Ch. # 10 SIMPLE HARMONIC MOTION AND WAVES

SHORT QUESTIONS

Vibratory motion:

To and fro motion of a body about its mean position is called vibratory motion. For examples

=>Motion of mass spring system.
=>Motion of ball and bowl system
=> Motion of simple pendulum

Simple harmonic motion:

Such a type of vibratory motion in which acceleration is directly proportional to displacement and always directed towards to mean position is called simple harmonic motion

Necessary conditions for S.H.M:

1. There must be inertia.
2. There must be restoring force.

Restoring force:

A force which always pull or push the object performing oscillatory motion towards the mean position is called restoring force.

Vibration:

One complete round trip of a body about its mean position is called one vibration.

Time period:

The time taken by a vibrating body to complete one vibration is called time period.

Frequency:

The number of vibration per second of vibrating body is called frequency. It is reciprocal of time period. Its unit is hertz or cycle per second.

Amplitude:

The maximum displacement of a vibrating body from mean position body to extreme position is called amplitude.

Displacement:

The distance of vibrating body from mean position at any instant of time is called displacement.

Wavelength:

The distance between two consecutive crests or troughs is called wavelength. It is denoted by 'λ'. Its unit is meter.

OR

The distance between two consecutive compressions or rarefactions is called wavelength. It is denoted by 'λ'. Its unit is meter.

Important features of S.H.M:

- ⇨ body vibrate about its mean position
- ⇨ Acceleration is directly proportional to displacement.
- ⇨ K.E is maximum at mean position and minimum at extreme position.
- ⇨ P.E is minimum at mean position and maximum at extreme position.

Damped oscillation:

Oscillation in which the amplitude is decreased with time is called damped oscillation.

Wave motion:

Such a disturbance in a medium which repeats itself in equal interval of time and reaches one part of medium to other part is called wave motion.

Types of waves:

Mechanical waves:

Waves which require any medium for their production and propagation are called mechanical waves.

For examples: water waves, string waves and sound waves.

Electromagnetic waves:

Waves which do not require any medium for their propagation are called electromagnetic waves.

For examples: Radio waves, x-rays, Heat and light waves.

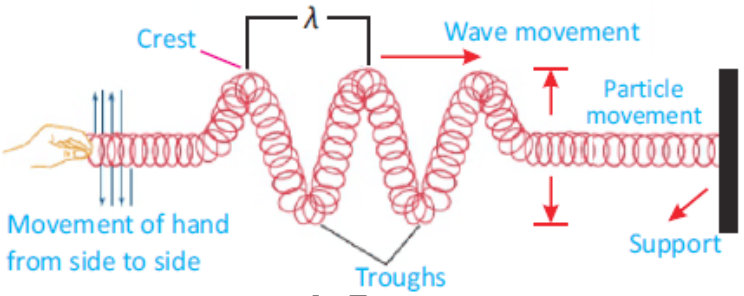
Types of mechanical waves:

Transverse waves:

Waves in which motion of particles of medium is perpendicular to the direction of waves are called transverse waves.

Trough and crest:

The part of transverse waves above the mean level is called crest and the part of transverse waves below the mean level is called trough.



For examples:

Water waves, string waves and spring waves.

Longitudinal or compressional waves:

Waves in which motion of particles of medium is parallel to the direction of waves are called longitudinal waves.

For examples:

Sounds waves, Waves of slinky spring etc.

Compression and rarefaction:

High pressure region of compressional waves is called compression and low pressure region is called rarefaction.

How transverse waves are produce:

=>Take a slinky spring along the bench with one end is fixed.

=> hold the other end and move it up and down quickly.

=> A waves in the form of crests and troughs will start traveling towards fix end.

Factors upon which waves energy depends:

- ⇨ amplitude of the waves
- ⇨ Frequency of waves.

Wave equation:

Relation between velocity, frequency and wavelength of the waves is known as wave equation.

Prove that v = f λ

A disturbance in a medium which travels from one place to another place with a specific velocity. This velocity is called wave velocity.

$$v = \frac{d}{t} \qquad \ldots\ldots\ldots 1$$

Distance covered by a wave in his time period is equal to its wavelength.

So d = λ t = T put in (1)

$$v = \frac{\lambda}{T} = \lambda(\frac{1}{T})$$

$$v = \lambda f \qquad \text{as } 1/T = f$$

Ripple tank:

A device which is used to produce water waves and to study their characteristic is called ripple tanks.

.**Diffraction of waves and its necessary condition:**

Bending of waves around the sharp edge or corners of slits is called diffraction.

Necessary conditions:

Wave length of waves is comparable with the size of slit.

What do the dark and bright fringe on the screen of ripple represents:

Dark and bright fringes on the screen of ripple represent trough and crest of water waves. Trough acts as concave lens which diverge light and crest acts as convex lens, converge the light.

What is seismic and its importance:

Due to earthquake, the vibrations of earth produce seismic waves.

Importance:

Geophysicists get information about the internal structure and future activity of earth.

Why the longitudinal waves move faster than transverse waves?

Because the restoring force exerted during up and down motion of particles is less than the restoring force exerted by back and forth motion of particles in case of longitudinal waves.

What is the effect of depth on the speed of water waves?

When water waves enter from shallow water to deep water. Its wavelength decrease but frequency remains constant. So according to equation v = f λ, speed of water decreased.

CONCEPTUAL QUESTIONS

Q.NO.1 Does increasing the frequency of a wave also increases its wavelength. If not how these quantities are related.

No, increasing frequency decreases its wavelength because they related inversely to each other.

Q.NO.2 if the length of a simple pendulum is doubled what will be change in its time period.

Time period will be increased $\sqrt{2}$ T times

$$T = 2\pi\sqrt{\frac{l}{g}}$$

If l = 2l

$$T' = 2\pi\sqrt{\frac{2l}{g}} = \sqrt{2}\,(2\pi\sqrt{\frac{l}{g}})$$

$$T' = \sqrt{2}\,(2\pi\sqrt{\frac{l}{g}})$$

$$T' = \sqrt{2}\,T$$

Q.NO.3 A ball is dropped from a certain height on to the floor and keeps bouncing. Is the motion of the ball simple harmonic? Explain.

No, this motion is not a simple harmonic motion. S.H.M is vibratory motion in which is vibrate about a mean position. In this case there is no mean position. So this motion is not S.H.M.

Q.NO.4 A student performed two experiments with a simple pendulum. He /She used two bobs of different masses by keeping other parameters constant. To his /her Astonishment the time period of the pendulum did not change! Why?

The time period of simple pendulum is T= $2\pi\sqrt{\frac{l}{g}}$

It is clear from above expression; time period does not depends upon the mass. It depend s upon the length of pendulum and value of 'g'.

Q.NO.4. what type of waves do not require any material medium for their propagation?

Electromagnetic waves

Q.NO.6

Plane waves in the ripple tank undergo refraction when they move from deep to shallow level. What change occurs in the speed of the waves?

When water waves enter from deep water to shallow water. Its wavelength increases but frequency remains constant. So according to equation v = f λ, speed of water increases.

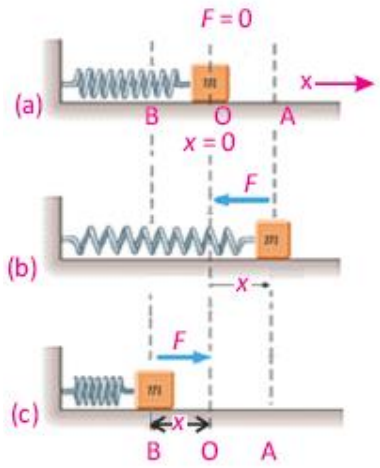
LONG QUESTIONS

SIMPLE HARMONIC MOTION:

Such types of vibratory motion in which acceleration is directly proportional to displacement and always directed towards the mean position.

