (at atmospheric or high pressure), the tube will behave like an open circuit (insulator), when p.d across it is strong enough it will cause an electric spark which will ionize the air and make it conduct electricity
- **Therefore** if the gas is maintained in the tube there is no production of cathode rays thus the fluoroscope screen will not form image

NB:

- Conduction in gases and response of the tube, depend on pressure of gas**.** At atmospheric pressure of a gas will behave simply as an insulator

Components of the Cathode-Ray Tube

- Electron Gun
- Deflection system
- Fluorescent Screen

1. **Electron Gun**
- It is used to produce electrons at a high fixed velocity.
- This is done through the process of thermionic emission
- It consists of **Heate**r, **cathode**, **control grid**, **accelerating** and **focusing anode**.

(a) **Heater**
- Its heating element is used to heat cathode to high temperatures from 800°C to several thousand degrees Celsius either directly by an electric current or indirectly

(b) **Cathode**
- This is a metal filament such as tungsten heated by electron gun resulting metal electrons attains enough kinetic energy than a Work Function of a metal and escape the cathode by thermionic emission

(c) **Control grid**
- This controls the brightness (intensity) of the beam by controlling the rate of flow of electrons

(d) **Accelerating anode**
- This is a metal disk maintained at a high positive voltage of 5 000 V to 50 000 V used to pull electrons from cathode to focusing anode

(e) **Focusing anode**
- This is a metal disk maintained at a high positive voltage of 5 000 V to 50 000 V used to pull electrons received from accelerating anode to deflection system up to fluoresce screen

2. **Deflection system**
- It is used to deflect the electron beam either vertically or horizontally
- It is used to control the image produced by controlling the position that the electrons hit the screen
- It consists of **horizontal (x) deflection plates** and **vertical (y) deflection plates**

(a) **Horizontal (X) Deflection Plates**
- They are used to deflect the electron beam horizontally (left or right).

(b) **Vertical (Y) Deflection Plates**
- They are used to deflect the beam vertically (up or down)

3. **Fluorescent Screen**
- This is the display component of the CRT where image displayed.
- It is phosphor coated so that it emits light wherever the electrons strike it

NB:
- The horizontal and vertical deflection plates can direct the beam towards any point on the screen. In some devices, the electrically charged plates are replaced by poles of electromagnets.

- The deflection plates move the electron beam to different points on the screen resulting in the formation of an image for a short time about (20^{-1} sec) or 0.05 Hz

Operation of the Cathode-Ray Tube

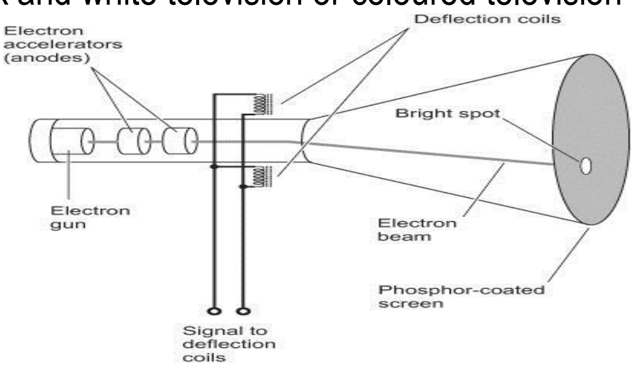
Cathode is heated indirectly by a heater (electric gun) until thermal electron emission. The electrons emitted are controlled by grid towards anode. After travelling through the hole in the anode the electrons hit the luminescent screen, causing them to slow down and excite the phosphor in the screen to fluorescence

Applications of the Cathode-Ray Tube

- computer display (Monitor)
- Televisions (TV)
- As a display device in RADAR
- cathode-ray oscilloscopes (CRO)

Televisions (TV)

- It may be black and white television or coloured television



Operation of black and white television

The signal is first amplified and then applied to the vertical deflection plates to deflect the beam vertically. At the same time, a voltage is applied to the horizontal deflection plates thus causing the beam to be deflected horizontally. The image is formed on the screen by varying the brightness at thousands of points on the screen. The brightness of a point on the screen depends on the number of electrons that strike it

Operation of colored television,

The signal is first amplified and then applied to the vertical deflection plates to deflect the beam vertically. At the same time, a voltage is applied to the horizontal deflection plates thus causing the beam to be deflected horizontally. The image is formed on the screen (**phosphors of primary colour**: **red**, **green** and **blue**). The image is formed by varying the intensity of the electron beam that strikes the different phosphors
NB:

- The intensity of the electron beam can be varied by **changing the voltage on the grid** located between the cathode and the anode

- The grid has a negative charge and so repels the electrons coming from the cathode
- By changing the grid's voltage it allows more or fewer electrons to pass on to the anode and ultimately to the screen
- Some color televisions use a single electron gun whereas others use three
- The process where plate voltage (signal) converted to image on fluorescent screen is called **scan**
- The horizontal and vertical motion of electrons towards fluorescent screen is called **scanning**

The Computer Displays

- Computer displays work in the same way as the television

The Cathode-Ray Oscilloscope (CRO)

- The cathode-ray oscilloscope is typically used to display signals in wave forms. It operates in a way similar to a television

Operation of Cathode-Ray Oscilloscope

- The signal is first amplified and then applied to the vertical deflection plates to deflect the beam vertically. At the same time, a voltage is applied to the horizontal deflection plates thus causing the beam to be deflected horizontally at a uniform (constant) rate. The signal applied to the vertical plates is thus displayed on the screen as a function of time. The horizontal axis serves as a uniform time scale. The screen of the CRO is covered with a grid to facilitate measurements.

Uses of Cathode-Ray Oscilloscope (CRO)

- Measuring frequencies
- Measuring Voltages
- Measuring phase differences
- Measuring small time intervals
- Comparison of frequencies

Advantages of the C.R.O for use as a Voltmeter

- It can measure both direct and alternating current
- It can measure very large voltages without getting damage
- It does not take any current due to its high resistance and therefore does not interfere with the circuit

X-Rays

- Are electromagnetic waves with very high frequencies and short wavelengths

How are they produced?

- X-rays are produced whenever fast moving electrons are sopped suddenly by metallic targets

The X-Ray tube

- Is a vacuum tube that converts electrical input power into X–Rays

OR

- Is a device for generating X- Rays by accelerating electrons to high energies and causing them to strike a metal target from which the X–Rays are emitted

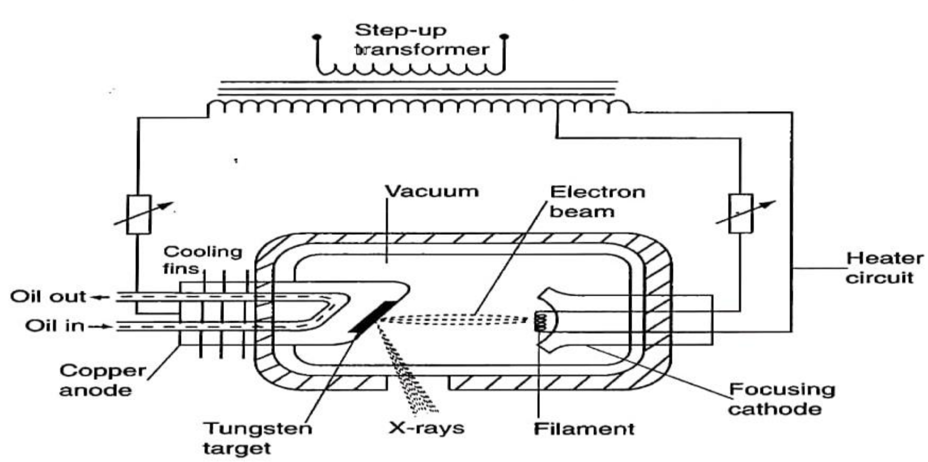
OR

- Is the highly evacuated glass bulb contains cathode and anode made of platinum and tungsten or heavy metal of high melting point

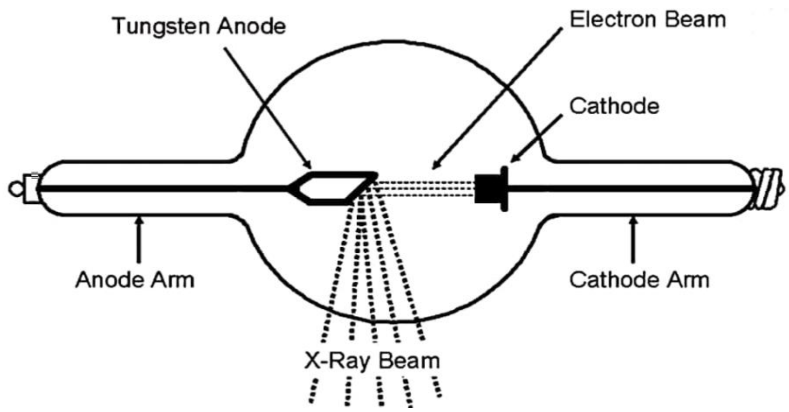
X – Rays tube consists of:-

- Heater – produce heat.
- The cathode is concave shaped **so that it can focus the electrons onto the target**
- The anode is made of a good conductor of heat such as copper. This is used to ensure that the heat generated when electron hits the target is quickly conducted away from the target
- The target is made of tungsten because tungsten has a high melting point therefore can withstand the heat generated without melting
- Cooling in X –ray tube is enhanced by
  (i) The cooling fins outside the tube
  (ii)The oil circulating through the channels in the copper anode
  (iii)The anode made of a good conductor of heat (copper)
- The tube is highly evacuated so that electrons don't collide with air particles on their way to the target. The air particles can cause the electrons to lose some of their kinetic energy
- **X –ray tube** is surrounded by lead shield .This is used to absorb and stray X-rays

THE X – RAY TUBE



Alternative diagram



How it works to produce X –rays?

- Current flows through the filament, which then becomes hot and electrons are then emitted by the process of thermionic emission
- The emitted electrons are then accelerated towards the target (anode) by the high potential difference between the anode and the cathode
- When the electrons hit the tungsten target, they are stopped and X–rays are produced
- Only 0.5% of the kinetic energy of the electrons is converted to X –Rays. The rest is converted to heat

Energy changes occurring in the X –ray tube during the production of X –rays

- **Electric energy** $\rightarrow \boldsymbol{Heat\ energy} \rightarrow \boldsymbol{Kinetic\ energy} \rightarrow \boldsymbol{Heat\ energy\ and\ X - rays}$

Types of X-Rays

- Soft X-rays
- Hard X-rays

Soft X-Rays

- Are the X-rays that produced by lower accelerating potential with longer wavelength and lower range of frequency
- They have less energy and less penetrating power

Hard X-Rays

- Are the X-ray produced by high accelerating potential with short wavelength and higher range of frequency.
- They have high energy and more penetrating power

Differences between hard and soft x-rays

Hard x-rays	**Soft x-rays**
Produced by high accelerating potential	Produced by low accelerating potential
Have shorter wavelength (high frequency)	Have longer wavelength (low frequency)
They have higher energy	They have less energy
Have higher penetrating power	Have lower penetrating power

N.B

- **The quality** (hardness or softness) of X-rays is controlled by **the potential difference between the filament and the target.** The higher the potential difference, the harder the X –rays produced
- **The intensity** (amount) of X –rays produced is controlled by **the heating current** .The higher the heating current , the more the electrons emitted and hence the higher the intensity of the X-rays

Properties of X-Rays

- ✓ They travel in straight line at the velocity of light
- ✓ They cannot be deflected by electric or magnetic field
- ✓ They can produce fluorescence
- ✓ They affect photographic film
- ✓ They penetrate matter but depend on density of matter
- ✓ They ionize gases.

Application (Uses) of X-Rays

1. **In the medical field soft X-rays are used**
   - To detect broken or fractured bones or some disease in soft tissue
   - Treatment of cancer
   - To detect growth inside the body
   - To detect foreign objects in the body
2. **Crystallography**: Experimental study of the arrangement of atoms in solid (study of arrangement of crystals)
3. **Astronomy**: X-rays emitted by celestial objects are used in observational astronomy
4. **X-ray microscopic analysis**: involves the use of electromagnetic radiation in the soft X-ray band to produce image of very small objects
5. **X-rays fluorescence**: technique in which X-rays are generated within a specimen and detected. The outgoing energy of the identified composition of the sample
6. **Security installation**: They are used for non-invasive security searches at airports and seaports
7. **In industries**:
   (i) It is used to inspect metal-casting and welded joints for hidden faults
   (ii) They are used to sterilize surgical equipment before packing

Effect of X – Rays to Human Beings

- ❖ Destroy body cells and can cause cancer
- ❖ Can cause mutation due to destroy of genitals

Precautions

- Exposure to X –rays should be limited to short time intervals
- Concrete walls should be used for rooms that store X- rays tubes
- X –rays tubes should be surrounded by lead shield to protect operators from stray X–rays

Class Activity

1. (a) State one way in which cathode rays differ from electromagnetic waves and describe an experiment which illustrates this difference
   (b) Draw a labeled diagram of a longitudinal section view of the cathode ray oscilloscope tube showing its main features

5. (a) (i) What are the two types of X – rays?
(ii) X – Rays are said to have harmful effect to human beings when used for a long time. Explain the effect that X – rays cause to human beings
(b) Describe how X – rays are produced in X – ray tube
(c) Show the three main parts of cathode ray oscilloscope on a well labeled diagram

6. (a) Write two properties of (i) X rays (ii) cathode rays
(b)(i) Give any four uses of cathode ray oscilloscope (CRO)
(ii) State two ways in which x – rays differ from gamma rays

7. (a) Explain briefly the following
(i) Thermionic emission
(ii) The production of a stream of electrons in cathode ray oscilloscope (**C.R.T**)
(b) What method in a device using the thermionic emission principle ensures that the electrons produced
(i) Do not accumulate at the source? (ii) Reach their range undeviated?
(iii) Travel without meet other forms of particles on their way to the target?

8. (a) (i) Explain why cathode ray tube (CRT) are evacuated
(ii) What happens to the CRT when a gas is maintained?
(iii) If gas is maintained in a CRT, will the image be formed onto the screen? Explain
(b) In the production of X – rays what are roles of:
(i) Low voltage (ii) High voltage? (iii) Tungsten target?
(c) How is hard X – rays produced?

9. (a) (i) Define thermionic emission
(ii) What is X – rays? (iii) Mention two uses of X – rays
(b) With the aid of a diagram, explain how X – rays are produced
(c) Draw a well labeled diagram of a cathode ray oscilloscope.

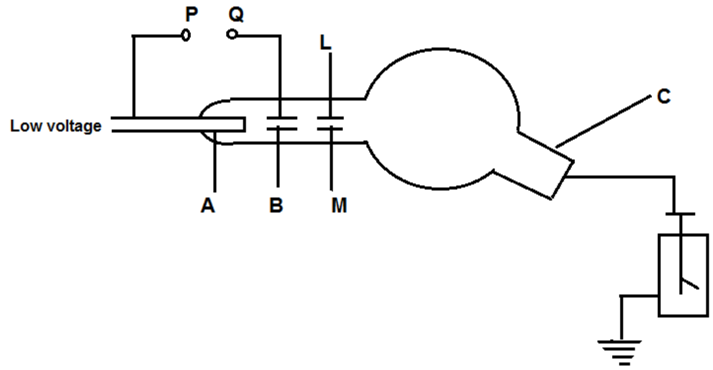
10. State one property of X –rays which makes it possible to detect fractured bones

11. The penetrating power of x –rays is normally varied depending on the intended use. Explain briefly how this is done

12. X –rays are passed through the air surrounding a charged electroscope. State what is observed.

13. How can the intensity of X-rays in an X –ray tube be increased

14. The figure below shows a circuit of a special type of a cathode ray tube



(a) Name the parts labeled A and B (**ANS: A = Cathode B = Grid**)

(b) C is a metal can mounted inside the tube and is connected externally to a negatively charged electroscope with its casing earthed. The p.d across the metal L and M was then adjusted so that the cathode rays were deflected into the can and it was observed that the electroscope leaf rose steadily

- **(i) Why** did the leaf rise steadily? (**ANS:** The leaf rose steadily due to the extra accumulation of negative charges. Like charges repel**)**
- **(ii) What does** the result in (ii) above tell you about the charge on the cathode rays (**ANS: cathode rays are negatively charged**)
- **(iii) Stat**e one other property of cathode rays not mentioned above

15. (i) What is thermionic emission?