MOTION OF MASS ATTACHED TO A SPRING

Consider a mass m is attached to one end of spring is lying on a horizontal smooth surface. At this position F = 0 so it is called mean position. If spring is compressed or stretched through a displacement 'x' then it exerts a force on mass m which is directly proportional to change in length of spring.



$F \alpha - x$

$F = - k x$ …… 1

Where k is constant of proportionality and is called spring constant.

Spring constant:

It is the ratio of the force to the change in length of spring. The stiffness of spring depends upon value of k. Its unit is **Nm^{-1}**.

According to Newton second's law of motion

$F = ma$ …… 2

Comparing 1 and 2

$ma = -k x$

$a = -\frac{k}{m} x$

$\frac{k}{m}$ = constant

$a \alpha -x$

Negative sign show that force exerted by spring towards the mean position. This force is called restoring force.

Restoring force:

A force which pulls or pushes the object executing vibratory motion towards the mean position is called restoring force.

When mass moves from extreme position A or B to mean position O, displacement is decreases and becomes zero at O so acceleration is also zero at O, but speed of mass increases and becomes maximum at O.

As mass 'm' moves from mean position O to extreme position A or B, displacement is increase so acceleration is increases but speed decreases and becomes zero at position A or B.

This process is repeated and mass continues to oscillate back and forth about mean position. Such a motion is known as S.H.M.

Time period:

The time period of mass attached to a spring is given by the fallowing formula

$$T = 2\pi \sqrt{\frac{m}{k}}$$

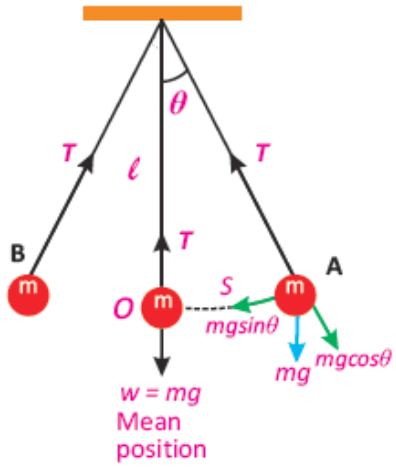
SIMPLE PENDULUM:

A simple pendulum is a small heavy bob suspended by mean of light string.

Initial, pendulum is in vertical position. In this position net force acts on bob is zero. So this is mean position. Now bob is displaced to extreme position A then released. There are two forces acts on bob

- ⇨ weight of bob mg downwards
- ⇨ tension T along the string

Component mg cosθ is equal but in opposite to tension T so they cancel each other. The component mgsinθ brings the bob towards the mean position and acts as restoring force but it does not stop at O due to inertia and continue its motion towards B.



When bob moves from extreme position A or B to mean position O, displacement is decreases and become zero at O, but speed of bob increases and becomes maximum at O.

As bob moves from mean position O to extreme position A or B, displacement is increase so acceleration is increases but speed decreases and becomes zero at position B.

This process is repeated and bob continues to oscillate back and forth about mean position. It is clear that acceleration is always directed towards the mean position. Such a motion is known as S.H.M.

Time period:

The time period of simple pendulum is given by the fallowing formula

$$T = 2\pi \sqrt{\frac{l}{g}}$$

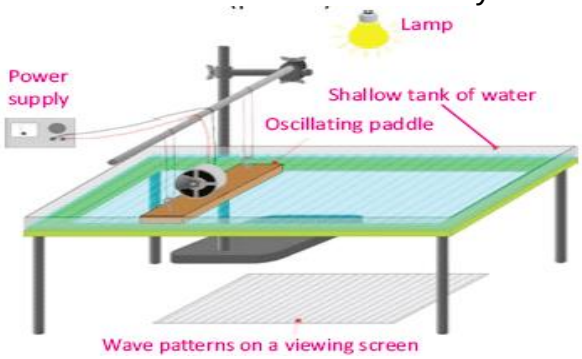
What is ripple tank? Describe its construction and working.

Ripple tank:

A device which is used to produce water waves and to study their characteristic is called ripple tanks.

Construction:

It is consists of rectangular tray having glass bottom and is placed nearly half meter above the surface of table. A vibrator (electric motor) is fixed on the wooden plate whose lower surface touches the surface of water. An electric lamp is hung over the tray to observe the image of water waves



Working:

When motor is on, the wooden plate starts vibrating and generates the plane water waves. The crests and troughs of the waves appear the bright and dark fringes respectively on the screen.

Why motion of ball and bowl system is S.H.M:

When ball at the center of bowl, its weight and reaction force are equal but in opposite direction, they cancel each other effect so net force is zero. This is called mean position.

If we bring it at point A then released , it will move towards the mean position due to the restoring force provided by it vertical component of its weight.

When ball is moving from extreme position' A' to mean position its speed increases and maximum at 'O' and due to inertia it moves towards 'B'. When it is moving from mean to extreme position, its speed decreases and zero at 'B'. This means direction of acceleration is towards mean position. So motion of ball and bowl system is S.H.M.

Damped oscillation:

Oscillation in which the amplitude is decreased with time is called damped oscillation.

OR

The oscillation of system in the presence of some resistive force is called damped oscillation.

Any system does not oscillate indefinitely. Friction reduces its energy as time passes, which causes the amplitude decreases.

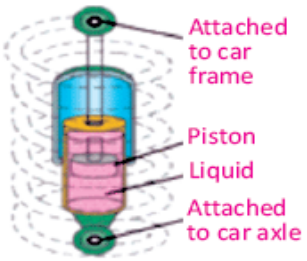
Example: Shock absorber is the good example of damped oscillation

=> It is consist of piston moving through a liquid such as oil.

=> Its upper part is connected with the body of car.

=> When car is passes over some bump. Its body vibrates violently.

=> Shock absorber damped this vibration.



Reflection of water waves;

When water waves moving in a one medium and incident at the surface of other medium, return back in same medium. This phenomenon is known as reflection of water waves.

Produce the water wave in ripple tank. Place a barrier in ripple tank. Water waves reflect back from barrier. In this case angle of incidence is equal to angle of reflection.

$$\angle i = \angle r$$

Refraction of water waves:

When water waves enter from one medium to another medium at some angle, its speed and direction are changed. This phenomenon is called refraction of water waves.

Refraction of wave depends upon the depth of water.

Case-i if a block is placed in ripple tank, then water will be shallow over the block. When water waves enter from deep water to shallow water. Its wavelength decreases but frequency remains constant. So according to equation v = f λ, speed of water decreased.
Case-ii if a block is placed at some angle then in addition to change in wavelength, waves change their direction of propagation. This is called refraction of water waves.

Diffraction of waves and its necessary condition:

Bending of waves around the sharp edge or corners of slits is called diffraction.

Generate the water wave in a ripple tank. Place the slits in front of it. After passing through the slits, water spread out in all direction in semicircular pattern.

Necessary conditions:

Wave length of waves is comparable with the size of slit.

NUMERICAL PROBLEMS

10.1 The time periods of simple pendulum is 2 s. what will be its length on the earth?What will be its length on the moon if $g_m = ge/6$ where $g_e = 10\ ms^{-2}$

To given:

T= 2 s

$g_e = 10\ ms^{-2}$

$g_m = ge/6 = 10/6 = 1.67\ ms^{-2}$

To find: l_e =? , l_m=?