(ii) Name two factors on which the rate of emission depends.

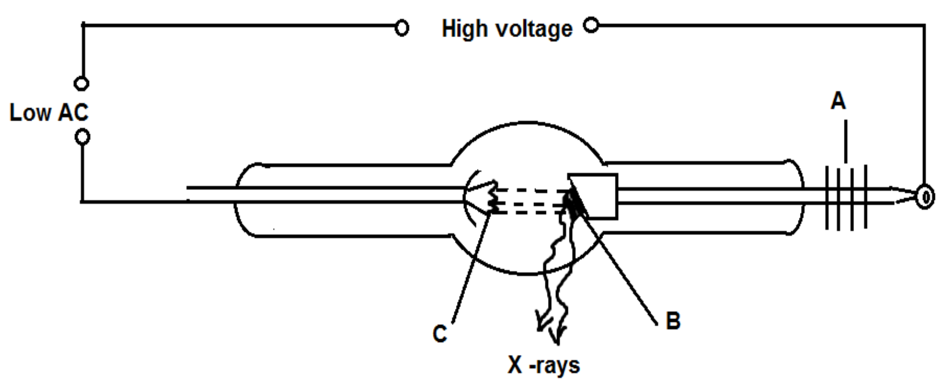
ANS.

(i) Thermionic emission: The phenomenon due to which free surface of the metal emits electrons, on being heated

(ii) Factors determining the rate of emission of thermion:

- ✓ It is inversely proportional to the work function of a material.
- ✓ It is directly proportional to the temperature of the surface emitting thermions.
- ✓ It is directly proportional to the surface area of the surface emitting thermions.

16. The figure below shows an X –rays tube



(a) Name the parts labeled A,B and C(**ANS: A =cooling fins B=metal target C= Filament cathode)**

(b) Explain how X –Rays are produced in a tube

(c) Why it is necessary to use an evacuated tube? (**ANS**: In order to minimize the chance of electrons colliding with air molecules)

(d) What are the purposes of high and low voltages.

- Low voltage heats up the cathode filament to emit electrons
- High voltage accelerates electrons towards the metal target

(e) With reason, state the most appropriate metal to be used to make part B

(**ANS**: tungsten/molybdenum, It has a high melting point)

17. In the production of X – Rays what are the roles of

(i) Low voltage? (ii) High voltage? (iii) Tungsten target?

ANS: **(i)** Used for heating the cathode

(ii) Used to provide a high p.d between the electrodes, for accelerating the electrons

(iii) Used for absorbing highly energetic electrons and emit X – Rays.(Converting K.E of electrons into electromagnetic waves and heat)

Topic – 5: Electronics

Electronics

Is a branch of physics that deals with the emission, behavior and effects of electrons in materials

OR

Is the study of how to control the flow of electrons

NB:

- ✓ The various electronic components connected to each other to form systems or circuits called **Electronic systems (Electronic circuits)**
- ✓ An electronic circuit is used to perform a wide variety of tasks. The main uses of electronic circuits are:
  - Conversion (ac to dc) and distribution of electric power.
  - Controlling and processing of data

Electronic Component

- Is any basic discrete device or physical entity in an electronic system used to affect electrons or their associated fields
- For example **power sources**, **resistors**, **capacitors**, **diodes**, **transistors**, and **integrated circuits** etc.

Types of Electronic Components

(a) Passive Electronic Components

- *Are electronic components that consume energy but do not produce energy*
- These include power sources (battery or generator), resistors, capacitors and inductors.

(b) Active Electronic Components

- Are electronic components that consume energy in the form of voltage or current and supply energy in the form of voltage or current.
- They include semiconductor devices such as **diodes**, **transistors** and **integrated circuits**

Insulators, Conductors and Semiconductors

An Insulator

- **I***s a material which resists the flow of electrical charges through it.*
- Insulator has infinite resistance and zero conductance.
- For example **glass**, **mica**, **paraffin**, **hard rubber** and also many plastics

Why resists the flow of electrical charges?

- It has no free electrons which are responsible to pass through electrical charges
- The atoms have tightly bound electrons

Conductor:

- *Is a material which allows the flow of electrical charges through it*
- For example **all metals** and **some non-metals** such as **graphite** (carbon)

A semiconductor

- Is a material in which its electrical conductivity intermediate between that of conductor and insulator.
- For example **silicon**, **germanium**, **cadmium sulphide** and **gallium arsenide**
- A semiconductor behaves as an insulator at very low temperature
  - Has a significant electrical conductance at room temperature, however, much lower than that of a conductor

Band theory

- Is the theory which explains about energy levels in a solid in terms of **energy band**

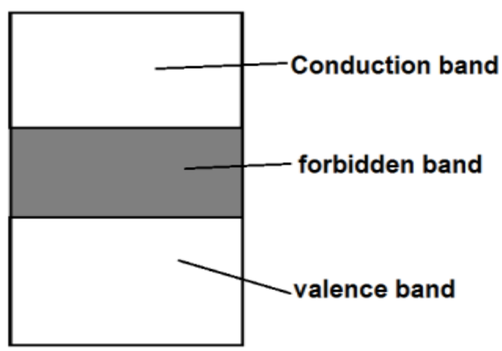
Energy Band

- Is a collection of closely spaced energy levels

OR

- Is the series of "**allowed**" and "**forbidden**" energy bands that it contains

Diagram:



- We have about three bands in which a band electrons possesses energy called **energy level**
  - Conduction band
  - Band gap (forbidden band)
  - Valence band

Conduction Band

- Is the upper most part of semiconductor in which there is few or no electrons
- It is sufficient to make the electrons free to accelerate under the influence of an applied electric field and thus constitute an electric current

N.B **In** conductors some electrons occupy the conduction band

Band Gap (Forbidden energy gap)

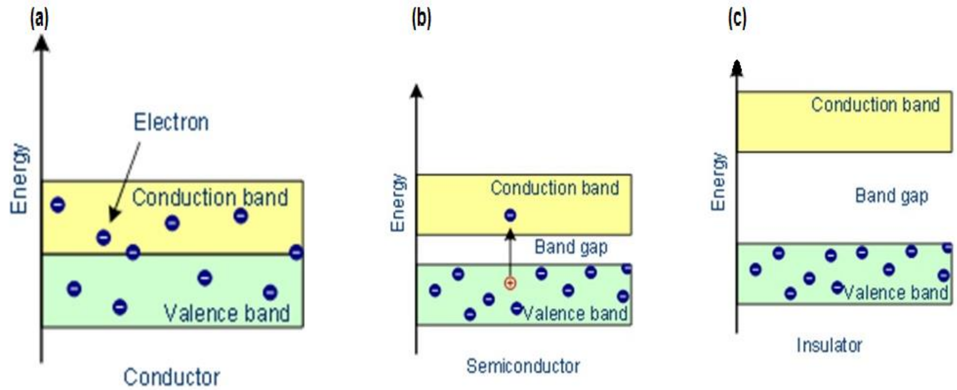
- Is the energy gap between the valence band and conduction band which cannot be occupied by electrons
- (**OR** Is the energy required to shift an electron from valence band to conduction band)

Valence Band

- Is the lower part of semiconductor in which there is completely filled with electrons
- The valence band is the highest range of electron energies where electrons are normally present at the absolute zero temperature

Forbidden energy gap (Fermi energy level).

- Is the energy gap between the valence band and conduction band which cannot be occupied by electrons
- The band obtained by separating conduction band and valence band is called forbidden energy band or forbidden gap.
- The figure below shows the conductor, semiconductor and insulator in terms of their energy level (band gap)



Energy bands of solids

For conductor

- There is no forbidden gap available, the valence and conduction band overlap each other (figure a)
- The electrons from valence band freely enter into conduction band
- Due to the overlapping of the valence and conduction bands, a very low potential difference can cause the continuous flow of current

For semiconductor

- The forbidden gap is very small (fig b)
- There are no electrons in the conduction band. The valence band is completely filled at **0 K**
- With a small amount of energy that is supplied, the electrons can easily jump from the valence band to the conduction band
- For example, if the temperature is raised, the forbidden gap is decreased and some electrons are liberated into the conduction band
- Germanium and Silicon are the best examples of semiconductors with forbidden energy gap of **0.7 eV and 1.1 eV** respectively

For insulator

- The forbidden energy gap is very large (fig c). It is more than **3 eV** and almost no electrons are available for conduction
- Therefore, a very large amount of energy must be supplied to a valence electron to enable it to move to the conduction band
- If the electron is supplied with high energy, it can jump across the forbidden gap. When the temperature is increased, some electrons will move to the conduction band. **This is the reason, why certain materials, which are insulators at room temperature become conductors at high temperature**

Difference between conductor, insulator and semiconductor

Conductor	Insulator	Semiconductor
The conductivity of conductor is very high.	The conductivity of insulator is very low.	The conductivity of semiconductor is moderate.
It has very low resistivity.	It has very high resistivity.	It has moderate resistivity.
It has no forbidden gap.	It has large forbidden gap.	It has small forbidden gap.
Has positive temperature coefficient of resistance.	Has negative temperature coefficient of resistance.	Has negative temperature coefficient of resistance
Both the effect of resistance and temperature are increasing	The effect of resistance decreases with the increase of temperature	The effect of resistance decreases with the of temperature increases.
There is large number of electrons available for conduction.	There is small number of electrons available for conduction.	There is moderate number of electrons available for conduction.
Examples: are Metals (aluminium, copper.etc)	Paper, Wood, Mica glass.	Silicon, Germanium.

How Semiconductor Conducts Electricity

- As the temperature is increased, some of the electrons in the valence band acquire thermal energy that is greater than the forbidden gap energy and move to the conduction band. Therefore, the material becomes a conductor. When an electron moves out of a valence band it leaves behind a small space called a **hole**. Electrons and holes in the conduction and valence bands, respectively, are referred to as **free charge carriers**.

Effect of temperature on metal conductivity

- Increase in temperature tends to increase the random motion of electrons. It reduces the electrical conductivity of metals

Types of Semiconductors

- Intrinsic semiconductors
- Extrinsic semiconductors

Intrinsic Semiconductors

- These are pure semiconductors in which there is no addition of impurities.
- Examples are silicon and germanium
- Conductivity in intrinsic semiconductors is limited hence ,they do not conduct electricity

Extrinsic Semiconductors

- *These are impure semiconductors materials which contains added impurities*
- *Examples are N – Silicon , N – Germanium P – Silicon and P – Germanium*

Difference between intrinsic from extrinsic semi-conductor

intrinsic	**extrinsic**
Is the pure form of semi-conductor	Is an impure form of semiconductor
It has equal number of holes and electrons in conduction and valence band respectively	It has unequal number of holes and electron
Its electrical conductivity depends on temperature only	Its electrical conductivity depends on both temperature and amount of doping
It has low conductivity	It has high conductivity
It is of no practical use	It is used in electronic devices

Doping

Is the process of adding impurities to intrinsic semiconductors to alter their properties

OR Is process of adding impurity atoms to intrinsic crystal to produce an extrinsic semiconductor.

OR Is the process of adding impurities in a pure semiconductor in order to increase electrical conductivity

Terms used In Doping

- Hosts are atoms which can accept or donate an electron. Example **All group IV** elements (Tetravalent) ie Silicon and Germanium
- **Acceptor atoms** are atoms which receive electrons from other atoms. Example **all group III** elements (Trivalent)
- **Donor atoms** are atoms which supply electrons to other atoms. Example **all group V elements** (Pentavalent)
- **Dopant** is the element/impurity which added to modify the conductivity of an atom

NB:

- Heavily doping a semiconductor increases its conductivity. That is why heavily doped **silicon** is often used as a replacement for metals

- **Silicon** and **Germanium** are the best semiconductors as they are used to make the most common electronic devices/components such as transistors and diodes (This is because the energy required to break their covalent bonds is very small **ie 0.7 eV for Ge and 1.1 eV for Si**)

Types of Doped Semiconductor (Extrinsic semiconductor)

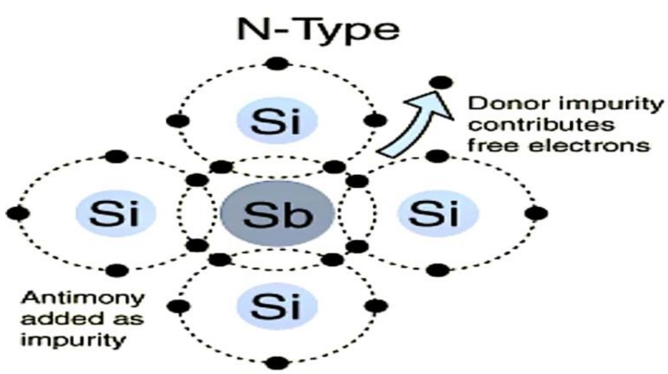
- N-type semiconductor
- P-type semiconductor

N-type Semiconductor

- Is the type of semiconductor in which the majority carriers are electrons
- Is formed when pure semiconductors are doped with pentavalent elements
- The purpose of n-type doping is to produce an abundance of mobile or carrier electrons in the material

Mechanism of Doping

- Consider the silicon with four valences (**with four electrons in their outer most shell**) combine with dopant of **more than four electrons** they will share the four valences results the extra electrons from dopant (group V) remaining as extra (free electrons). This extra electron is only weakly bound to the atom and can easily be excited into the conduction band, since the silicon atoms with five valence atoms have an extra electron to "**donate**", they are called **donor atoms**
- **Diagram of silicon after doping (**n-doping with Antimony, Sb)



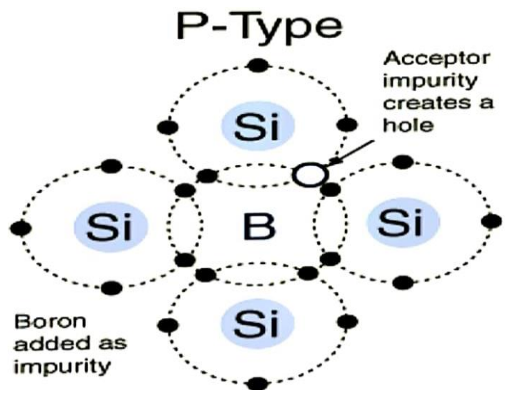
P-type Semiconductor

- Is the type of semiconductor in which the majority carriers are holes
- Is formed when pure semiconductors are doped with trivalent elements
- The purpose of p-type doping is to produce an abundance of holes in the valence band.

Mechanism of Doping

- Consider the silicon with four valences (**with four electrons in their outer most shell**) combine with Dopant (group III) of **less than four electrons** in their outer most shell they will share the three electrons results the semiconductor with less electrons (holes) to attain stability, since the silicon atoms with three valence atoms have a less electron to "**acceptor**", they are called **acceptor atoms**

- **Diagram of silicon after doping (**P-doping with boron)



COMPARISON BETWEEN N – TYPE AND P – TYPE SEMICONDUCTOR

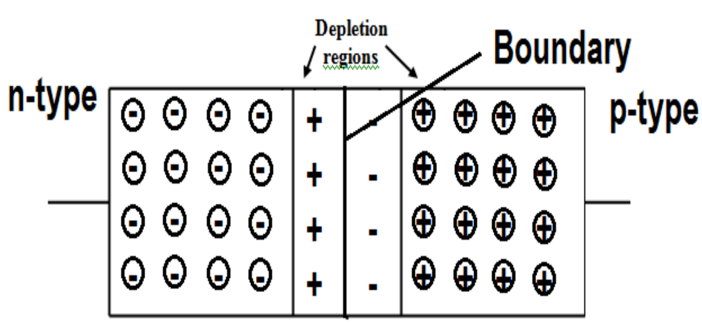
N – TYPE	P – TYPE
Produced by adding pentavalent impurities to a pure semiconductor.	Produced by adding trivalent impurities to a pure semiconductor.
The number of free electrons exceed the number of holes.	The number of holes exceeds the number of free electrons.
The majority charges are negative charges.	The majority charges are positive charges.
The donor energy level is just below the bottom of the conduction band.	The acceptor energy level is just above the valence band.

JUNCTION DIODE

- This is the p–n junction semiconductor material which is connected to supply voltage.