Calculation:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Squaring on both sides

$$T^2 = 4\pi^2 l/g$$

$$l = \frac{T^2 \times g}{4\pi^2}$$

Length of pendulum on earth:

$$= \frac{2^2 \times 10}{4 \times (3.14)^2} = \frac{4 \times 10}{4 \times 9.85}$$

$$= \frac{10}{9.85} = 1.02m$$

Length of pendulum on moon:

$$= \frac{2^2 \times 1.67}{4 \times (3.14)^2} = \frac{4 \times 1.67}{4 \times 9.85}$$

$$= \frac{1.67}{3.14} = 0.17\ \text{m}$$

10.2 A pendulum of length 0.99 m is taken to the moon by an astronaut. The period of the pendulum 4.9 s. what is the value of g on the surface of the moon.

To given: $l = 0.99\text{m}$

T = 4.9 s

To find: g_m =?

Calculation:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Squaring on both sides

$T^2 = 4\pi^2 l/g$

$$g_m = \frac{4\pi^2 \times l}{T^2} = \frac{4\times(3.14)^2\times.99}{(4.9)^2} = \frac{39.04}{24.01}$$

$= 1.63\ ms^{-2}$

10.3 find the time period of simple pendulum of 1 meter length, placed on the earth and on the moon. The value of g on the surface of earth is 1/6th of its value on the earth. Where g_e =10 ms^{-2}

To given: $l = 1$ m

$g_e = 10\ ms^{-2}$

$g_m = ge/6 = 10/6 = 1.67\ ms^{-2}$

To find: T =?

Calculation:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Period on the earth:

$$= 2\times3.14\sqrt{\frac{1}{10}} = 6.28\times\sqrt{.1}$$

$= 6.28 \times .31 = 1.9 = 2s$

Period on the moon:

$$= 2\times3.14\sqrt{\frac{1}{1.67}} = 6.28\times.773 = 4.85\ s = 4.9s$$

10.4 a simple pendulum complete one vibration in two seconds. Calculate its length where g =10 ms^{-2}.

To given:

T= 2 s

$g_e = 10\ ms^{-2}$

To find: l_e =?

Calculation:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Squaring on both sides

$T^2 = 4\pi^2 l/g$

$$l = \frac{T^2\times g}{4\pi}$$

Length of pendulum on earth:

$$= \frac{2^2\times10}{4\times(3.14)^2} = \frac{4\times10}{4\times9.85}$$

$$= \frac{10}{9.85} = 1.02m$$

10.5 If 100 waves pass through a point of a medium in 20 seconds. What is the frequency and time period of the waves? If its wavelength is 6cm, calculate the waves speed?

To given:

No. of waves = n = 100

t = 20s

Wavelength = λ = 6cm = .06 m

To find: f=? , T=? And v=?

Calculation:

$$f = \frac{n}{t} = \frac{100}{20} = 5\text{Hz}$$

$$T = 1/f = 1/5 = 0.2\ s$$

$$v = f\lambda$$

$$= 5 \times .06 = 0.3\ ms^{-1}$$

10.6 A wooden bar vibrating in to the water surface in a ripple tank has a frequency of 12Hz. The resulting wave has a wavelength 3cm. what is the speed of waves?

To given:

$f = 12$ Hz

$\lambda = 3cm = .03m$

To find: v =?

Calculation:

$$v = f\lambda$$

$$= 12 \times 0.03 = 0.36\ ms^{-2}$$

10.7 A transverse waves produced on a spring has frequency of 190 Hz and travel along the length of the spring of 90 m, in 0.5 s

(a) What is the period of waves?

(b) What is the speed pf the wave?

(c)What is the wavelength of the waves?

To given:

$f = 190$ Hz

$d = 90m, \quad t = 0.5s$

To find: T=? v=? λ =?

Calculation:

$$T = 1/f = 1/190 = 0.005 = 0.01\ s$$

$$v = d/t = 90/.5 = 180\ ms^{-1}$$

$$v = f\lambda$$

$$180 = 190 \times \lambda$$

$$\frac{180}{190} = \lambda$$

$$.947\ m = \lambda$$

10.8 water waves in a shallow dish are 6.0cm long. At one point, the water moves up down at the rate 4.8 oscillation per second.

(a) What is the speed of water waves?

(b) What is the period of water wave?

To given:

$d = 6cm = 0.06m$

$f = 4.8$ osc/s

To find: v =? T =?

Calculation:

$$T = 1/f = 1/4.8$$

$$= 0.208\ s = 0.21\ s$$

$$V = d/t = 0.06/\ 0.21$$

$$= 0.285 = 0.29\ ms^{-1}$$

10.9 At one end of a ripple tank 80cm across, a 5 Hz vibrator produce waves whose wavelength is 40 mm. find the time the waves need to cross the tank.

To given:

$d = 80cm = 0.8m$

λ = 40 mm = 40/1000 = 0.04 m
f = 5 Hz

To find: Time = t =?

Calculation:

V= f λ
= 5 × 0.04 = 0.2 ms^{-1}
V= d/t
0.2 = 0.8 / t
t = 0.8 / 0.2 = 4 s

10.10 What is the wavelength of the radio waves transmitted by an FM station at 90 MHZ? Where 1M = 10^6, and speed of radio wave is 3 ×10^8 ms^{-1}

To given:

f = 90MHz
= 90 × 10^6 Hz
V = 3 ×10^8 ms^{-1}

To find: λ =?

Calculation:

v = f λ
3 ×10^8 = 90 × 10^6 × λ

$$\frac{3\times10^8}{90\times10^6} = \lambda$$

0.0333 × 10^2 =
3.33 m = λ

Ch. # 11 SOUND

SHORT QUESTIONS

What are sound waves how can be it produced:

Sound is the form of energy which can be produced by the vibrating body. The study of sound is called acoustics.

What is tuning fork?

In school laboratories, we used a device to produce sound is called tuning fork.

Loudness:

Loudness is the characteristic of sound by which loud and faint sounds can be distinguished.

Factors upon which loudness depends:

- ⇨ amplitude of vibrating body
- ⇨ area of vibrating body
- ⇨ Distance from vibrating body.

Pitch:

It is the characteristics of sound by which we can distinguish between a shrill and a grave sound. It depends upon the frequency of sound wave.

Quality:

It is the characteristics of sound by which we can distinguish between two sounds of same loudness and pitch. Quality of sound depends upon the waveform.

Intensity:

Sound energy passing per second through a unit area held perpendicular to the direction of propagation of sound waves is called intensity of sound.

Unit: watt per square meter (Wm^{-2})

Intensity of faintest audible sound: 10^{-12} Wm^{-2}

Intensity of loudest sound: 1 Wm^{-2}

What is zero bel?

The intensity level of intensity of faintest sound is zero, so it is called zero bel. It is taken as reference intensity.

Weber Fechner's law:

The loudness of sound is directly proportional to logarithm of intensity.

$$L \propto \log I$$

$$L = k \log I$$

This is called Weber Fechner's law.

Decibel scale:

$$S.L = 10 \log I/I_o$$

Using this equation, we construct a scale to measure the intensity level of sound. This scale is called decibel scale.

Reflection of sound (echo):

When sound is incident on the surface of medium, it bounces back in to the first medium. This phenomenon is called reflection of sound or echo.

Minimum distance to produced echo:

The sensation of sound persists in our brains is 0.1s. To hear the clear echo, it is time interval between our sound and reflection of sound.

Speed of sound in air= 340 ms^{-1}

Total distance of sound (back and forth) = 340 × 0.1 = 34.0m

One side distance = 17m

So the minimum distance form the obstacle and sound source is 17 m.

Why sound can not be traveled in vacuum?

Sound can only be transmitted through a medium in which particles can vibrate. So sound can not be traveled in vacuum.