P–N Junction

- This is the junction made up by two semiconductor material of n – type and p – type melted together to form a junction.
- The boundary (junction formed) between the p – side and n – side is referred to as a **p – n junction**



Terms used in P-N Junction

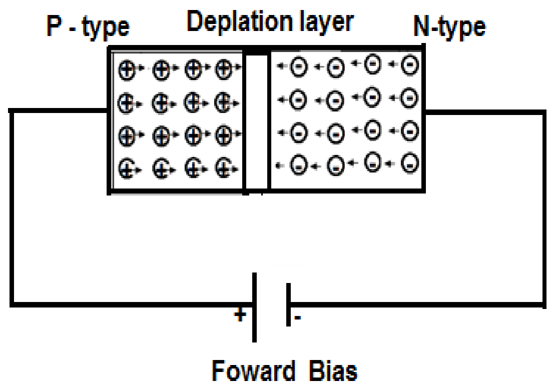
1. **Diffusion of charge** is the spreading out of charges (holes and electrons) which can result repelling and attraction of charge
2. **Potential barrier** is the maximum voltage at the junction when there is no further diffusion of charge
3. **Depletion layer**
    - Is a region in a P–N junction diode where no mobile charge carriers are present
    - It acts like a barrier that opposes the flow of electrons from n – side and holes from p – side

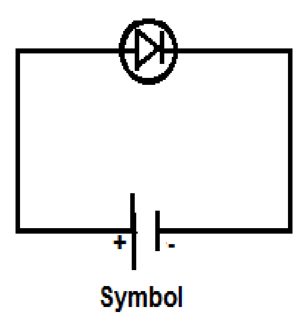
Biasing of the P – N Junction

- **A** p–n junction is said to be biased when a potential difference is applied across it
- When a P- N junction is connected to a power supply it is said to be biased
- A P- N junction allows current to flow only in one direction when the p – side is connected to the positive terminal of the power source and n – side to the negative terminal of the power source
- There are two modes of action of P-N junction, these are
    (a) Forward – bias
    (b) Reverse- bias

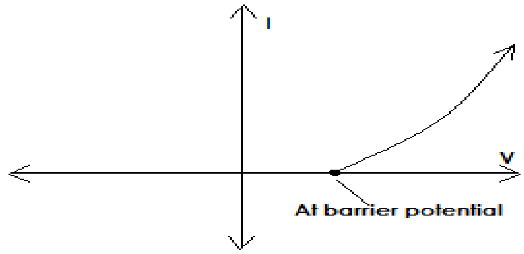
(a) Forward- Bias of P-N Junction

- A p–n junction is said to be forward biased when the p–type region is connected to the positive terminal while the n–type region is connected to the negative terminal of an external cell or battery





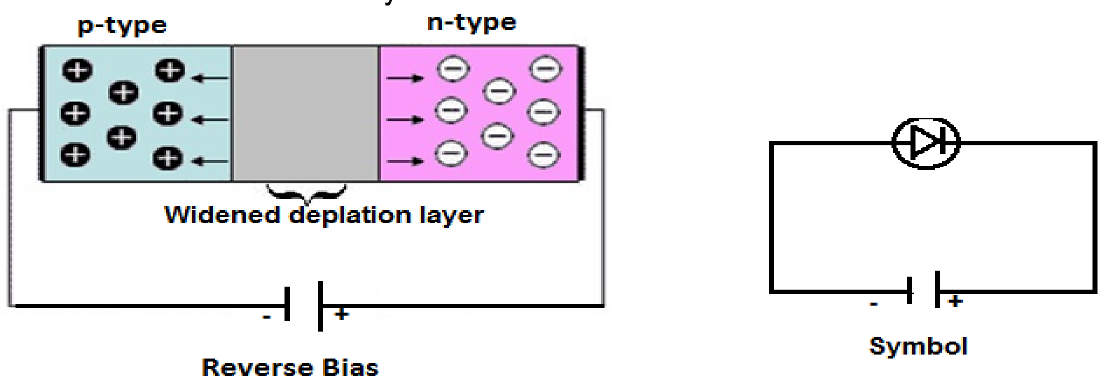
- In forward bias, the positive charge applied to the p–region repels the holes while the negative charge applied to the n–type repels the electrons .As the electrons and holes are pushed toward the junction, the distance between them decreases This reduces the size of depletion layer and lowers the potential barrier
- Therefore the charge carriers interact easily and makes the flow of an electric current possible
- The graph of voltage against current for forward is given below



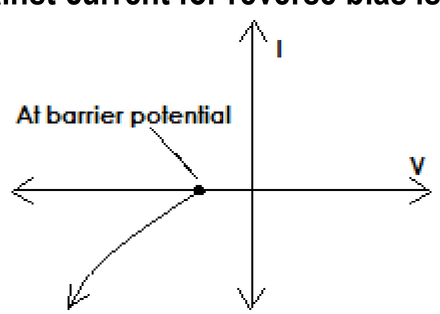
- When the voltage of the battery is greater than potential barrier majority charge carries (holes and electrons) are pulled towards and large electric current flowing

(b) Reverse - Bias in P-N Junction

- A p–n junction is said to be reverse biased when the p–region is connected to the negative terminal of the cell or battery while the n–region is connected to the positive terminal of the battery



- When the diode is connected in this manner, the holes in the p-type are attracted away from the junction by the external negative potential. Also electrons are attracted away from the junction by the external positive potential. This increases the thickness of the depletion layer .Thus the potential barrier and hence the resistance of the junction is increased .A very small current (leakage current) may flow in the circuit due to the flow of minority charge carries.
- The **graph of voltage against current for reverse bias is shown from the fig below**



- When the voltage of the battery is greater than barrier potential majority charge carries (holes and electrons)are pushed away and very small or no electric current is flowing

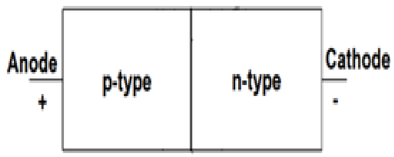
N.B

- **Potential barrier** is the potential required to overcome the barrier at the PN junction
- **Zener/Break down voltage** Is the reverse Voltage at which p-n junction breaks down with the sudden rise in reverse current.

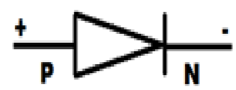
- **Knee voltage** Is the forward biased voltage at which the current through the junction starts to increase rapidly.
- **Reverse (leakage) current** Is the current in a semiconductor device when the device is reverse biased
- **Saturation current (Scale current)** Is that part of **reverse current** of the reverse current in a semiconductor diode caused by diffusion of minority carriers from the neutral regions to the depletion layer

Diodes

- A diode is an electrical device that allows current to flow through it in one direction.



Diagram



Symbol

NB:

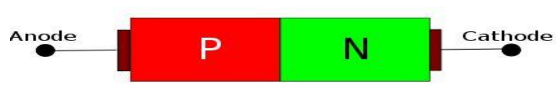
- ✓ When the junction is reverse-biased, the diode blocks the voltage
- ✓ When the junction is forward-biased, the diode conducts
- ✓ The magnitude of the current through the diode depends on the current in the external circuit

Types of Diode

- ❖ Semiconductor diode
- ❖ Metal semiconductor diode
- ❖ Light-emitting diode
- ❖ Zener Diode

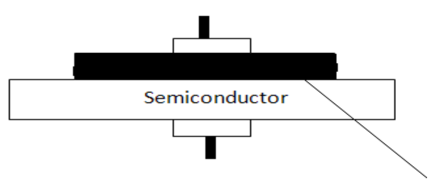
Semiconductor Diode

- ➢ Most semiconductor diodes are made up of silicon or germanium.
- ➢ Semiconductor diodes are most used for rectification



Metal Semiconductor Diode

- ➢ These types of diodes are formed by the deposition of a metal on the surface of a metal conductor.
- ➢ The metal-semiconductor diode is used for very fast switching and microwave applications.



Light-Emitting Diode (LED)

- Is a semiconductor diode that emits light when an electrical current is applied in the forward direction of the diode

A LED Symbol

NB:

- ✓ LEDs are made from a variety of semiconductor materials depending on the wavelength of the light required
- ✓ The most commonly used materials for visible LEDs are gallium phosphide and gallium arsenic phosphide
- ✓ LEDs have a wide range of applications, from simple indicator lamps and huge display screens to optical fiber communication links

Zener Diode

- ➢ Zener diodes are specifically manufactured and designed to be operated in the reverse breakdown voltage.
- ➢ Every Zener diode is manufactured for a specific reverse breakdown voltage called the **Zener voltage**.

Its symbol:

NB:

- Zener diodes are used as voltage regulator devices.
- It allows required voltage to pass through

Advantage of semiconductor junction diode over vacuum tube diodes

- **Th**ey are less expensive to make
- They consume less power
- They are reliable in circuits
- They are much easier to produce
- They occupy less space due to their small size

APPLICATIONS OF JUNCTION DIODES IN RECTIFICATION

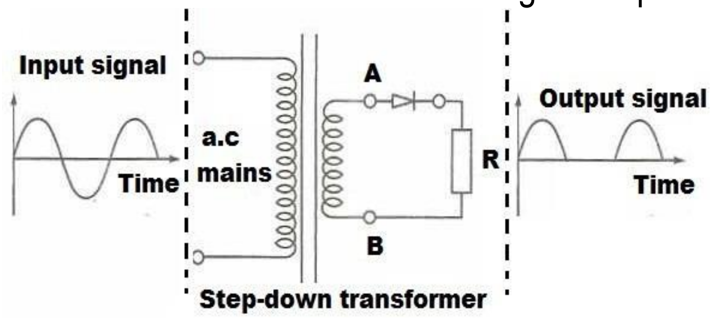
- **A rectifier** Is an electrical device used to convert an alternating current into a direct current by allowing a current to flow through it in one direction only
- **OR** Is a device that is used to convert alternating voltage into a direct (unidirectional) voltage
- **Rectification** Is the process of converting alternating current to direct current
- **OR** Is the process of conversion of alternating voltage to direct voltage
- **Diodes** are used in rectification because they offer **high resistance** when reverse biased and **low resistance** when forward biased

There are two types of rectification

- ❖ Half-wave rectifiers
- ❖ Full -wave rectifiers

Half-Wave Rectification

- The half wave rectification is achieved by connecting a single diode in series with the load across which a unidirectional voltage is required



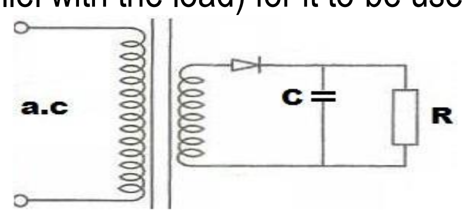
Mechanism

✓ During the first half-cycle of the AC sine wave, A is positive and B is negative. The diode is forward-biased and current flows around the circuit formed by the diode, the transformer winding and the load (R)

✓ During the second half-cycle, A is negative and, B is positive. The diode is reverse-biased therefore no current flows in the circuit

NB:

- The output signal can be displayed on a CRO screen which outlines the above trace
- The output voltage of half wave rectification **flows in pulse** (half rectified) because the diode allows current to flow during the first half of the cycle when it is forward biased and stops the current during the second half when it is reversed biased
- The diode conducts on every half- cycle
- The rectified voltage is d.c and is always positive in value
- If the diode is reversed, then the output voltage is negative
- The voltage is not steady and needs to be **smoothed** (by putting a large capacitor, C in parallel with the load) for it to be useful (see fig below)



- The capacitor is charged during the positive half-cycle of the a.c. and discharges through the load in the negative half-cycle

Advantages of half wave rectification

- Low cost of construction, since it includes few components
- Easy to constructs

Disadvantages of half wave rectifier

- **Power loss.** This is because it allows either a positive half cycle or negative half cycle. So the remaining half cycle is wasted
- **Pulsating direct current.** It produces impure direct current which is not much useful
- **Produces low output voltage**

Full – Wave Rectification

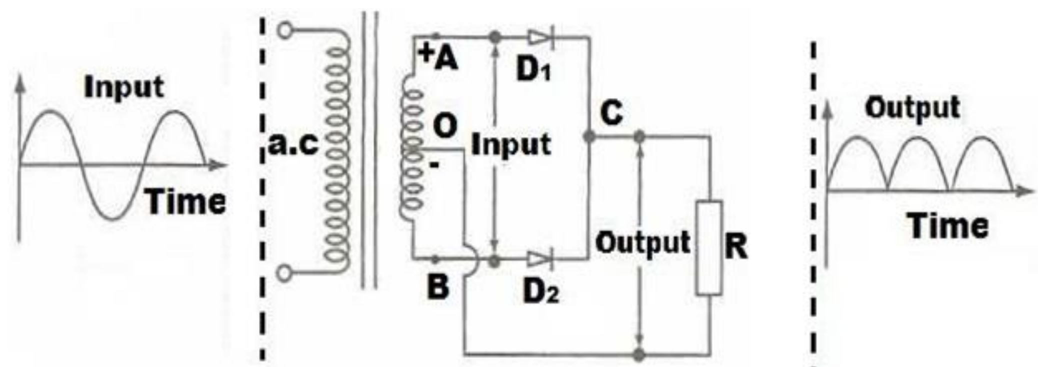
- There are two ways of achieving full – wave rectification:
  - **(a)** Using two diodes and center – tapped transformer
  - **(b)** Using four diodes (**the bridge rectifier)**

(a) Using two diodes

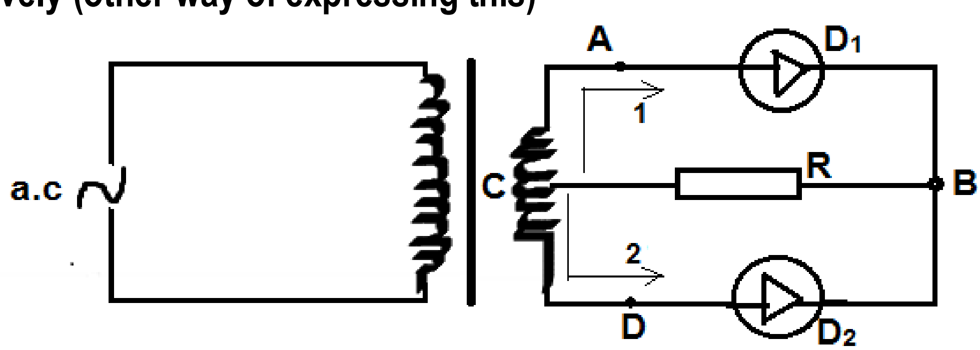
- In this circuit both halves of the a.c. cycles are transmitted but in the same direction. One way of achieving this is to have a transformer whose **output has a Centre tap,** that is, its output can be taken at two points one being half the other

Mechanism

- In the positive half-cycle, point A is positive with respect to O. Diode D_1 conducts but diode D_2 is reverse-biased. The current passes through D_1, C, R and back to O
- In the negative half-cycle, point B is positive with respect to O. Diode D_2 conducts but diode D_1 is reverse- biased. The current passes through D2, C, R and back to O



Alternatively (other way of expressing this)

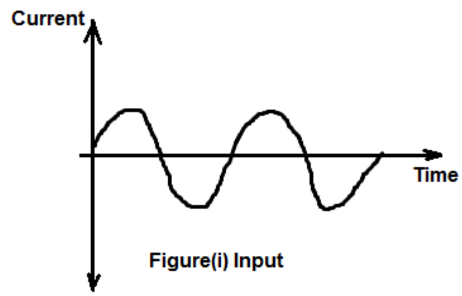


Mechanism

- During the first half cycle, diode D_1 is forward biased while D_2 is reverse biased. Hence current flows through **AD_1BCA**
- During the second half cycle, diode D_2 will now be forward biased while D_1 reversed biased .Thus current flows through **DD_2BCD**.