Factors upon which speed of sound depends:

- ⇨ temperature
- ⇨ pressure
- ⇨ humidity
- ⇨ nature of medium

Speed of sound at 21^{o}C and 1 atmospheric pressure is 343 ms^{-1}.

- Speed of sound in a liquid is 5 times greater than gasses.
- Speed of sound in a solid is 15 times greater than gasses.

Noise pollution:

The unwanted sound that is harmful for the health of human and other species.

Musical sound:

Sounds which are pleasant to our ears are musical sounds such as sounds of flute harmonium and violin.

Noise:

Sounds which are unpleasant effects to our ears are called noise such as sounds of heavy machinery, the slamming of door and sound of traffic.

Negative effects of noise:

1- It causes the conditions such as hearing loss, sleep disturbance, aggression and hypertension.

2- It causes the accident by interfering with communication and warning signals.

Factors upon which a safe level of noise depends:

- ⇨ Level or volume of noise
- ⇨ period of exposure

In most countries level of noise 85-90 db over eight hours are recommended.

How noise pollution can be reduced:

- ⇨ By replacing noise machinery with friendly machinery
- ⇨ By sound reducing barriers
- ⇨ By hearing protection devices

Acoustics protection:

The technique or method used to absorb undesirable sounds by soft and porous surfaces is called acoustics sounds.

Reverberation:

The multiple reflections of sounds are called reverberation.

Why the ceiling of lecture hall conference hall and theater hall are curved?

So that sound after reflection may reach all the corners of the hall.

Audible frequency range:

The range of the frequencies which human hear is called audible frequency range. It is 20 Hz to 20 kHz.

Ultrasounds:

Sound waves of frequency more than 20,000 Hz are called ultrasound waves.

What is SONAR?

It can be used to locate the objects lying deep on the ocean.

This technique is called SONAR, (sound navigation and ranging)

Why the voice of women is more shrill than that of men?

Because frequency of sound waves of women is higher than frequency of sound waves of men.

CONCEPTUAL QUESTIONS

11.1 Why two tin cans with a string stretched between them could be better way to communicate than merely shouting through the air?

Speed of sound in solid is 15 times greater than in gasses. So communication with the help of string is batter than shouting in air.

11.2 We can recognize persons speaking with the same loudness from their voice. How is this possible?

Yes it possible to recognize the voice those are speaking with same loudness.

Reasons: waveform of their sounds is different. This characteristic of sound is called quality.

11.3 You can listen to your friend round a corner, but you cannot watch him/her. Why?

Due to diffraction, sound waves bend around the corner and reaches to you. So you can listen to your friend.

11.4 Why must the volume of a stereo in a room with wall-to-wall carpet be tuned higher than in a room with a wooden floor?

Volume of a stereo in a room with wall to wall carpet must be tuned higher than in a room with a wooden floor because reflection of sound is more prominent if the surface is smooth, and less if the surface is irregular

11.5 A student says that the two terms speed and frequency of the wave refer to the same thing. What is your response?

No, these are different quantities. Speed is the disturbance reaches from one part of medium to other part in one second and frequency is no. of vibration of particles of medium in one second.

11.6 Two people are listening to the same music at the same distance. They disagree on its loudness. Explain how this could happen.

Loudness also depends upon physical condition of ear. It may be possible physical condition of one person is better than other.

11.7 Is there any difference between echo and reflection of sound? Explain.

No, they are same things.

11.8 Will two separate 50dB sounds together constitute a100dB sound? Explain

No, two separate 50dB sounds together will constitute a100dB sound.

Reason: Decibel scale is logarithm scale. So it can not be added by simple mathematical rule.

11.9 Why ultrasound is useful in medical field?

Due to small wave length, ultra sounds carry more energy, so it is very useful for diagnose and treat different ailments.

What is acoustics pressure or sound pressure?

Sound Pressure is the force of sound on a surface area perpendicular to the direction of the sound.

What would happen to the loudness of sound with increase in its frequency?

With increase of frequency, the loudness of sound will be increased.

LONG QUESTIONS

Sound Requires Material Medium for its Propagation

Experiment:

=>The bell jar is placed on the platform of a vacuum pump.

=>An electric bell is suspended in the bell jar with the help of two wires connected to a power supply.

=> By setting ON the power supply, electric bell will begin to ring. We can hear the sound of the bell.

=> Now starts escape the air from jar with the vacuum pump.

=> Sound will feeble and eventually dies out.

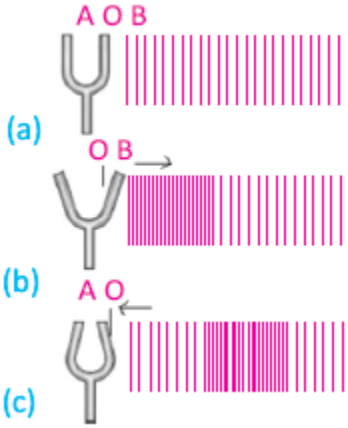
=> Again put the air back in to the jar, we can hear sound again

C0nclusion:

Sound waves can only travel/propagate in the presence of air (medium).

NATURE AND PROPAGATION OF SOUND WAVES

The propagation of sound waves can be explained by vibrating tuning fork. Before the vibration of tuning fork, density of air molecules on right is uniform.



Formation of compression:

When right prong of tuning fork moves from O to B, it compresses the adjacent layer of air molecules and produces the compression. This compression is shifted to next layers and so an.

Formation of rarefaction:

When prong moves from B to A, it decreases the pressure on the adjacent layer and produce rarefaction. This rarefaction is transferred to next layer and so on.

As tuning fork moves forth and back, a series of compression and rarefaction are produced in air and propagate through air.

WHAT IS LOUDNESS? DICUSS FACTORS DEPENDS UPON LOUDNESS.

Loudness:

Loudness is the characteristic of sound by which loud and faint sounds can be distinguished.

Factors upon which loudness depends:

- ⇨ amplitude of vibrating body
- ⇨ area of vibrating body
- ⇨ Distance from vibrating body.

Amplitude of vibrating body:

Loudness varies directly with the amplitude of vibrating body. Greater amplitude of vibrating body, loudness will be greater.

For example when we beat the drum forcefully, we hear loud sound.

Area of vibrating body:

Loudness varies directly with the area of vibrating body. Greater area of vibrating body, loudness will be greater.

For example, sound produce by large drum is louder than by small drum because of large vibrating area.

Distance from the vibrating body:

Loudness of sound also depends upon the distance of listener from vibrating body. Because amplitude of sound wave decreases as the distance increases. Loudness also depends upon the physical condition of ear.

DERIVE THE FORMULA OF INTENSITY LEVEL OF SOUND

It is experimentally observed that loudness of sound is directly proportional to the log of intensity.

$$L \propto \log I$$

$$L = k \log I \quad \ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where k is constant of proportionality.

Let L_o is the loudness and I_o is the intensity of faintest audible sound

Then above equation can be written as

$$L_o = k \log I_o \quad \ldots\ldots\ldots\ldots\ldots\ldots 2$$

Subtracting the eq. 2 from 1

$$L - L_o = k \log I - k \log I_o$$

$$= k (\log I - \log I_o)$$

$$= k \log \frac{I}{Io}$$

The difference $L - L_o$ is known as intensity level or sound level.

$$\text{Sound level} = k \log \frac{I}{Io} \quad \ldots\ldots\ldots\ldots 3$$

If $I = 10\ I_o$ then value of k is 1 so eq. 3 become

$$\text{Sound level} = \log \frac{I}{Io} \text{ (bel)}$$

Bel is very large unit of intensity level. Generally it is measured in decibel.