N.B

- In both half cycles, the direction of flow of current through the resistor is the same. The resultant output will therefore take the form shown below



Figure(i) Input

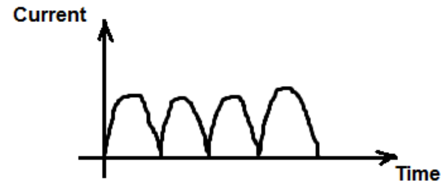
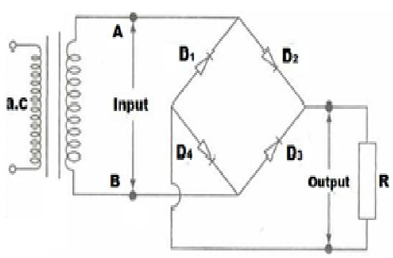


Figure (ii) Output

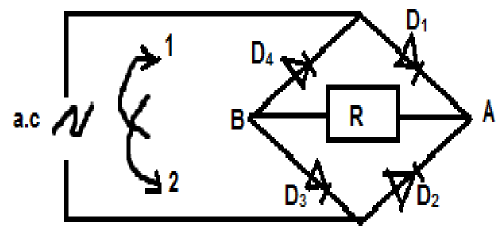
(b) Using four diodes (bridge rectifier)

- A bridge rectifier uses four diodes such that in each half cycle two diodes are forward biased and the remaining two are reversed biased (see the fig. below)



A bridge rectifier

OR



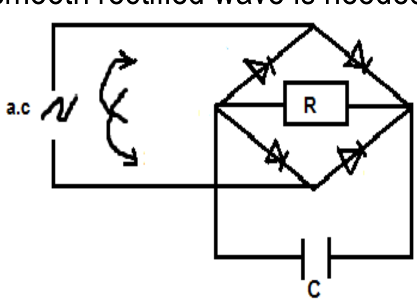
Alternative diagram for bridge rectifier

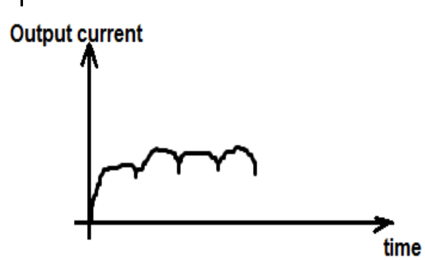
Mechanism

- During the first half cycle, the diodes D_1 and D_3 are forward biased while D_2 and D_4 are reversed biased. Current thus flows through diode D_1 and D_3 via the resistor R.
- During the second half cycle, diodes D_1 and D_3 are now reversed biased while D_2 and D_4 are forward biased. Current thus flows through D_2 and D_4 via the resistor R

N.B

- In both half cycles current flows through the resistor R in one direction only.ie from end A to B. This kind of rectifier can be used with very high voltage
- If a smooth rectified wave is needed, then a capacitor is connected across the resistor





A smoothed wave

Advantages of the bridge rectification

- A smaller transformer can be used, because there is no need for centre – tapping
- It is suitable for high voltage regulation

Disadvantage of the bridge rectifiers

- **High cost of making.** Since it uses four diodes
- **The** value of the diodes used should be precise, else there will be an error in rectification

N.B

- In general, the full wave rectifier gives a stronger and smoothened output than the half – wave rectifier. If a capacitor is connected across the resistor, the rectified output is smoothened. **The capacitor is therefore used in this case to smoothen the output of the transformer**

Advantages of center tapped full wave rectifier

- Output and efficiency are high because an AC supply delivers power during the both half cycles

Disadvantages of center tapped full wave rectifier

- It is difficult to locate the center on the secondary winding for the tapping
- **The diode used must be capable of bearing high peak inverse voltage** (PIV). This is because PIV coming across each diode is twice the maximum voltage across the half of the secondary winding

Transistors

Transistor Is a semiconductor device for amplifying, controlling, and generating electrical signals.

OR

Is a semiconductor device used to amplify or switch electronic signals and electrical power

Terminals of Transistor

- There are three terminals namely **emitter** (E), **collector** (C) and **base** (B)

Emitter (E)

- Is a terminal used to supplies (remove /push) charge carriers to Collector
- It is the negative lead (region)

Collector (C)

- Is a terminal used to receive charge carriers repelled from emitter terminal
- It is the positive lead (region)
- The maximum possible current obtained at the output (collector) is called Saturation current

Base (B)

- Base is a terminal between emitter terminal and collector terminal
- It is used to control the flow of charge carriers from **E to C or C to E**

N B:

- ✓ Some transistors are packaged individually but most are found in integrated circuits, IC (more than one transistor)
- ✓ Base terminal is thin and lightly doped

Types of Transistors

- ❖ Field-effect transistors (**FETs**)
- ❖ Bipolar transistors (**BJT**)

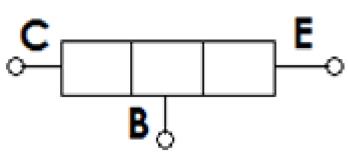
Field-Effect Transistor (Unipolar transistor)

- It is a type of transistor which uses an electric field to control the flow of current
- It requires only one charge carrier to operate (**eg N–channel FET or P–channel FET are used for conduction)**
- The three terminals of FET are **source, gate and drain**
- Examples of FET's are **MOSFET, JFET** etc
- Are used in low noise amplifier, buffer amplifier and analog switch

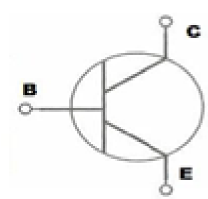
N.B: In this section (according to our level) we will only consider bipolar transistors

Bipolar Junction Transistor (BJT)

- Is a type of transistor that uses both electrons and holes as charge carriers
- It is a three-terminal device that acts as electrically controlled switch or as amplifier controls.
- It consists of a pair of p -n junction diodes that are joined back-to-back (sandwich form). The leads (regions) are labeled as base (B), collector (C) and emitter (E) (Fig below)



Block diagram



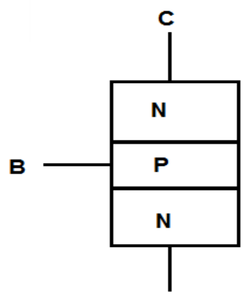
Symbol

Types of Bipolar Transistors

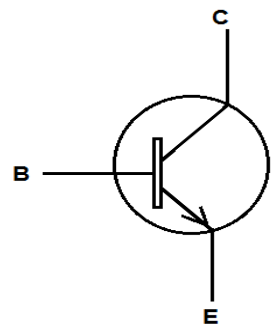
- n-p-n transistor
- p-n-p transistor

NPN Transistor

- Is a type of transistor in which one p–type material is doped with two n–type materials
- The diagram and symbol of npn transistor is shown in the figure below



Diagram



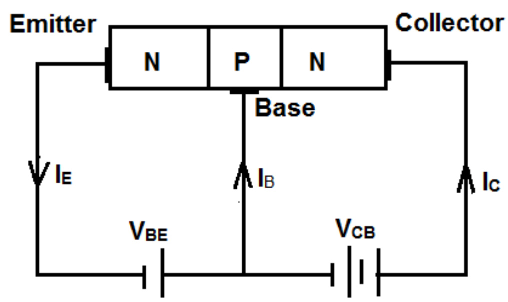
Symbol

NB:

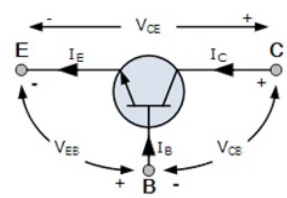
- **The outward arrow** shows that the direction of current in npn transistor is from the collector through the base to the emitter (**NPN** → **N**ever **P**oints i**N)**

Construction of NPN Transistor

- The construction of NPN transistor is shown in the figure below. The emitter–base junction is connected in forward biased while the collector–base junction in reverse biased



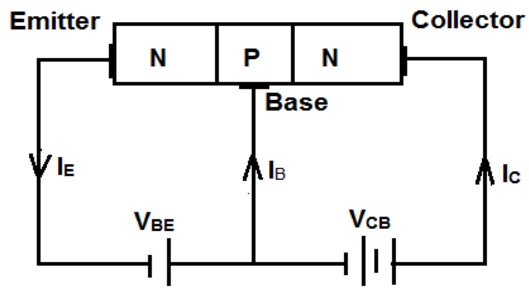
NPN Transistor Construction



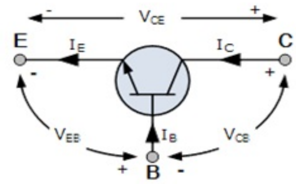
Circuit Symbol

Operation of NPN Transistor

- The forward biased is applied across the emitter –base junction while the reverse biased is applied across the collector–base junction.(See the fig below)
- **The emitter is heavily doped**. When the forward bias is applied across the emitter, the majority charge carriers (electrons) move towards the base. This causes the emitter current I_E .The **electrons** enter into the P–type material and combine with the **holes**
- **Since the base is thin and lightly doped**. Thus only a few electrons are combined with holes and the remaining (most of electrons) are moved towards the collector to constitute the base current I_B. This base current enters into the collector region
- The reversed bias potential of the collector region applies the high attractive force on the electrons reaching the collector junction. Thus attract or collect the electrons at the collector



NPN Transistor



Circuit Symbol

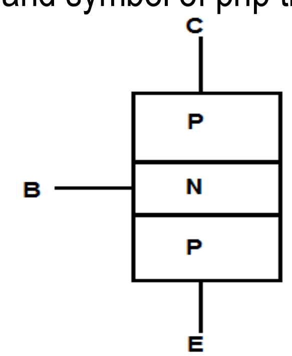
- The whole of the emitter current is entered into the base. Thus, we can say that the emitter current is the sum of the collector or the base current (**$I_E = I_C + I_B$**)

N.B

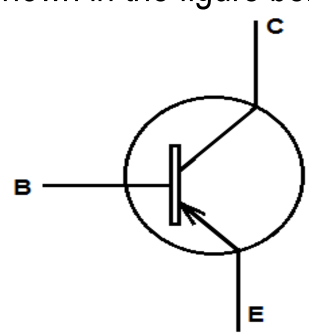
- The collector current in any transistor is less than the emitter current because of **the recombination of holes and electrons occurring in the base area**
- In order for a transistor to work, the emitter should always be connected in forward biased while Collector is always connected in reverse biased
- The main difference between PNP and NPN transistor is that, the current conduction in NPN carried by electrons while the charge carriers in PNP are carried by holes

PNP Transistor

- Is a type of transistor in which one n–type material is doped with two p–type materials
- The diagram and symbol of pnp transistor is shown in the figure below



Diagram

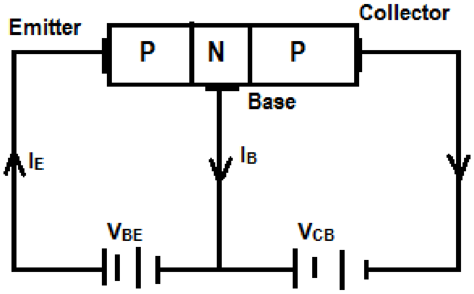


Symbol

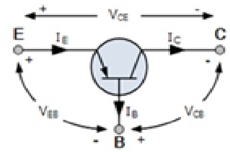
- **The inward arrow** shows that the direction of current in pnp transistor is from the emitter to collector (PNP → **P**oints i**N** **P**ermanently**)**

Construction of PNP Transistor

- The construction of PNP transistor is shown in the figure below. The emitter–base junction is connected in forward biased while the collector–base junction in reverse biased
- The emitter in forward biased attracts the electrons towards the battery and hence constitutes the current to flow from emitter to collector



PNP Transistor Construction

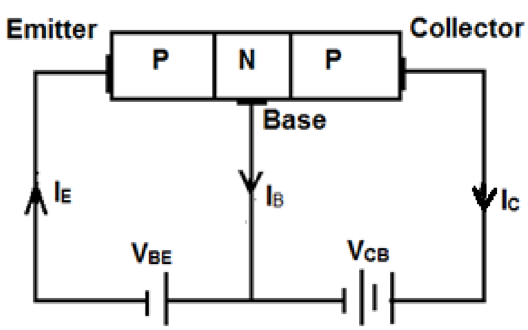


Circuit Symbol

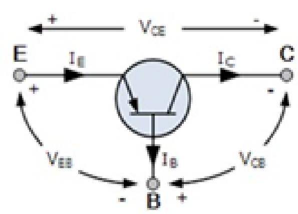
- The base of the transistor is always kept positive with respect to the collector so that the hole from the collector junction cannot enter into the base
- And the base–emitter is kept in forward due to which the holes from the emitter region enter into the base and then into the collector region by crossing the depletion layer

Working of PNP Transistor

- The emitter base junction is connected in forward biased due to which the emitter pushes the holes in the base region. These holes constitute the emitter current
- When these holes move into the base, they combine with electrons.
- Since the base of the transistor is thin and very lightly doped .Hence **only a few holes** combine with the electrons and the most (remaining) are moved towards the collector space charge layer. Hence develops the base current (See the fig below)



PNP Transistor



Circuit Symbol

- The collector base region is connected in reverse biased. The holes which collect around the depletion region when coming under the impact of negative polarity attracted by the collector. This develops the collector current. The complete emitter current flows through the collector current I_C
- Thus, we can say that the emitter current is the sum of the collector or the base current ($I_E = I_C + I_B$)

Difference between PNP and NPN transistors

PNP Transistor	NPN Transistor
It consists of an N–type sandwiched by two P–type semiconductor	It consists of an P–type sandwiched by two N–type semiconductor
It has holes as majority charge carriers	It has electrons as majority charge carriers
It is slower than NPN because holes are slower than electrons	It is faster than PNP because electrons are faster than holes
Less preferred than NPN	Most preferred than PNP (most used)
Both collector and base are negative with respect to emitter	The collector is positive with respect to both emitter and base

Why always NPN most used rather than PNP?

- This is because the mobility of electrons in N type material is more than the mobility of holes in P type material
- **Addition reason:** Silicon is used to make N type semiconductors. Since it is found abundantly in nature

Uses of Transistors

- They are used in virtually all electronic devices such as **calculators**, **televisions**, **radios**, **computers**, etc.

Application of Transistor

- As an amplifier (electronic amplifier)
- As a switch (electronic switch)

Transistor as Regulator/Amplifier/Active Mode

Electronic amplifier is the circuit that increases the amplitude (intensity) of a given input
OR is the magnification of input signal

Types of electronic Amplifiers

- Single-stage amplifier
- Multi-stage amplifier

NB:

- Relationship between the input and output of an amplifier is called the **transfer function**
- The magnitude of the transfer function is referred to as the **gain**
- Amplifiers commonly used in **radio** and **television transmitters** and **receivers**, **stereo equipment**, **microcomputers** and **digital musical instruments**
- Transistors are commonly used as amplifying elements
- In this section we will consider **Single-Stage Amplifiers Only**

Single-Stage Amplifier

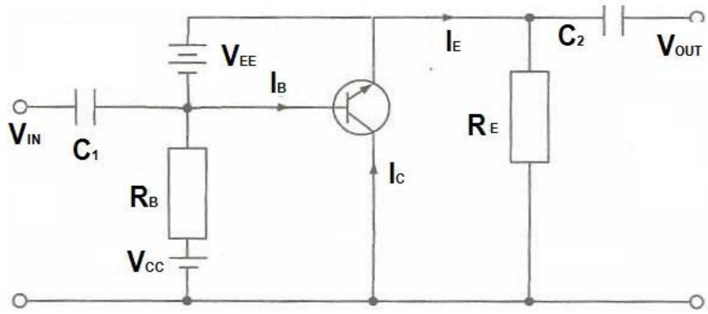
- Is the type of amplifier which consists of only one amplifying device.
- It consists of transistor (amplification stage) which is connected to a load resistor through which a load current flows

Types of Single-Stage Amplifiers

- Common-collector (CC) amplifiers
- Common-base (CB) amplifiers
- Common- emitter (CE) amplifiers

Common-Collector Amplifier

- The base terminal of the transistor serves as the input, the emitter the output, while the collector is common to both. The emitter-base junction is forward-biased by the power supply VEE while the collector- base junction is reverse-biased by VCC

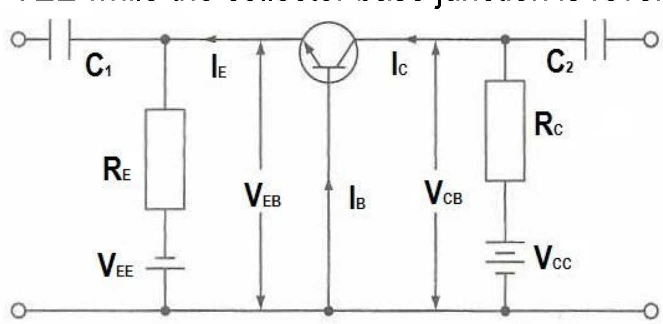


Mechanism

- The input signal is fed to the base-collector circuit while the output signal is tapped from the emitter terminal with respect to the ground
- C_1 and C_2 are coupling capacitors to provide direct current isolation at the input and output of the amplifier