It is noted that 1 bel is equal to 10 dB.

$$\text{Sound level} = 10 \log \frac{I}{Io} \text{ (dB)}$$

Decibel scale:

Using the equation of intensity level we construct a scale for measuring the intensity level of sound. Such a scale is known as decibel scale.

Measuring speed of sound by echo method.

Apparatus:

Measuring tap, stop watch, flat wall

Procedure:

- ⇨ first measure the 50 m distance from the wall with measuring tap
- ⇨ Now clap your hands in front of the wall and find the position where you hear echo clearly.
- ⇨ Restart the clapping and start the stop watch at the first clap.
- ⇨ Note the time when you hear the echo of the 10^{th} clap.
- ⇨ Find the average time of 10^{th} claps.
- ⇨ Calculate the speed of sound using the formula $S = v\ t$

Ultrasound and its uses:

Sound with frequency higher than 20,000 Hz is called ultrasonic wave.

Uses of ultrasound:

- ⇨ Due to small wave length, ultra sounds carry more energy, so it is very useful for detecting the small objects.
- ⇨ **In medical field:**

It is used to diagnose and treat different ailments. For this, ultrasounds are made to enter the human body. These waves are reflected from the defected part of body and form an image on the screen. Such an image helps diagnose the diseases.

- ⇨ It can be used to get the picture of thyroid gland.
- ⇨ It can be used to remove the blood clots formed in the arteries.
- ⇨ It can be used to locate the objects lying deep on the ocean.

This technique is called SONAR, (sound navigation and ranging)

- ⇨ SONAR ranging is also used to see the shape and size of object.
- ⇨ Germs and bacteria in liquids are destroyed with high intensity ultrasound.
- ⇨ To find the cracks in the interior of heavy machinery, ultrasounds are used.

NUMERICAL PROBLEMS

11.1 A normal conversation involves sound intensities of about 3.0×10^{-6} Wm^{-2}. What is the decibel level for this intensity? What is the intensity of the sound for 100 dB?

To given $I = 3 \times 10^{-6} Wm^{-2}$

$Io = 10^{-12}\ Wm^{-2}$

Intensity level =?

Solution If Intensity level = 100 then I =?

Part i $S.L = 10 \log \frac{I}{I_o} = 10 \log \frac{3\times10^{-6}}{10^{-12}}$

$= 10 \log 3\times10^{-6+12} = 10 \log 3 \times10^{6}$

$= 10 (\log 3 + \log 10^6)$

$= 10(.4771 + 6 \log 10)$

$= 10(.4771 + 6\times1) = 10(.4771+6)$

$= 10(6.4771) = 64.77$ dB

Part ii

$$S.L = 10 \log \frac{I}{I_o}$$

$$100 = 10 \log \frac{I}{Io}$$

$$100/10 = \log \frac{I}{10^{-12}}$$

$$10 = \log \frac{I}{10^{-12}}$$

Taking anti log on both sides

$$\text{Antilog } 10 = \frac{I}{10^{-12}}$$

$$10^{10} = \frac{I}{10^{-12}}$$

$$10^{10} \times 10^{-12} = I$$

$$10^{10-12} =$$

$$10^{-2} = I$$

$.01 wm^{-2} = I$

11.2 If at Anarkali bazar Lahore, intensity level is 80 dB, what will be the intensity of sound there?

To given

S.L= 80 dB

$I_o = 10^{-12}\ Wm^{-2}$

Intensity=?

Solution

$$S.L = 10 \log \frac{I}{I_o}$$

$$80/10 = \log \frac{I}{10^{-12}}$$

$$8 = \log \frac{I}{10^{-12}}$$

Taking anti log on both sides

$$\text{Antilog } 8 = \frac{I}{10^{-12}}$$

$$10^8 = \frac{I}{10^{-12}}$$

$$10^8 \times 10^{-12} = I$$

$$10^{-4}\ wm^{-2} = I$$

11.3 At a particular temperature, the speed of sound in air is 330 ms^{-1}. If the wavelength of a note is 5 cm, calculate the frequency of the sound wave. Is this frequency lie in the audible range of the human ear?

To given $v = 330 ms^{-1}$

$\lambda = 5cm = .05m$

$f = ?$

$v = f \lambda$

$330 = f \times .05$

$330/.05 = f$

$6.6 \times 10^3\ Hz = f$

11.4 A doctor counts 72 heartbeats in 1 min. Calculate the frequency and period of the heartbeats.

To given

No. heat beats = 72

Time = 1 min = 60 sec

(i) f =? (ii) T =?

Solution

f = no. heart beats / time

$$= \frac{72}{60} = 1.2\ Hz$$

$T = 1/f = 1/1.2 = 0.83\ s$

11.5 A marine survey ship sends a sound wave straight to the seabed. It receives an echo1.5 s later. The speed of sound in sea water is 1500 ms^{-1}. Find the depth of the sea at this position.

To given

Total time = 1.5 s

One sided time = 1.5/2= .75 s

$v = 1500\ ms^{-1}$

S = ?

S = v t

S = 1500 × .75 = 1125 m

11.6 A student clapped his hands near a cliff and heard the echo after 5 s. What is the distance of the cliff from the student if the speed of the sound, *v* is taken as 346 m s^{-1}?

To given

Total time = 5 s

One sided time = 5/2= 2.5 s

$v = 346\ ms^{-1}$

S =?

S = v t

S = 346 × 2.5

S = 865 m

11.7 A ship sends out ultrasound that returns from the seabed and is detected after 3.42 s. If the speed of ultrasound through seawater is 1531 ms^{-1}, what is the distance of the seabed from the ship?

Total time = 3.42s

One sided time = 3.42/2= 1.71 s

$v = 1531\ ms^{-1}$

s = v t

s = 1531× 1.71

s = 2618m

11.8 The highest frequency sound humans can hear is about 20,000 Hz. What is the wavelength of sound in air at this frequency at a temperature of 200 ºC? What is the wavelength of the lowest sounds we can hear of about 20 Hz? Assume the speed of sound in air at 200 ºC is 343 ms^{-1}

To given

$f_{max} = 20{,}000$ Hz

$v = 34ms^{-1}$

$f_{min} = 20$ Hz

To find $\lambda_{min} =?$ $\lambda_{max} =?$

Solution

$v = f_{max}\,\lambda_{min}$

$343 = 20000 \times \lambda_{min}$

$$\frac{343}{20000} = \lambda_{min}$$

$0.0171 =$

$1.71 \times 10^{-2}\ m = \lambda_{min}$

Part ii

$v = f_{min} \times \lambda_{max}$

$343 = 20 \times \lambda_{max}$

$$\frac{343}{20} =$$

$17.15m =$

11.9 A sound wavers has a frequency of 2 kHz and wavelength 35cm. how long will it take to travel 1.5km.

To given f= 2 kHz = 2000 Hz

λ = 35 cm = .35m

s = 1.5 km = 1500m

t =?

Solution

$$V = f\lambda$$
$$= 2000 \times .35 = 700\ ms^{-1}$$
$$S = v\,t$$
$$1500 = 700 \times t$$
$$\frac{1500}{700} = t$$
$$2.1\ s = t$$

Ch. # 12 GEOMETRICAL OPTICS

SHORT QUESTIONS

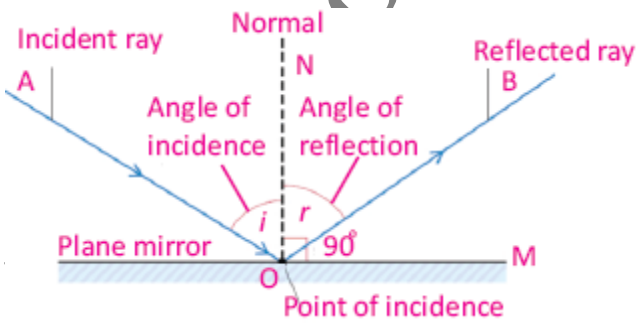
What is light? Light is the form of energy which produces sense of vision.