Common-Base Amplifier

- The emitter terminal serves as the input, the collector as the output, and the base is common to both. The emitter-base junction is forward-biased by the power supply VEE while the collector base junction is reverse-biased by VCC

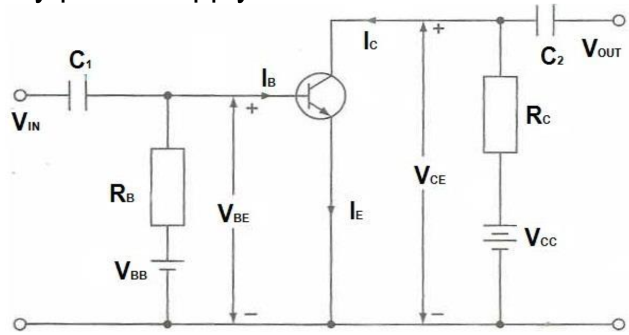


Mechanism

- The input signal is fed to the emitter-base circuit while the output signal is tapped from the collector-base circuit
- C_1 and C_2 are coupling capacitors to provide direct current isolation at the input and output of the amplifier

Common-Emitter Amplifier

- The base terminal of the transistor serves as the input, the collector as the output, and the emitter is common to both. The emitter-base junction is forward-biased by power supply VBB while the collector-base junction is reverse-biased by power supply VCC



Mechanism

- The input signal is fed to the base-emitter circuit and the amplified signal is tapped from the collector terminal with respect to the ground emitter circuit
- C_1 and C_2 are coupling capacitors to provide direct current isolation at the input and output of the amplifier

Light Dependant Resistor (LDR)

- Is a semiconductor device whose resistance depends on the light falling on it
- Is used to switch on or switch off automatically street lamp

Thermistor

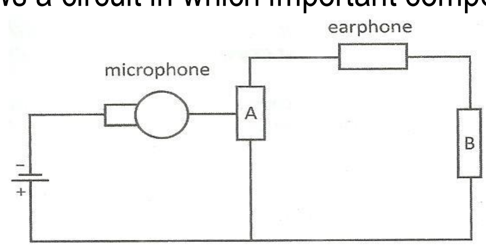
- Is a semiconductor device whose resistance depends on thermal energy
- It is used to control maximum temperature of hot liquid

Example Form IV NECTA 2002 QN: 10 SECT. C

(a) Explain how an extrinsic semiconductor is constructed

(b) Describe the model of action and application of PN junction diode

(c) The diagram below shows a circuit in which important components A and B are removed



Answer the following questions

(a) What does A and B represents?

(b) Describe briefly the purpose of component A and B

(c) Draw a well labeled circuit diagram for the circuit above

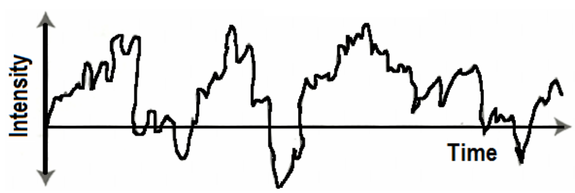
Integrated Circuit (IC)
- Is a combination of several resistors, capacitors or transistors which are built out of the same crystal

OR
- Is an electronic device made of semiconductor material containing up to billions of electronic circuits and components such as transistors in a small space (chip)
- Two or more transistors can be joined together to increase the amplification
- An integrated circuit is sometimes known as a **chip or microchip**

Information Signals
- Are current or voltage variations (waveforms) through which information is relayed in electronic circuits

Types of Information Signals
- Analogue signals
- Digital signals

Analogue Signals
- Are electrical signals that convey or store information by means of variation in a *continuous* wave form



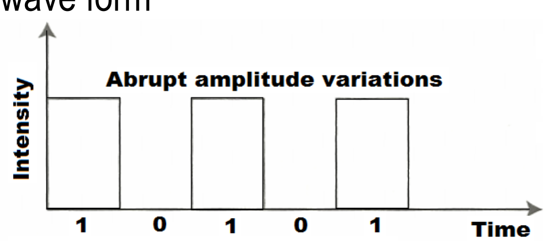
- Electrical signals may represent information by changing factors such as their voltage, current, frequency or total charge. The information is converted from some physical form (such as sound, light, temperature, pressure) to an electrical signal by a device known as a **transducer**

Transducer: Is a device that converts an input signal of one form into an output signal of another form

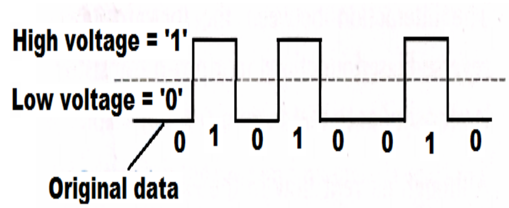
OR **Is a device which converts a physical variation such as temperature, pressure or sound to an electrical signal**

OR Is a device which converts energy from one form to another

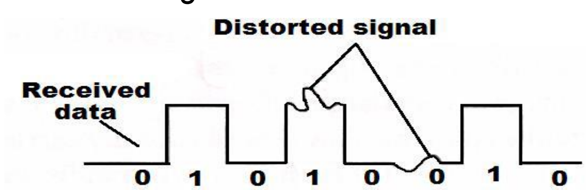
Digital Signals
- Are electrical signals that convey or store information by means of variation in a non-continuous wave form



- Digital signals have only two amplitude levels, usually called **nodes**. This means the values can only be given in one of two ways. The values may be specified, for Example, as **1** or **0**, **TRUE** or **FALSE**, and **HIGH** or **LOW**
- Digital signals are often derived from analogue signals
- The main advantage of digital signals over analogue signals is that the signal level or value need not be precise
- It can be approximated within a fixed number of **digits** or **bits**
- The process of approximating the precise value within a fixed number of digits is called **quantization**



- Signal can be distorted during transmission can still read correctly

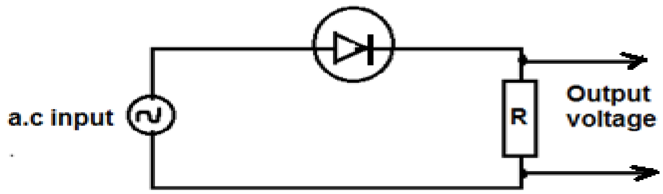


Class Activity – 5

1. Explain why an ordinary junction transistor is called bipolar?
   ANS: Because, the transistor operation is carried out by two types of charges carriers (majority and minority carriers)
2. Why transistor is called current controlled device?
   ANS: Because, the output voltage, current or power is controlled by the input current in a transistor
3. **What is the significance of the arrow –head in the transistor symbol?**
   ANS: Is to show the conventional direction of current flow.(From emitter – to – base in case of p-n-p transistor and from base – to – emitter in case of n – p –n transistor)
   N.B: Arrow head is always marked on the emitter and not for collector, since collector always reverses its leakage current opposite to the direction of emitter current
4. **Discuss the need for biasing the transistor.**
   ANS: For normal operation, base–emitter junction should be forward biased and the collector base Junction reverse biased
5. What are the differences between a semiconductor and an insulator in terms of their conductivity
6. In case the transistor is not biased properly, what would happen?
   ANS: It would
   - Work inefficiently
   - Produce distortion in the output signal

- With the change in transistor parameters or temperature rise, the operating point may shift and the amplifier output will be unstable

7. Which of the transistor currents is always the largest? Which is always the smallest? Which two currents are relatively close?
   ANS: The emitter current I_E is always the largest one. The base current I_B is always the smallest one .The collector current I_C and emitter current I_E are relatively close in magnitude
8. **Why collector is made larger than emitter and base?**
   ANS: Collector is made physically larger than emitter and base because collector is to dissipate much power
9. **Why silicon type transistors are more often used than germanium type?**
   ANS: This is because:
   (i) At room temperature, Silicon crystal has fewer free electrons than Germanium crystal. This implies that Silicon will have much smaller collector cut off current than Germanium
   (ii) The variation of collector cut off current with temperature is less in Silicon compared to Germanium
   (iii) The structure of Germanium crystals will be destroyed at higher temperature while Silicon crystal are not easily damaged by excess heat
10. Why the width of the base region of a transistor is kept very small compared to other region? (**ANS: In order to pass most of the injected charge carriers to the collector**)
11. **Why emitter is always forward biased?**
    ANS: Emitter is always forward biased with respect to base so as to supply the majority charge carriers to the base.
12. **Why collector is always reverse biased w.r.t base?**
    ANS: In order to remove the charge carriers from the base–collector junction
13. A diode has a certain characteristic when operating. Explain this characteristic**.**
    ANS: The main operating characteristic of a diode is that it allows current in one direction and blocks current in the opposite direction.
14. Distinguish between semiconductors and conductors and give one example for each
15. What must the conditions be for a LED to emit light?
    ANS: A LED emits light when the diode is forward biased allowing current to flow.
16. Transistors have two main functions, what are they?
    ANS: Amplification and switching.
17. **Define doping. (**ANS: The process of adding impurities to the intrinsic or pure semiconductor)
18. What are the differences between a conductor, semiconductor and insulator in terms of their energy levels?
19. Your provided with a diode, a resistor R an a.c source of low voltage and connecting wires , Sketch the circuit diagram for a half – wave rectifier and indicate the terminals where the output voltage v_o may be connected
    ANS:



Correct circuit

20. What is meant by Donor impurity in semiconductors?
(ANS: Is an atom introduced into the semiconductor (doping) to provide an extra electron for conduction)

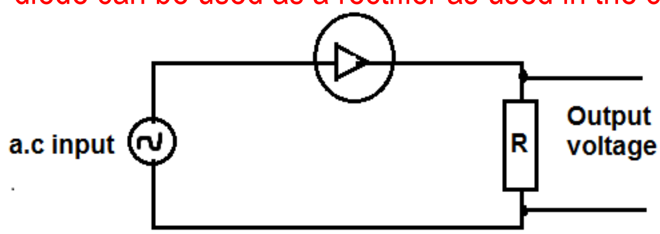
21. Explain how intrinsic semiconductor can be changed into a transistor

22. Mention two types of : (a) Semiconductors (b) Diode

23. What is the difference between analogue and digital signals?

24. (a) What is the difference between PNP and NPN transistors?
(b) Draw their circuit symbols, label them and describe each connection

25. The semiconductor diode can be used as a rectifier as used in the circuit below



(a) What does the term rectification means?
(b) The rectification described by the circuit above is half wave rectification. Sketch its waveform which would be seen on a suitably adjusted CRO and explain why the output voltage is so rectified

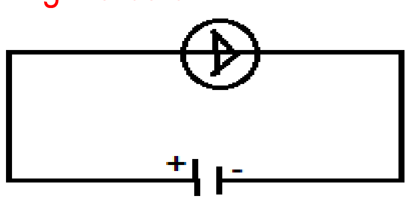
26. The output power of a signal is 50 W and the input power is 0.1 W .Calculate the power gain

27. What is an IC?

28. State the majority carriers for a p – type semi conductors

29. Explain how doping produces an n – type semiconductor

30. Study the circuit diagrams in the figure below carefully. Which of the two circuits will light a bulb?



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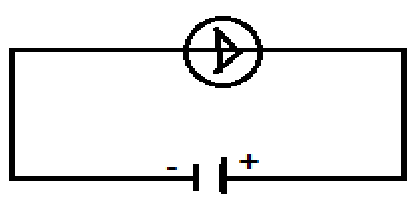


B

31. Name two semiconductors which are widely used in electronics

32. Explain why semiconductor solid state diodes are fast replacing the vacuum type diodes in many applications

33. (a) Give an illustration of a p – n junction diode and its symbol
(b) How does a junction diode work?

34. How is an intrinsic semiconductor different from an extrinsic semiconductor? .Explain how an extrinsic semiconductor is constructed?

35. Define the following terms (a) Transistor (b) Doping (c) Rectification

36. Draw the circuit diagram of the (a) half wave rectification (b) Full wave rectifier(use 2 diodes)

Topic – 6: Elementary Astronomy

- The word astronomy is derived from two Greek words: **astron** for **"star"** and **Nomo's** for **"law"**.
- **Astronomy is the** study of the universe and celestial bodies.

OR

- **Astronom**y is the branch of science that deals with the study of the origin, evolution, composition, distance and the motion of all bodies and scattered matters in the universe.
- People who are involved in astronomy are known as **astronomers**.
- **Universe** is all of the space and everything in it

OR

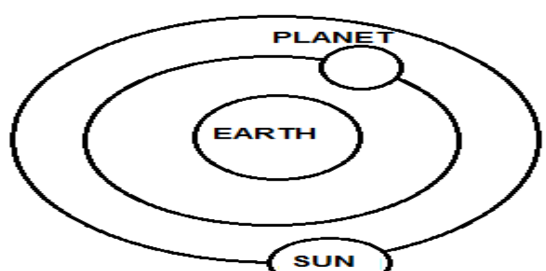
- **Universe** is the totality of space and time together with matter and energy.

Importance of Astronomy

- ❖ **Measurement of time**
  Duration of the day, month and year were determined by using position and phases of the sun, moon and stars
- ❖ **Development of calendars**.
  Were used to predict seasons for agriculture by studying position of stars in space
- ❖ **Navigation on land and sea uses the knowledge of astronomy**
- ❖ To study the origin of the earth and life
- ❖ **Used in space exploration**

Geocentric Theory (Earth centered)

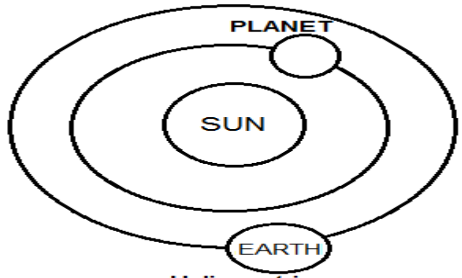
- Is the theory which considers that the earth is at the centre of the universe and other heavenly bodies such as the Sun and other planets to be orbiting around it
- It was based on religious beliefs, observations and common-sense.



Geocentric model

Heliocentric Theory (Sun centered)

- Is the astronomical model in which the Earth and planets revolve around the Sun at the center of the solar system
- It was put forward by Nicolaus Corpenicus to replace the Geocentric Theory



The Solar System

- The solar system is the collection of heavenly bodies that revolve around the sun.
- The Solar System composed **of dwarf planets**, **eight planets** and their **moons**, as well as **asteroids**, **comets** and **meteors**.

Stars

- A star is a large celestial body made up of hot gases known as plasma.
- **Plasma** refers to an ionized gas in which a certain proportion of electrons are free rather than bound to an atom or molecules.
- **Stars** radiate energy derived from the thermonuclear reactions in the interior region.
- **The sun** is the largest star.
- **The sun** is the closest star to the earth at a mean distance of 149.60 million kilometers
- **Th**is distance is known as Astronomical Unit (AU) and is used to measure distances across the solar system
- $1AU = 1.4960 \times 10^{11}m$
- **Light year** Is the distance that light travels in one year, or about 6 trillion miles [Light Moves about a distance of 186,000 miles per second (3×10^8 m/s)]
- **Variable star** Is a star whose brightness changes over the course of days, weeks, months or year
- **Super Nova** is the end of life of a star in a huge explosion
- **Double Star (Binary Star) Are** two stars that lie very close to, and are often orbiting each other

Galaxy

- A Galaxy is a giant collection of stars, gas and dust.
- Most of stars in the universe are in the galaxies.

Milky Way

- Is the galaxy that contains our Solar System.
- Nearly all of the stars visible in the night sky are within our galaxy, the **Milky Way**.

Planets

- A planet is a major (large) object which is in its orbit around a star (sun).
- The planets revolve around the sun. They are held in orbit by the **gravitational pull** of the sun.
- Planets do not give their own light, but rather reflect the sun's light.

- These planets are

(i) **Mercury**

- ✓ It is the closest planet to the sun
- ✓ It gets more direct heat, but even it isn't the hottest planet (427^0 C)
- ✓ It is the smallest planet in the solar system
- ✓ It has no moons, no rings and an atmosphere

(ii) **Venus**

- ✓ Is the second planet from the sun and has no moon
- ✓ It is also known as **morning star or evening star**
- ✓ It is the hottest planet in the solar system (482^0 C)
- ✓ It has very thick atmosphere 90 times that of the earth

Question, Mercury is the closest planet to the sun but not hotter than Venus, Why?

ANS:

- This is because any heat that mercury receives from the sun is quickly lost back into space **because it does not have any atmosphere to trap and hold heat**
- Similarly Venus is the hottest due to presence of very thick atmosphere of carbon dioxide. This atmosphere makes the surface of Venus hotter because heat does not escape back into space **(Greenhouse effect)**

(iii) **Earth**

- ✓ Is the third planet from the sun and largest terrestrial planet
- ✓ Is the only planet to host living beings and the only one known to have liquid water on its surface
- ✓ It has atmosphere which supports life
- ✓ It is the only known planet to have current geological activity
- ✓ It has a radius of 6371 km and its distance is 1.0 AU from the sun
- ✓ It has one large moon

(iv) **Mars**

- ✓ Is the fourth planet from the sun
- ✓ It is reddish planet. The red color comes from iron oxide or rust in the soil
- ✓ It experiences frequent planet – wide wind storms
- ✓ It's colder than earth. The surface temperature ranges from -113^0 C to 0^0 C

(v) **Jupiter**

- ✓ Is the fifth planet from the sun
- ✓ Is the largest planet in the solar system
- ✓ It has 63 moons and a faint ring system

(vi) **Saturn**

- ✓ Is the sixth planet from the Sun. It is also a gas giant planet
- ✓ It has the rings that orbit the planets in a thin band about a mile thick
- ✓ Its radius is about 9.5 times that of the Earth.

(vii) **Uranus.**

- ✓ It is the seventh planet from the Sun
- ✓ It has a diameter of about 50,723 km
- ✓ It is made of a large atmosphere of methane with a dense core of frozen methane.
- ✓ It has a faint ring system and 27 moons in its orbit
- ✓ It has a radius four times that of the earth

(viii) **Neptune**

- ✓ **Is** the eighth planets from the sun
- ✓ It has a radius four times that of the earth as Uranus
- ✓ It has the atmosphere made of methane
- ✓ Its surface temperature is about $-214^{0}C$
- ✓ It has 13 moons and a faint ring system orbit the planet

NB:

- **A**ll of these planets excepts the Earth, have names from Greek or Roman **mythology**
  - **(a)** Mercury means god of commerce because it moves so quickly across the sky
  - **(b)** Venus means goddess of love and beauty due to beautiful sight in the sky
  - **(c)** Mars means god of war due to its red color
  - **(d)** Jupiter means King of the Gods due to its biggest size in the solar system
  - **(e)** Saturn means god of agriculture,
  - **(f)** Uranus (the ancient Greek deity of the heavens) means the earliest supreme god
  - **(g)** Neptune means god of the sea due to its beautiful **blue color**
  - **(h)** Pluto means god underworld because it's so far away from the Sun

Types of planets

- The planets in the solar system are divided into two types namely:-
  - **(i) Terrestrial planets (**innermost planets)
  - **(ii) Jovian planets (**Outer planets / Gas giants)

The difference between the two types of planets

Terrestrial planets	**Jovian planets**
Are the planets which are made of solid surfaces	Are the planets which are made of gaseous surfaces
Examples are Mercury, Venus, Earth and Mars	Examples are Jupiter, Saturn, Uranus, Neptune
They are small in size	They are large in size
They are closer to the sun	They are far away from the sun
They have few number of moons	They have many number of moons
Their core are more denser	Their core are less denser

Characteristics of Planets

(i) It is a celestial body that orbits a star.
(ii) It is massive enough so that its own gravity causes it to assume a spherical shape.
(iii) It has cleared the neighborhood around its orbit.

Dwarf Planet

- **I**s a celestial body orbiting the Sun that is massive enough to be rounded by its own gravity but has not cleared its neighboring region and hasn't satellite.
- Pluto is an example of dwarf planet

Difference between Stars and Planets

Stars	Planets
Emit their own light	Do not emit their own light
Twinkle at night.	Do not twinkle at night.
Appear to be moving from east to west.	Planets move around the sun from west to east.
Their temperatures are usually very high.	Their temperatures depend on their distances from the sun.
Countless in number.	There are eight in the solar system.
Very big in size but they appear small because they are very far away.	Very small in size as compared to stars.
Are in gaseous form	Are in solid form

Question: Why stars twinkle at night?

ANS: **Stars are so distant such that they appear as pinpoints of light in the night sky, even when viewed through a telescope.**
Because all the light is coming from a single point, its path is highly susceptible to atmospheric interference

Satellite

- Satellite is the celestial body that revolves around the planets.

Types of Satellite

1. **Natural Satellite**

- Natural satellite is the natural celestial in which revolves around the planet. **Example, moon**

2. **Artificial Satellite**

- Artificial satellite is the man made satellite and spacecraft that orbit the planet.

Uses of the earth Satellites

- The moon leads to ocean tides

- Man – made satellite used to reflect radio waves for communication

Asteroids (minor planets)

- Asteroid is a large rocky body in space that revolve around the sun

OR

- Asteroid is an astronomical body smaller than planets that orbit the sun

NB:

- Asteroids are of different sizes and shapes
- Asteroids are mostly small Solar system bodies composed mainly of rocky and metallic non-volatile minerals
- They lie between mars and Jupiter

Meteors

- Are asteroids which enter the earth's atmosphere and burn completely before reaching the earth's surface
- Are also called **shooting stars**

Meteorites

- Are meteors that survive the passage through the earth's and reach the ground

OR A meteorite is a piece of rock or metal that has fallen to the earth's surface from outer space as a meteor

- In Tanzania a 16 ton piece of meteorite found at Mbozi Mbeya called **Mbozi meteorite**

Comets

- **Comet:** Is a small icy celestial body that when passing close to the sun heat up and emit gas displaying a visible atmosphere and a tail

OR

- Is a small icy celestial body that revolves around the sun
- They can often be seen by naked eyes. They stop glowing once the gaseous materials are all burnt off or when they are once again far away from the sun

Meteoroid

- Is a smaller body than asteroid that moves in the solar system that would become a meteor if it entered the earth's atmosphere

Gravitational Force

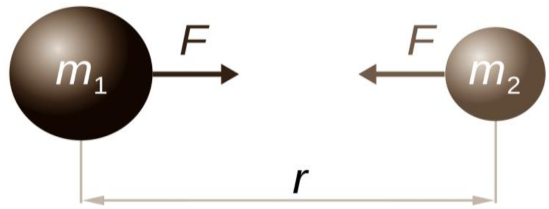
- Gravitational force is the attractive force existing between any two objects that have masses

Newton's Law of Universal Gravitation

The law States that

"*Any two bodies in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them*"

Consider the fig. below



- The gravitational force is given by **F =** $\frac{G(m_1 m_2)}{r^2}$
- **Whereby: G** is the universal gravitation constant , $\mathbf{m_1}$ is the mass of the first body,$\mathbf{m_2}$ is the mass of the second body and **r** is the distance between the two bodies

Gravity

- Is the gravitational force that attracts a body towards the centre of the Earth
- This is the force that holds us on the ground and causes objects to fall back to the ground after being thrown up in the air
- The further you move away from the center of the earth, the weaker the force becomes
- The measure of the force of gravity on an object on the earth's surface is called the **weight**
- As we go above the surface of the earth, acceleration due to gravity goes on decreasing,
- That is why, the astronaut in space can float without falling because the **gravitational force is almost zero in the outer space**

NB:

- **If the astronaut goes in the outer space he needs a spacesuit. This special suit is important because it is used to:-**
  (i) Protect his body from low pressure
  (ii) Supply astronaut with oxygen to breath
  (iii) Supply water to drink during spacewalks
  (iv) Protect his body from being injured from impacts of small bits of space dust
  (v) Protect the astronaut from cold and dangerous radiation

- **What could happen if an astronaut would not put on a spacesuit?**
  (i) **Boiling blood**. The lower the pressure, the lower the boiling point, in space there no air pressure. So boiling point could easily drop to his body temperature .That means his blood would start to boil
  (ii) **Cell mutation**. He also be bombarded with dangerous radiation from the sun and other stars .This radiation could warp his cells and cause poisoning or cancer and eventually cause death
  (iii) **Loss of bowel control**. He could lose control due to severe lack of oxygen
  (iv) **Bloating**. If the liquid in his blood stream started boiling, it would turn into gas that would make his skin swell

- The astronaut use small jets of gas in his movements (maneuvers) instead of swimming like fish because there is **no matter (no atmosphere)** to cause resistance of his movements to move forward (due to Newton's third law of motion)
- **Gravitation I**s the force of attraction which acts between two bodies in the universe
- The Sun's gravity keeps the planets in their orbits

Constellations

- A Constellation: Is a group of stars that form a definite shape or pattern when viewed from the earth

OR

- Constellations: Are small groups of bright stars that form patterns in the sky which resemble familiar with animals and objects on the earth.

- Some of known constellations are: **LEO**, **IRON**, **SCORPIO**, **URSA MAJOR**, **CORPUS**, **CANIS MAJOR**, **PISCES, GEMIN** and the **SOUTHER CROSS**
- There are about 88 known constellations.

Types of Constellations

- ❖ Circumpolar constellations
- ❖ Seasonal constellations
- ❖ Zodiac constellations

Circumpolar Constellations

- Are seen all of the year round in the night sky for observers in high northern or high southern latitudes because of the rotation of the Earth

Seasonal Constellations

- Seasonal constellations are the constellations that appear at some time of the year and are not seen at other times of the year.
- In Tanzania and in central Africa are close to the equator so we do not see any circumpolar stars or circumpolar constellations. Hence In Tanzania night sky we see only **seasonal constellations**

Zodiac

- Is a set of constellations situated along the ecliptic in the sky, through which the sun, moon and planets move

Zodiac Light

- Is very faint cone of light in the sky, visible in the east just before sunrise and in the west just after sunset
- It is probably caused by the reflection of sunlight from cosmic dust in the plane of the ecliptic

Asterism:

- Is any prominent star pattern that is not a whole constellation

Black Hole

- Is a concentration of mass so dense that nothing – not even light – can escape its gravitational pull once swallowed up

Celestial Coordinate: Is a grid system for locating things in the sky

Significance (importance) of Constellations

The study of the constellation is important since they are used by the man from ancient times up to the present.

- **Religion**
  Early religions believed that constellations were God's way of communicating to people on the earth
- **Agriculture:**
  Early farmers used constellations to determine the different seasons for growing crops
- **Navigation:**
  Can help travelers to determine the direction of their destinations by locating neighboring constellations

Earth's Moon

- **M**oon is a natural satellite that moves in a circular orbit around the earth, held on orbit by gravitational force.

Properties of Earth's Moon

- The moon's gravitation field is one sixth of the earth's field **(g_{moon} = 1.6N/Kg)**
- It takes 27.3 days to revolve around the earth. This period called **sidereal month**
- It has a diameter of 3476 km
- It has a mass of 7.35×10^{22}kg
- Moon Surface temperature are on the average of 107^0 C during the day and **-153^0 C** during night
- It has non molten iron core so its haven't magnetism
- Iron core is surrounded by a rocky mantle and crust
- It revolves in an anticlockwise direction around the earth
- Moon has no atmosphere

N.B

- **Perigee**: Is the moon's position when it is nearest the earth. **Perigee is 356,000 km**
- **Apogee**: Is the moon's position when it is furthest from the earth **Apogee is 406,000 km**
- **Proxigee (Closest Perigee)**: Is the moon's position when it is usually close to the earth

Surface features of the moon

There are two primary types of terrain on the moon, these include the following

- ✓ Lunar highlands
- ✓ Maria

Lunar Highlands

- Are bright zones on the surface of the moon
- A lunar highland is the bright area viewed with unaided eye. It consists of;

(a) **Craters** caused by impact of meteorites. The young craters are often surrounded by lines of splash material

(b) **Mountains** rise up to 5km high

Maria

- Maria is an Italian word Means Sea
- **Maria is the dark region on the surface of the moon**
- It is caused by hug impact craters that were later flooded with molten lava.
- Most of Maria is covered with regolith, a mixture of fine dust and rocky debris produced by meteor impact

Ocean tides

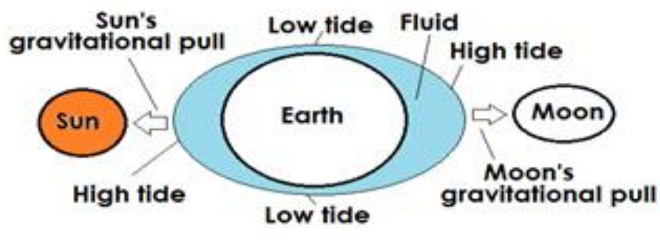
- Are periodic rises and falls of large bodies of water
- **Tides energy**: Is the rising and falling of the ocean level

Causes of Ocean tides

- Are caused by the gravitational pull (force) between the earth and the moon

How Ocean tides Occurs

- Due to different in gravitational force the earth pulls the moon to keep it in orbit also the moon pulls the earth and the sun pulls the earth to keep it in orbit also the earth pull the sun. This gravitational interaction tends to pull earth's fluid (gas and liquid especially in ocean) results in rising and falling of the ocean level. As the earth rotates on its axis two tides occur each day



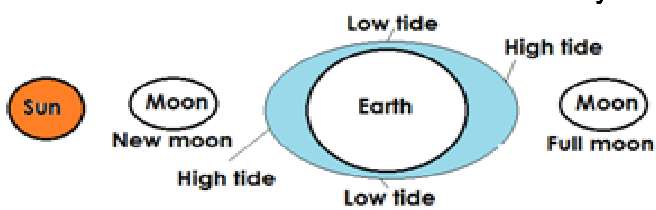
Ocean tides

Types of Ocean Tides

- Spring tides
- Neap tides

Spring Ocean Tides

- Spring tides occur when the sun, moon and earth line up in a straight line
- They typically occur around a full or new moon and they are strong tides

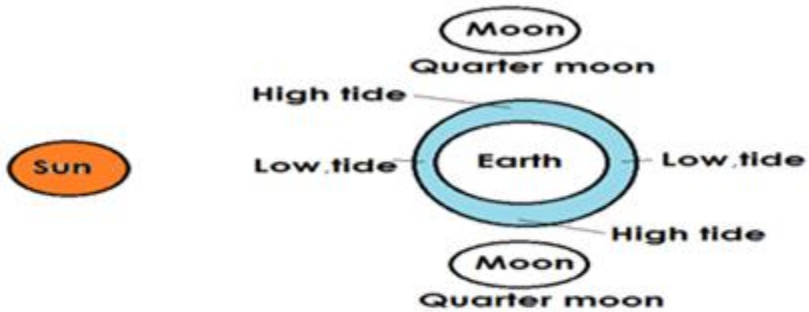


Spring tides

- The Spring tides are called **Proxigean spring ocean tides**
- Are rare and unusually high spring tides which occur when the moon is both unusually close to the earth and the new moon phase

Neap Ocean Tides

- Neap tides occur when the gravitational forces of the moon and the sun are perpendicular to one another (with respect to the earth)
- Neap tides occur during quarter moons. At this time, the sun and the moon are pulling at right angles to each other causing their gravitational forces to cancel each other. They are weaker tides



Neap tides

Advantage of tides

- During high tides the water level in the harbor rises, This enable bigger ships to move into harbor and unloaded
- The high tides clear the sea shore from garbage, etc
- High tides are used for generating electricity

Class Activity–6

1. What is solar system?
2. How many known planets are there in our solar system? Name them.
3. Briefly explain how astronomy gave rise to the 12 months of the year
4. Why is Pluto not a planet as it used to be?
5. (a) Which one is the largest planet in our solar system? (**ANS: Jupiter)**
   (b)Which planets in the solar system have satellites?
6. What is a milk way
7. **What are the real names of objects in the sky which are commonly known by the following names?**
   (i) An evening star (ii) A morning star (iii) A shooting star
8. Can humans breathe normally in space as they can on Earth? (Give reason)
9. Why Venus is hotter than Mercury, although Mercury is very closer to the Sun than Venus?
10. State reasons why an astronaut in space
    (a) Needs a special space suit to prevent blood from boiling
    (b) Can float without falling