Reflection of light:

When light traveling in a certain medium falls on the surface of another medium, a part of it turns back in the same medium.

Angle of incidence:

The angle between incident ray and normal ray is called angle of incidence.



Angle of reflection:

The angle between reflected ray and normal ray is called angle of reflection.

Law of reflection:

(i) The incident ray, the normal, and the reflected ray at the point of incidence all lie In the same plane.

(ii) The angle of incidence is equal to the angle of reflection i.e., $\angle i = \angle r$.

Type of reflection:

Regular reflection:

The reflection which obeys the law of reflection is called regular reflection. This reflection is done by smooth surface.

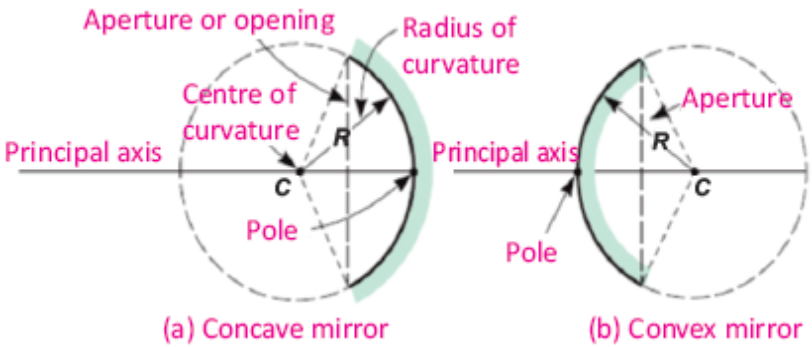
Irregular reflection:

The reflection which does not obey the law of reflection is called irregular reflection. This reflection is done by rough surface.

Spherical mirror:

A part of reflecting surface of hollow sphere is called spherical mirror.

Type of spherical mirror:



Concave Mirror: A spherical mirror whose inner curved surface is reflecting is called concave mirror.

=>the size of the image depends on the position of the object.

=>It form both real and virtual image.

Convex Mirror: A spherical mirror whose outer curved surface is reflecting is called convex mirror. Convex mirrors are also called diverging mirrors.

=>The size of the image is always smaller than the object.

=> It forms only virtual image.

Pole:

The centre of spherical mirror is called pole. It is also called vertex.

Centre of Curvature (C):

A spherical mirror is a part of a sphere. The centre of this sphere is called centre of curvature.

Radius of Curvature (R):

It is the radius of the sphere of which spherical mirror is a part.

Principal Axis:

It is the line joining centre of curvature and pole of the spherical mirror.

The Principal focus (*F*): (concave mirror)

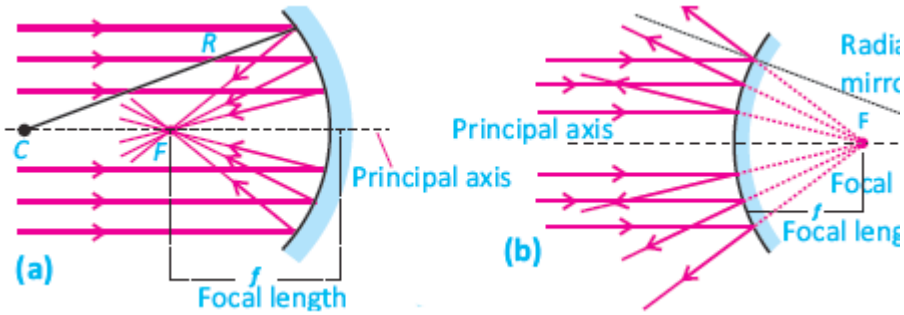
After reflection from a concave mirror, rays of light parallel to the principal axis converge to a point *F*. This point is called "The Principal Focus" of the mirror

Real focus:

The principle focus of the concave mirror is real focus since rays actually passes this point.

The Principal focus (*F*): (convex mirror)

In the case of a convex mirror, rays parallel to the principal axis after reflection appear to come from a point *F* situated behind the mirror. This point is called principle focus.



Virtual focus:

The principal focus of a convex mirror is virtual focus because the reflected rays do not actually pass through it but appear to do so.

Focal length (f):

The distance between pole and principal focus is called focal length.

The focal length is related to the radius of curvature by $f = R/2$.

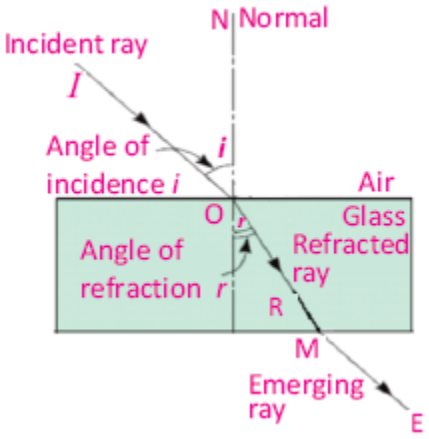
characteristics of Focus of a Concave and a Convex Mirror

Convex Mirror	Concave Mirror
The focus lies behind the mirror.	The focus is in front of the mirror.
The focus is virtual as the rays of light after reflection appear to come from the focus.	The focus is real as the rays of light after reflection converge at the focus.

Mirror formula:

The relation between focal length, distance of object and distance of image form the mirror represented by an equation. This equation is known as mirror formula.

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$



REFRACTION OF LIGHT

The process of bending of light as it passes from air into glass and vice versa is called refraction of light.

LAWS OF REFRACTION:

(i) The incident ray, the refracted ray, and the normal at the point of incidence all lie in the same plane.

(ii) The ratio of the sine of the angle of incidence 'i' to the sine of the angle of refraction 'r' is always equal to a constant. This constant is called refractive index.

Sin ∠ i / sin ∠ r = constant = n

This is also called Snell's law.

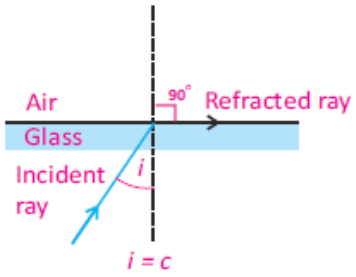
Refractive Index:

The refractive index '*n*' of a medium is the ratio of the speed of light '*c*' in air to the speed '*v*' of light in the medium:

$$n = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}} = \frac{c}{v}$$

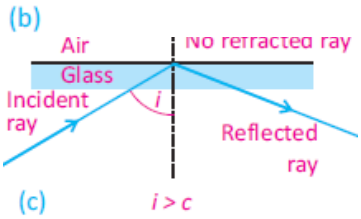
Critical angle:

The angle of incidence for which corresponding angle of refraction is 90o is called critical angle.



Total internal reflection:

When the angle of incidence becomes larger than the critical angle, no refraction occurs. The entire light is reflected back into the denser medium this is known as total internal reflection of light.

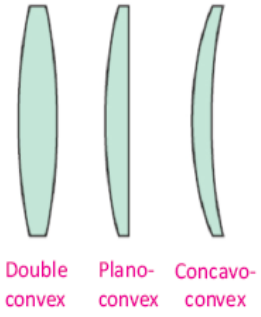


Conditions of total internal reflection:

- ⇨ light travel from denser to rare medium
- ⇨ the angle of incidence is larger than the critical angle

What is lens?

Lens is transparent glass or plastic material which refracts light after passing through it.



Types of lens:

Convex lens:

This lens is thick at the centre and thin at the edges. It converge the ray of light when passing through it. So it is also called converging lens.