(c) Uses small jets of gas in his maneuvers(movements) instead of swimming like fish in water

11. What planet is famous for its big red spot on it
12. What planet is famous for the beautiful rings that surround it?
13. Differentiate between spring and neap tides
14. The distance of Jupiter from the sun is 7.80 x 10^8 km and one year of Jupiter is equivalent to 12 earth years. Calculate the
    (i) The distance of its path in one year (**ANS: d = 4.903 x 10^9 km)**
    (ii) Speed of the planet in km per hour (**ANS: v = 46.6 x 10^3 km/hr)**
15. (a) How a star differs from a planet
    (e) Name two objects in space which are the earth's nearest neighbors
    (f) What planet is known as the red planet?
    (g) What is the hottest planet in our solar system?
    (h) What is the name of the force holding us to the earth?
16. What is the name of Saturn's largest moon? (**ANS: Titan)**
17. **How** do the planets stay in orbit around the sun?
18. **Who** was the first person to walk on the moon? (ANS: **Neil Armstrong - 1969)**
19. Olympus Mons is large volcanic mountain on which planet? (**ANS: Mars)**
20. The earth appears to be stationary, but it is always in motion. Calculate the unnoticed speed of a man along the equator in km/h due to:
    (a) Rotational motion of the earth about its axis
    (b) Revolution of the earth around the sun (Take 1 year = 365 days)
21. Define star and give the name of the one closest to the earth
22. Mercury planet is 58 x 10^6 km from the sun and it takes 88 days to complete one orbit around the sun .Calculate the speed of the planet in km/hr to 3 significant figures. (**ANS: 1.73 x 10^5 km/hr)**
23. (a) Name two largest planets in the solar system
    (b) Name two brightest planets in the solar system
24. **S**tate the following terms (a) Heliocentric theory (b) Geocentric theory
25. A communication satellite appears to be stationary over one point on the earth's surface when it is moving in a circular orbit of radius 42,000 km. Find its speed in km/hr given that it must complete one orbit in 24 hours **(v = 11 x 10^3 m/s)**
26. x

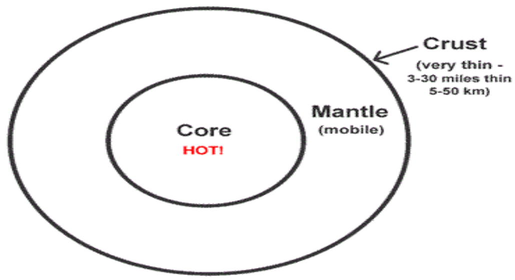
Topic – 7: Geophysics

Geophysics: Is a branch of science which deals with the composition, properties and behaviors of the earth

Interior Structure of the Earth

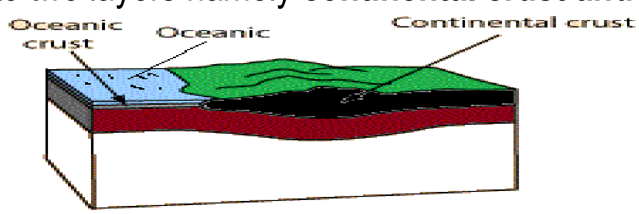
The Interior earth structure is divided into three zones namely

- Earth's Core
- Earth's Mantle
- Earth's Crust



Earth's Crust

- The crust is the outer solid layer of the earth.
- The earth's crust ranges from 5 km – 70 km
- It is divided into two layers namely **continental crust and oceanic crust**



Continental Crust (under the land)

- Continental crust is thick (25 km – 70 km) and light **because it is made of rocks with a low density** (about 2 – 2.8 tones per cubic meter).
- It is composed mainly by granites and sedimentary rocks.
- **Land mass and mountains** are located at continental crust.

Oceanic Crust (under the sea)

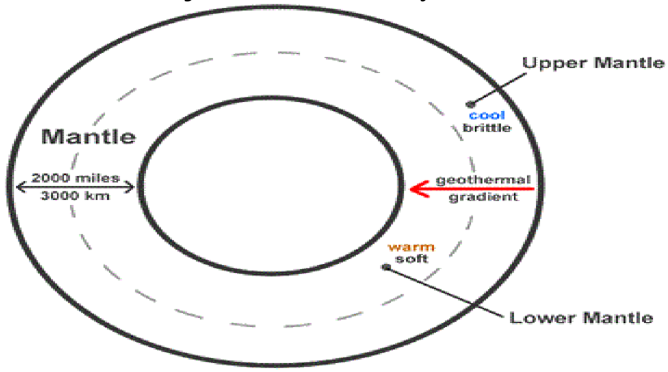
- Oceanic crust is basaltic with high density (about 3 – 3.1 tonnes per cubic metre).
- It is thin (6 – 11km) and heavy because it is made of rocks (volcanic rocks) that have a high density
- It covers two third (2/3) of the earth's surface

NB:

- The low density of the thick continental crust allows it to "float" in high relief on the much higher density mantle below
- **Mohorovicic discontinuity(Moho)** is the boundary that separates the crust and mantle

Earth's Mantle

- Earth's Mantle is starting from Moho and extends to a depth of 2900km below the earth surface up to its boundary with the earth's core.
- **Gutenberg Discontinuity** is the boundary between the mantle and the core

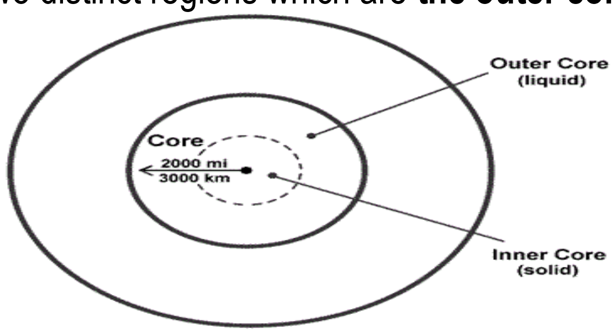


N B:

- ✓ Mantle contains about 70% of the earth's mass
- ✓ It is made by plastic rocks (both in solid and molten state)
- ✓ Upper part of mantle has a temperature of about 870^0C
- ✓ Lower part of mantle has a temperature of about 2200^0C
- ✓ The lower limit of brittle behavior is the boundary between the upper and lower mantle
- ✓ This steady increase of temperature with depth is known as the **geothermal gradient**
- ✓ The heat energy is the source of force that causes continental movement like volcanism and earthquakes

Earth's Core

- Earth's Core is the innermost part of the earth.
- It extends from Gutenberg discontinuity to earth's geometric center.
- It consists of two distinct regions which are **the outer core and the inner core**



Outer Core

- The outer core is the second largest layer and composed of liquid of molten nickel and iron known as **magma**. It is about 2200 km thick
- The magma surrounds the inner core and creates the earth's magnetic field

The inner Core

- The inner core is the hottest part of the earth. Its surface temperature is estimated to be approximately 5700 K(5430^0 C) which is as hot as the surface of the sun
- It is made of solid iron and nickel that are under so much pressure they cannot melt

- It is 1200 km thick (radius) and heavy radioactive elements within the core generate the intense heat as they decay
- Inner core is a solid even though its temperature is higher than the outer core. **This is because it is composed of very dense materials – like iron and nickel alloys. The materials are solid due to the high pressure at the depth of more than 5000 km below the earth's surface.**

Tectonic Plates

- Tectonic plates are the huge pieces of cracked earth's crust and mantle parts which float over semi-molten rock.
- Also is called **lithospheric plate.** Tectonic plates are in slow motion.This movement means continents are moving apart and toward each other. This process in which continents move is called **continental drift.**

Boundary

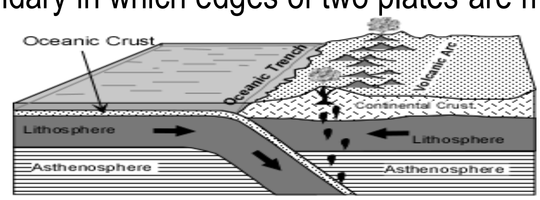
- Boundary is the line where two tectonic plates meet

Types of Boundary

✓ Destructive/ converging boundary
✓ Constructive/diverging boundary
✓ Conservative boundary

Destructive (Convergent) Boundary

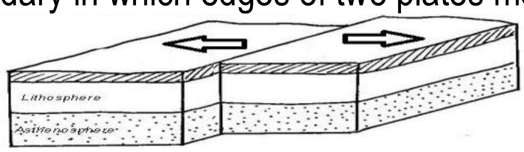
- Is the kind of boundary in which edges of two plates are moving toward each other



Ocean - Continent Convergence

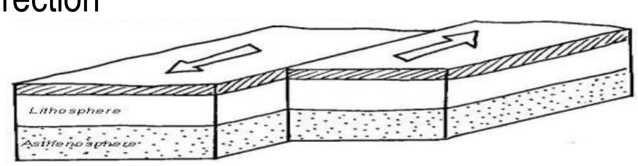
Constructive (Divergent) Boundary

- Is the kind of boundary in which edges of two plates moving away each other



Conservative Boundary

- Is the kind of boundary in which two plates slide moving each other in opposite or the same direction



Volcanoes

- **V**olcanoes are places where molten rock called magma leaks out through a hole or a crack in the earth's crust

Causes of Volcanoes

- Volcanoes are caused by movement of molten rock and heat energy inside the earth. These movements are called **subterranean movements**
- Most volcanoes form along constructive and destructive boundaries and few form far from plate boundaries
- Magma that reached the earth's surface is called **lava**

Volcanoes at destructive boundaries

- When ocean plate plunges under another plate, the ocean plate rubs against the plate above it and gets hot. Rock melts resulting magma under the upper plate. Magma forces away through weak points in the crust

Volcanoes at Constructive boundaries

- At the mid-oceanic ridges, two tectonic plates diverge from one another. For example, the Mid-Atlantic Ridge, has examples of volcanoes caused by divergent tectonic plates pulling apart

Volcanoes at far from Plate Boundaries

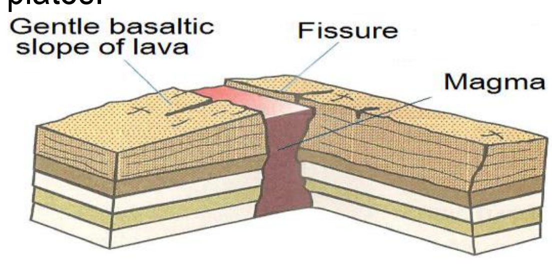
- This eruption occurs when mantle is hotter than normal. The magma formed is forced toward earth's surface. For Example, Nyamalagira volcano located at Congo. This kind of volcanoes are called **Hot-sport volcanoes**

Types of Volcanoes

- Fissure volcanoes
- Central volcanoes

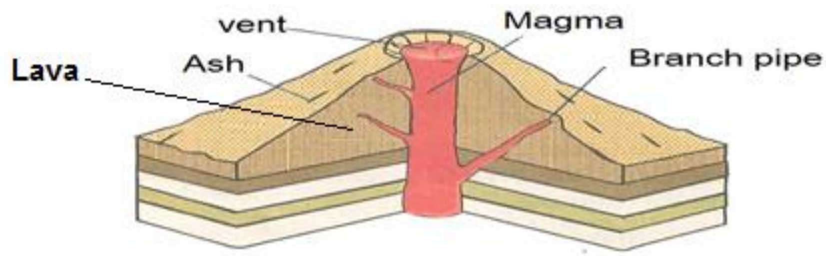
Fissure Volcanoes

- Fissure volcanoes are kinds of volcanoes which occur along cracks in and between tectonic plates.



Central Volcanoes

- Central volcanoes are a single vertical main vent through which magma reaches the earth's surface.
- It is a cone shaped, builds up from successive layers of lava and ash
- The process by which magma is forced from interior of the earth through a vent in the earth crust is called **Vulcanicity**



Classification of Volcanoes

- **Active Volcanoes**
  - Active volcanoes are those that erupt regularly in recent times.
  - Example, Mt. Nyiragongo–Congo, Santa Maria–Guatemala and **Ol Doinyo Lengai–Tz**
- **Dormant Volcanoes**
  - Are those that have erupted in historical times but are now quiet but can erupt again
  - Example, **Mt. Kilimanjaro in Tanzania and Mt. Fuji in Japan**
- **Extinct Volcanoes**
  - Are those which have not erupted in human history, probably never erupt again
  - Example Mt. **Thielsen** in Oregon in the US

Effects of Volcanoes

Negative effects of volcanoes

- **Destruction property and loss of human life** : Eruptions occurring close to human settlements may spill and destroy lives and property
- **Environmental Pollution** : Ash discharged very high into the stratosphere can have negative consequences on the ozone layer
- **Lahars**: Ash and mud can mix with rain and melting snow, forming lahars. ***Lahars are mudflows flowing at very fast pace***
- **Acidic rain**: Gas emissions from volcanoes are a natural contributor to acidic rain
- **Accident**: Ash thrown into the air by eruptions can present a hazard to aircraft, especially jet aircraft where the particles can be melted by the high operating temperature.

Positive effects of volcanoes

- **Landscape formation**: Volcanoes lead to formation of mountains ,islands , plateaus and valley
- **Tourism**: Provide extraordinary scenery, so beautiful and natural that they attract tourists to the area, bringing in some economic value.
- **Geothermal energy**: Places close to volcanic activities tend to have higher potential for geothermal energy, which can be an advantage to the towns and cities
- **Soil**: Ash and lava breakdown become soil that are rich in nutrients, and become good areas for crop planting activities
- **Mineral**: it brings valuable mineral to the earth's surface

Earthquakes

- Earthquakes are the rumblings, shaking or rolling of the earth's surface.
- The study of earthquakes and seismic waves that move through and around the earth is known as **“Seismology”**
- Scientist who studies earthquakes and seismic waves is called **seismologist**

Causes of Earthquakes

- Movements of tectonic plates
- Volcanic eruptions

How earthquake occur?

- **Earthquakes** are usually caused when rock underground suddenly breaks along a fault. This sudden release of energy causes the **seismic waves** that make the ground shake.
- When two blocks of rock (plates) are rubbing against each other, they stick a little , after a while the rocks break ,and the earthquake occurs

NB:

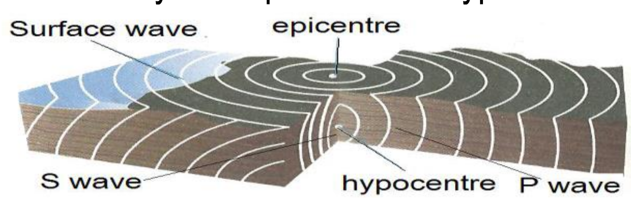
- **Hypocenter(Focus)** is the point within the earth where an earthquake originates
- Wave energy released by earthquakes is called **seismic waves**
- **Epicenter** Is the point on the earth’s surface directly above where an earthquake occurs and spread

Seismic Waves

- Are mechanical waves through which earthquake energy is transmitted and released

OR

- Is the energy released by earthquakes from hypocenter



Types of Seismic Waves

There are two main types of seismic waves namely:-

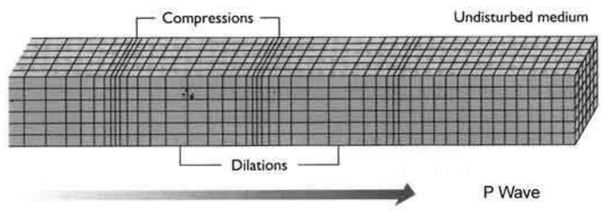
- **Body waves:** Are the waves which can travel through the earth’s inner layers
- **Surface waves:** Are the waves which can only move along the surface of the planet like ripples on water

Types of body waves

- Primary waves or P waves
- Secondary waves or S waves

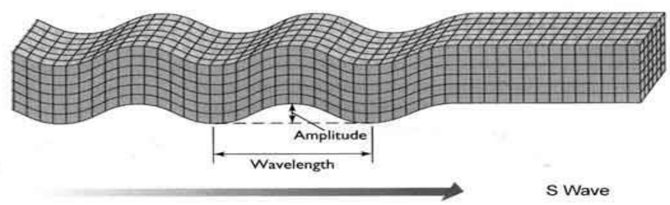
Primary Waves (P waves)

- Are **the first earthquake waves released from the hypocenter**
- Its motion is the same as that of a sound wave in that, as it spreads out, it alternately pushes (compresses) and pulls (dilates) the rock. These P waves are felt as a sudden jolt
- It travels through the Earth's core and through both solid rock, such as **Granite Mountains**, and **liquid material**, such as volcanic magma and the water of the oceans.