Type of convex lens:

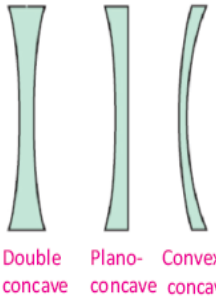
(I) Double convex lens (ii) Plano - convex lens (iii) concavo - convex lens

Concave lens:

This lens is thin at the centre and thick at the edges. It diverge the ray of light when passing through it. So it is also called diverging lens.

Type of concave lens:

(i) Double concave lens (ii) Plano- concave lens (iii) convexo- concave lens



Principle axis:

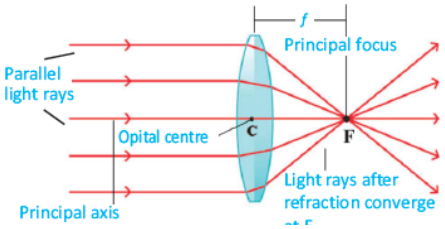
A line passing though the optical centre and centre of curvature is called principle axis.

Optical centre:

The centre of lens is called optical centre.

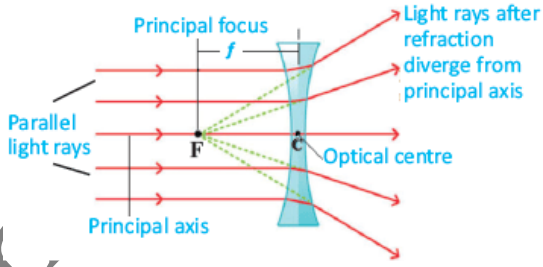
Principle focus. (Convex lens)

A light ray parallel to principle axis after passing through the lens meet at a point. This point is called principle focus.



Principle focus. (Concave lens)

A light ray parallel to principle axis after passing through the lens appear to come from a point. This point is called principle focus.



Power of lens:

It is the reciprocal of focal length in meter.

$$\text{Power of lens} = \frac{1}{f} \text{ (meter)}$$

Unit: its unit is dioptre. Its symbol is D.

Power of lens is 1 dioptre if the focal length of lens is 1 meter.

- ⇨ Power of convex lens is positive.
- ⇨ Power of concave lens is negative.

Totally internal reflecting prism.

A prism whose one angle is 90° and remaining two angles 45o is called totally internal reflecting prism. It works on the principle of total internal reflection

Uses:

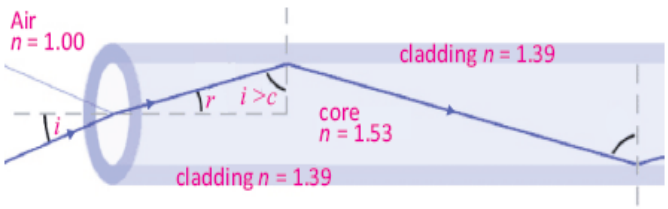
- ⇨ It is used in periscope to bend the image by 90o.
- ⇨ It is used in projector to invert the image.

Optical fiber:

It is consist of hair size threads of glass or plastics through which light can traveled.

Parts of optical fiber:

1- core 2- cladding 3- jacket



The inner part of the optical fiber through which light is traveled is called core.

Its refractive index is 1.53

The outer part of the optical fiber is called cladding. Its refractive index is 1.39.

Jacket:

The outermost layer which protects the optical fiber is called jacket.

What is light pipe?

It is consists of thousand optical fiber in the form of bundle.

Uses:

- ⇨ To illuminate the inaccessible places
- ⇨ To transmit the image from one place to other place.

Endo scope:

A device used to diagnostics and surgical purposes.

Parts:

Gastroscpoe:

⇨ Used to investigate the stomach.

Cystoscope:

⇨ Used to diagnose the bladder.

Bronchoscope:

⇨ Used to diagnose the throat.

How work endoscope?

Light enter through one optical fiber. This light is reflected back through other light pipe whose one end is inserted the body through mouth. A camera is attached with other end. Doctor can see the view recorded by camera is display on the computer screen.

Endoscopy:

A medical procedure using any type of endoscope is called endoscopy.

Magnifying power:

It is the ratio of angle subtended by the image produced by lens to the angle subtended by object seen with out lens.

$$\text{Formula} = \frac{angular size of image produced by lens}{angular size of object seen without lens} = \frac{\theta'}{\theta}$$

Resolving power:

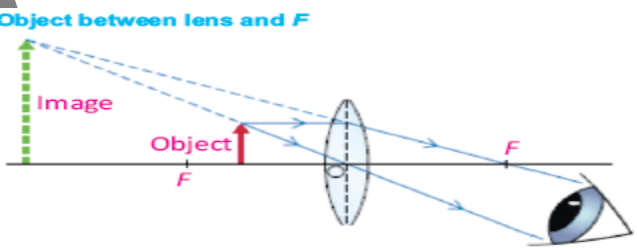
It is the ability of optical instrument to distinguish between two close placed object or point sources. For example to see tiny organism high resolving power is required.

SIMPLE MICROSCOPE:

It is a device which is used to see the magnified image of small object. It is consist of a single lens.

How image is formed:

When object is placed with in the focal length of lens, upright, virtual and magnified image is obtained.



Magnification:

$$M = 1 + \frac{d}{f}$$

Near point:

It is minimum distance where human eye can see the object clearly. It is 25 cm for normal eye, 50 cm at the age of 40 years and 500 cm at the age of 60 years.

Far point:

It is maximum distance where human eye can see the object clearly. It is infinity for normal eye.

Why the position of fish inside the water seems to be less depth than that of its actual position.

Due to the refraction of light.

Reason: After reflection from fish when light enter from denser medium to rare medium, it bends away from normal and appear to come at a certain height. So position of fish inside the water seems to be less depth than that of its actual position.

What is optics?

The study of light behavior is called optics. It is also includes study of eye because human eye form an image with lens.

Geometrical optics:

The branch of optics that deals the formation of image because it is based on relationship between angles and lines that describe the light rays.

What is the difference between terrestrial and refraction telescope?

Terrestrial telescope is similar to the refracting telescope except with an extra lens between objective and eye piece.

Prism:

Prism is a transparent object (made of optical glass) with two faces triangles and three rectangles.

sign Conventions for Lenses

Focal length:

• *f* is positive for a converging lens
• *f* is negative for a diverging lens.

Object Distance:

• *p* is positive, if the object is towards the left side of the lens. It is called a real object.
• *p* is negative, if the object is on the right side of the lens. It is called virtual object.

Image Distance:

• *q* is positive for a real image made on the right side of the lens by real object.
• *q* is negative for a virtual image made on the left side on the lens by real object.

Linear Magnification: It is the ratio of size of image to size of object.

$$M = \frac{size of image}{size of object}$$

Focal length:

Distance between optical centre and principle focus is called focal length.

Why convex mirror is used as security purpose.

In case convex mirror, object is any where we get virtual erect and small image of object.

CONCEPTUAL QUESTIONS

12.1. A man raises his left hand in a plane mirror; the image facing him is raising his right hand. Explain why.

The image formed by plane mirror is inverted so left hand of man seems as right hand.

12.2. In your own words, explain why light waves are refracted at a boundary between two materials.

Light refracts or bends when it leaves one medium and enters another one (i.e. when it goes from air to water; when it goes from glass to air). This is because the speed of light is different in different materials

12.3. Why the position of fish inside the water seems to be less depth than that of its actual position.

Due to the refraction of light.

Reason: After reflection form fish when light enter from denser medium to rare medium, it bends away from normal and appear to come at a certain height. So position of fish inside the water seems to be less depth than that of its actual position

12.4. Why or why not concave mirrors are suitable for makeup?

Concave mirror is suitable for make up.