Secondary waves (S waves)

- Are seismic waves produced after primary waves and which are felt as a series of side to side tremors
- When S wave propagates, it shears the rock sideways at right angles to the direction of travel. If a liquid is sheared sideways or twisted, it will not spring back; hence S waves cannot propagate in the liquid parts of the earth, such as oceans and lakes.



Surface Waves

- Are seismic waves which originate from and travel radically from the epicenter

OR

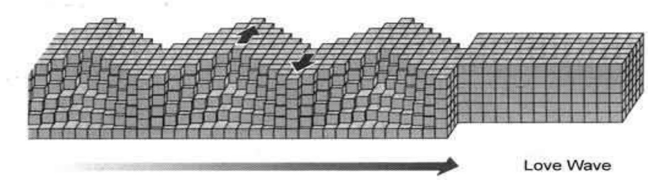
- Surface wave is the seismic waves which propagate in earth's surface.

Types of Surface Waves

- Love waves
- Rayleigh waves

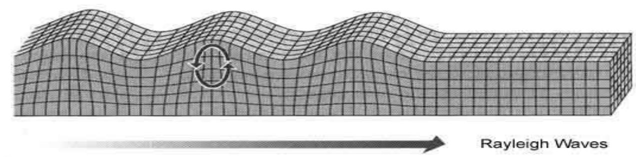
Love Waves

- Are the waves that travel by a transverse motion of particles that is parallel to the ground surface
- They make the ground shifting from one side to another
- The surface waves do damage to surface structure such as buildings and hydroelectric power plants
- Love waves generally travel faster than Rayleigh waves



Rayleigh

- Rayleigh are seismic surface waves which create a rolling movement and makes the ground to move up and down



NB:

- P waves is faster than S wave to be detected at seismic station
- **Surface waves** travel more slowly than **body waves** (P and S)
- Love waves (do not propagate through water) can effect surface water only insofar as the sides of lakes and ocean bays pushing water sideways like the sides of a vibrating tank
- Rayleigh waves propagates through water due to vertical components of their motion

Earthquake Scales

- The nature of an earthquakes described in terms of their **magnitude** and **intensity**

Earthquakes Magnitude

- The magnitude of an earthquake **Is a measure of the energy it releases**.
- It is usually measured on the **Richter scale**.
- **The Richter scale** is based on the amplitude of the largest seismic wave recorded for an earthquake, no matter what type of wave was the strongest
- The Richter scale magnitudes are based on a logarithmic scale (base 10)
- The scale has no upper limit
- The small magnitude expressed in negative numbers while large magnitude expressed in positive numbers

Earthquakes Intensity

- The intensity of an earthquake **Is a measure of its strength based on the changes it causes to the landscape.**
- The intensity of an earthquake is usually measured on the Modified **Mercalli scale**. The scale is calibrated from 1 to 12. On this scale, level 1 is a minor tremor that **CAUSES NO DAMAGE** whereas level 12 causes **TOTAL DEVASTATION.**
- Earthquake can only have one magnitude but, its intensity reduces as the seismic waves spread out from the **Hypocenter**

Seismograph

- Is an instrument used to record ground movements caused by earthquakes.
- The seismograph records both the magnitude and the intensity of the earthquake.

Types of Seismograph

- Simple pendulum Seismograph
- Inverted pendulum: Seismograph

Recording the Pendulum Motion

- The recording of the motion of the pendulum can be done through Optical mechanical or electronic methods

Effect (Hazards) of Earthquakes

- **Landslides**: Earthquakes can cause unstable hillsides, mountain slopes and cliffs to move downwards, creating landslides
- **Snow slopes**: Earthquakes can also trigger avalanches on snow slopes which can collide with people, house etc
- **Tsunamis**: Tsunamis are the hug water waves cause water to rise or fall. When a tsunami reaches shallow water, it slows down, its wavelength reduces and its height grows.
- **Collapsing of buildings:** A strong earthquake can flatten a whole city. An example, is the Japanese city of Kobe which was completely flattened by an earthquake measuring 7.2 on the Richter scale
- **Fire outbreak**: Breaking of gas or oil pipes and collapsing of electricity lines activate a fire outbreak
- **Loss of Life:** People in areas where an earthquake has stricken may get buried under buildings and soil or get hurt or even get killed when items fall on them
- **Destruction of property**: When earthquakes occur in places with buildings can lead to collapse of buildings and structures
- **Floods**: Tsunamis lead to coastal floods since ocean water suddenly rises above its normal
- **Backward rivers**: Tilting ground can also make rivers change their course. This can result in the creation of earthquake lakes that cover huge tracts of previously settled land

Earthquake Warning Signs

- **Thermal indicator**:

  Few months before the earthquake, the average temperature of particular area increasing. On the day of the earthquake, the temperature of a place is about 5 to 9 degrees Celsius above the average normal temperature for that day.

- **Water indicator**: About one or three days before an earthquake, there is
  1. Sudden rise or fall in water levels in wells. The rise can be as high as one meter. The well water may turn muddy
  2. At times a fountain appears inside the well. Sometimes a fountain may appear in the ground. This normally happens a few hours before the quake
  3. There is also a sudden and rapid increase or decrease of water flow in the rivers. This happens about one to two days before the quake

- **Seismo electromagnetic indicator**:
  When temperature raises results geomagnetic field to reduce which affects the propagation of electromagnetic waves (radio, television and telephone). This is a very reliable indicator. It is usually recorded about 10 to 20 hours before the quake.
- **Animal indicator**: Between 10 and 20 hours before the occurrence of an earthquake, the entire animal kingdom becomes highly disturbed and restless.
- **Human indicator**:
  Sensitive patients in hospitals become highly disturbed before an earthquake. They exhibit a sudden rise in blood pressure, heart trouble, headache, migraine and respiratory disorders. Indeed, the number of outpatients in hospitals increases by five to seven times, some 10 to 20 hours before the quake

Precaution taken during an earthquake

- If you are indoors during an earthquake, drop, cover and hold on. Get under a desk, table or bench. Hold on to one of the legs and cover your eyes. If there is no table or desk nearby, sit down against an interior wall.
- Pick a safe place where things will not fall on you
- Wait in your safe place until the shaking stops, then check to see if you are hurt
- Move carefully and watch out for things that have fallen or broken, creating hazards. Be ready for additional earthquakes called **aftershocks**
- Be on the lookout for fires. Fire is the most common earthquake-related hazard due to damaged gas and electrical lines.
- If you must leave a building after the shaking stops, use the stairs and not the elevator.

Similarities between earthquakes and volcanoes

- ✓ They are both caused by movement of molten rock and heat deep inside the earth
- ✓ They mostly occur near tectonic boundaries

Structure and composition of the atmosphere

Atmospheric Structure

- **The atmosphere** is a layer of gas and dust that surrounds the earth

Layers (Regions) of Atmosphere

- Atmosphere is divided into five regions based on its **thermal characteristics** (temperature changes), **chemical composition**, **movement** and **density**

Therefore there are five regions includes

- Troposphere region
- Stratosphere region
- Mesosphere region
- Thermosphere region
- Exosphere region

Troposphere Region

- Troposphere region is the region nearest to the earth.
- It extends to an altitude of up to 10 km above the poles and 20 km above the equator.

NB:

- This region is the densest part of the atmosphere. It contains 80% by mass of the atmosphere. It contains most of the atmosphere's water vapor
- The temperature in this region decreases with altitude at an average rate of 6°C/km
- Air molecules can travel to the top of the troposphere and back down again in just a few days. This mixing encourages changing weather
- Most weather phenomena occur in the troposphere. **Clouds** and **rain** are formed within this region.
- Boundary separates the troposphere and the stratosphere is called the **tropopause**
- Temperatures stop decreasing with height and become constant

Stratosphere Region

- Stratosphere Is a region that starts from the tropopause and extends to about 50 km high.
- This layer is more stable, drier and less dense compared to the troposphere.
- The temperature in the stratosphere slowly increases with altitude
- Temperature increase due to the presence of the **ozone layer** which absorbs ultraviolet rays from the sun. The ozone layer lies in the middle of the stratosphere between 20 and 30 km. Ozone**(O_3)** is a **triatomic** form of oxygen
- This layer plays the important role of absorbing ultraviolet radiations which would otherwise reach the earth's surface **.**This radiation is harmful to both animal and plant life on earth
- The stable air of the stratosphere also prevents large storms from extending much beyond the tropopause
- Planes also fly in the stratosphere. This is because it has **strong steady horizontal winds** which are above the stormy weather of the troposphere
- Troposphere and stratosphere are collectively known as the **lower atmosphere**
- Boundary separates the stratosphere and the other layer is called **stratopause**

Mesosphere Region

- Mesosphere is region that starts just above the stratosphere and extends to 85 km high
- Temperature at this layer decreases with altitude. The lowest temperature of the atmosphere (-90°C) occurs within this region
- Mesosphere is the layer in which most meteors burn while entering the earth's atmosphere
- Boundary separates the mesosphere and the thermosphere is called **mesopause**

Thermosphere Region

- Thermosphere Is region that starts just above the mesosphere and extends up to 690 km high
- Temperature increases with increase in altitude due to the sun's heat
- The temperature in this region can go as high as 1, 727°C
- Chemical reactions occur much faster here than on the surface of the earth.
- This layer is also known as the **upper atmosphere**
- The lower part of the thermosphere, from 80 to 550 km above the earth's surface, called **ionosphere**
- This region containing a high concentration of charged particles called **ions** and **free electrons**
- The large number of free electrons in the ionosphere allow the propagation of electromagnetic waves
- Ionosphere also absorbs dangerous radiation. The radiation absorbed in the ionosphere includes **hard and soft X-rays** and **extreme ultraviolet (EUV) radiation**.

Importance of Ionosphere

- The ionosphere plays an important role in **communications**. Radio waves can be reflected off the ionosphere allowing radio communications over long distances

Exosphere Region

- Exosphere region is the outermost region of the atmosphere
- Atmospheric gas pressure is very low. Light atoms such as hydrogen and helium may acquire sufficient energy to escape the earth's gravitational pull
- The upper part of the exosphere is called **magnetosphere**. The motion of ions in this region is strongly constrained by the presence of the earth's magnetic field
- Is the region where satellites orbit the earth

Importance of the Atmosphere

- ✓ The troposphere controls the climate and ultimately determines the quality of life on the earth
- ✓ The troposphere is important for life on the earth. The layer contains gases which include
  - **Oxygen** which is used for respiration by animals
  - **Carbon dioxide** which is used by plants in photosynthesis
  - **Nitrogen** found in this layer also provides an inactive environment for many chemical processes to take place
  - Gases also support many important chemical processes such as **combustion**, **weathering** and **oxidation**
- ✓ The stratosphere prevents harmful ultraviolet radiation from reaching the earth
- ✓ The mesosphere, thermosphere and exosphere also prevent harmful radiation such as cosmic rays from reaching the earth's surface
- ✓ **Communicatio**n is also made possible by some layers of the atmosphere, specifically the ionosphere

Greenhouse Effect

- Is the process in which the emission of radiation by the atmosphere warms the earth's surface

OR

- Is the trapping back of Sun's energy by a planet from atmospheres

OR

- Is the process that occurs when gases in Earth's atmosphere trap the sun's heat

How Greenhouse effect occurs

- When a planet's surface is heated by sunlight it emits radiation which is absorbed by the greenhouse gases in the atmosphere. The atmosphere reflects back thermal radiation in all directions to the earth's surface. Over time, this increases the planet's temperature due to presence of greenhouse gases

Sources of Greenhouse Effect

- ❖ Water vapor
- ❖ Ozone layer
- ❖ Carbon dioxide
- ❖ Methane
- ❖ Chlorofluorocarbons
- ❖ Nitrous Oxide (Dinitrogen Oxide)

Carbon Dioxide (CO_2)

- Carbon dioxide is the main greenhouse gas. The gas contributes over 50% of the greenhouse effect.

The following are some of the sources of carbon dioxide

- Clearing and burning of vegetation (deforestation)
- Burning of fossil fuels (coal, oil and natural gas)

Methane (CH_4)

- Is one of the trace gases in the atmosphere that is considered to play a major role in the greenhouse effect
- The main source of methane is;
  - **(i)** **Agricultural activities**. It is released from wetlands, such as rice fields and from animals, particularly cud-chewing animals like cows.
  - **(ii)** Mining of coal and oil (**Fossil methane emission during the exploration and transport of fossil fuels)**
  - **(iii)** Biomass burning **(Forest fires, charcoal combustion and firewood burning)**
  - **(iv)** Anaerobic decomposition of organic waste in landfills
- **Note**: Methane molecules have a lifetime of 10 years in the atmosphere

Nitrous Oxide (Dinitrogen Oxide – N_2O)

- Is the third most important **GHG** for the enhanced greenhouse effect after **CO_2** and **CH_4**
- Nitrous oxide is produced from both natural and human-made processes.

Human activities includes

- ✓ Combustion of fossil fuels in vehicles and power stations
- ✓ Use of nitrogenous fertilizers
- ✓ Burning of vegetation
- ✓ Animal waste.

Chlorofluorocarbons (CFCs)

- Chlorofluorocarbons are organic compounds made up of chlorine, fluorine and carbon.
- The sources of CFCs in the atmosphere include **fridges**, **air conditioners**, **sprays** and **aerosols**
- CFCs are extremely effective greenhouse gases. A CFC molecule is 10 000 times more effective in trapping heat than a carbon dioxide molecule

Global Warming

- *Global warming is the increase of the average temperatures near or on the earth's surface caused by greenhouse gases*

OR

- *Global warming is the increase in temperature near or on the surface of the earth resulting into greenhouse effect*

Causes of global warming

- Global warming is mainly caused by greenhouse gases

How Global warming occurs?

- A Global warming occurs when green house gases collect in the atmosphere and absorb sunlight and solar radiation that have bounced off the earth's surface
- Normally this radiation would escape into space – but these pollutants in the atmosphere , trap the heat and cause the planet to get hotter (**Greenhouse effect**)

Effects of Global Warming

- ❖ Increase in the temperature of the oceans
- ❖ **Rise in sea levels due to melting of land ice**. This will lead to coastal flooding of the coastal land.
- ❖ Acidification of the oceans CO_2 dissolves in water and forms a weak carbonic acid and hence concept of PH of ocean
- ❖ **Extreme weather events** which include floods, drought, heat waves, hurricanes and tornadoes

- **Destroying of agriculture and fisheries.** This is due to forests, farms and cities will face troublesome new pests, heat waves, heavy downpours and increased flooding.
- **Melting glaciers, snowmelt and severe droughts** will cause more dramatic water shortages and increase the risk of wildfires
- **Extinction (Death) of some animal and plant species**. Disruption of habitats such as coral reefs and Alpine meadows could drive many plant and animal species to extinction
- **Diseases outbreaks**. Asthma, allergies and other infectious diseases will become more common due to increased growth of pollen – producing ragweed, higher levels of air pollution and the spread of conditions favorable to pathogens and mosquitoes
- Change in world's climate patterns

Solutions to minimize Global warming

- Reduce the use of fossil fuels by using public transport which will minimize the number of vehicles in the roads
- Use of fuel-efficient cars
- Use of renewable sources of energy such as solar and wind.
- **Afforestation**. Replant trees that would absorb carbon dioxide
- Countries to make a policy of minimizing the emission of greenhouse gases. Example, Kyoto protocol

Class Activity – 7:1

1. (a) Define the term earthquake
   (b) Briefly explain the meaning of the following terms as used on earthquake
   (i) Hypocenter (ii) Epicenter
   (c) (i)What is global warming?
   (ii)Name four gases that contribute to global warming and give one source of each
   (d) (i) Mention two merits and two demerits of volcanoes
   (ii) Briefly explain two hazards associated with earth quakes
2. What is meant by the following terms as used in geophysics
   (i) Magma (ii)Tsunami

ANS: (i) Magma: Are molten rocks inside the earth's mantle which are ejected during a volcanic eruption

(ii) Tsunami is a sea wave which is caused by disturbance of the ocean floor either by an earthquake or a volcanic activity

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