Reason: when face is very close to mirror. Then erect, virtual and large image is in the same side.

12.5. Why is the driver's side mirror in many cars convex rather than plane or concave?

Yes.

Reason:

In case convex mirror, object is any where we get virtual erect and small image of object.

12.6. When an optician's testing room is small, he uses a mirror to help him test the eyesight of his patients. Explain why.

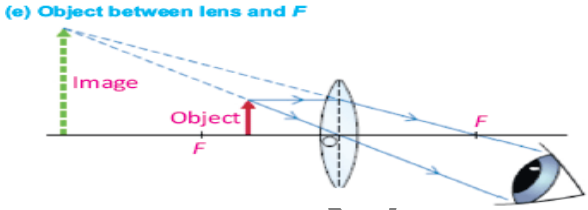
So that patient is very close to the mirror. Then erect and large image is obtained. An other reason is that mirror forms the image on same side. If they use the lens, they form the image on opposite side so large room is required.

12.7. How does the thickness of a lens affect its focal length?

Thick lens has shorter focal length. Due to decreases in curvature.

12.8. Under what conditions will a converging lens form a virtual image?

When object is lies with in the focal length of lens. In this way erect, virtual and large image is in the same side.



12.9. Under what conditions will a converging lens form a real image that is the same size as the object?

When object is place at 2F. Then real and image of same size is obtained.

12.10. Why do we use refracting telescope with large objective lens of large focal length?

So that maximum light rays fall on the object. In this way, brightness of image increases and clear image can be seen.

LONG QUESTIONS

(1)COMPOUND MISCROSCOPE:

A device which is used to get the higher magnification of small objects is called **compound microscope.**

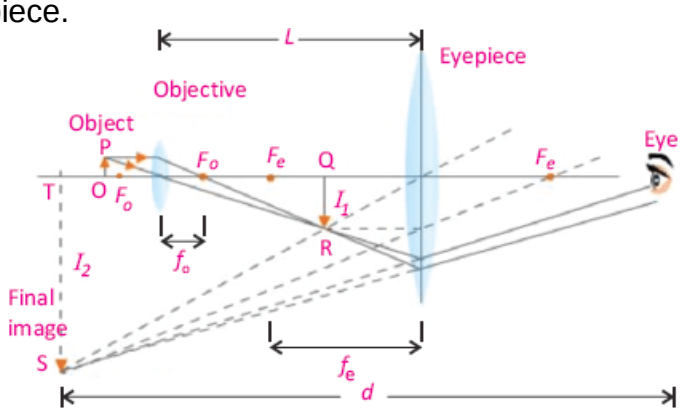
Construction:

It is consists of two lens. Lens which is near to the object is called objective and lens which is near to eye is called eye piece.

Ray diagram:

Image formation:

Objective lens forms a small image I_1 inside the focal length of eye piece. This image acts an object for eye piece. Final larger image I_2 is obtained out side the focal length of objective.



Magnification:

Magnification of compound microscope is

$$M = \frac{L}{f_o}\left(1+\frac{d}{f_e}\right)$$

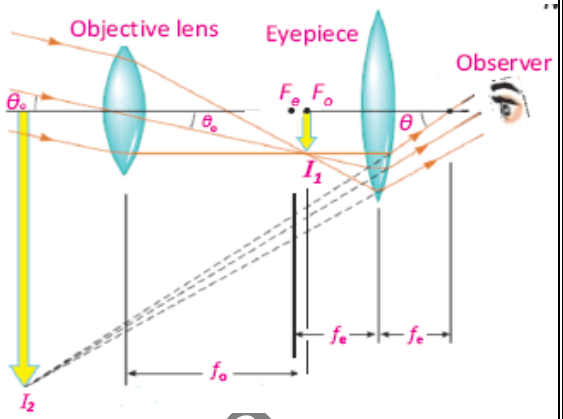
Where L is the length of microscope which is equal to the distance between objective and eye piece.

Uses:

⇨ It is used to study the bacteria and micro objects.
⇨ It is used in the field of research like microbiology. Botany, geology and genetics.

Some features of compound microscope:

⇨ It gives greater magnification than single lens.
⇨ Object lens has a shorter focal length $f_o < 1$ cm.
⇨ The eye piece has a focal length of few cm.



(2)TELESCOPE:

It is an optical device which is used to observe the distant objects.

Construction:

It is consists of two lens. Lens which is near to the object is called objective and lens which is near to eye is called eye piece. Focal length of objective is large than eye piece.

Ray diagram:

Image formation:

Objective lens forms a small image I_1 at the focal length of objective. This image acts as object for eye piece. A larger and virtual image I_2 is obtained at a large distance from the objectives lens.

Magnification:

Magnification of telescopes is

$$M = \frac{f_o}{f_e}$$

Human eye:

Human eye acts like a camera. Eye lens forms an image at the retina which is light sensitive layer at the back of eye.

Cornea:

Light enter the eye through a transparent membrane called cornea.

What is iris and pupil?

Colored portion of eye which controls the amount of light reaching the retina is called iris It has an opening at its centre called pupil. In bright light, iris contracts the size of pupil while in dim light, pupils enlarged.

(3)Accommodation.

The variation of focal length of eye lens to adjust the image on retina is called accommodation.

For far object:

To see the far object, ciliary's muscles relax. In this way curvature of lens decrease and focal length is increased. Ray coming from object focused at retina and sharp image is formed.

For near object:

To see the near object, ciliary's muscles increase the curvature of lens so focal length is decreased. Ray coming from object focused at retina and sharp image is formed.

(4)Defect in vision:

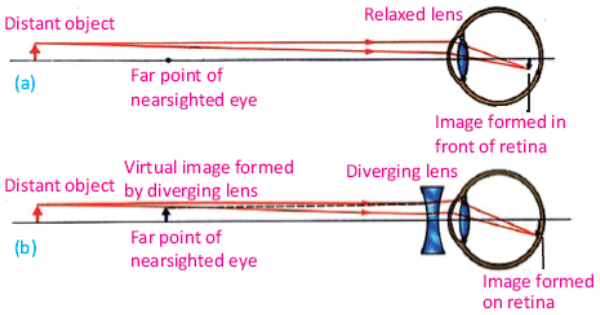
Inability of eye to see image of object clearly is called defect of vision. In this case eye lens can't adjust the image on retina exactly.

Near sightedness (myopia)

Inability of eye to see image of distant object clearly is called near sightedness.

Reason:

Eye ball is too large so that focal length of eye lens is increased. Light rays coming from object focused in front of retina so blurred image is formed.



Correctness:

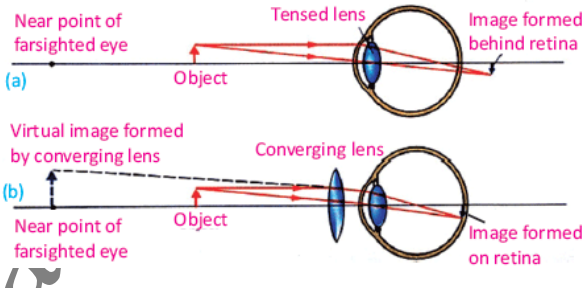
This defect can be removed by using concave lens. Light rays before entering the eye diverge by concave lens. To observer these rays appear to come from a far point and focused at retina. Thus sharp image is formed.

Far sightedness (hypermetropia)

Inability of eye to see image of near object clearly is called far sightedness.

Reason:

Eye ball is too small so that focal length of eye lens is decreased. Light rays coming from object focused behind the retina so blurred image is formed.



Correctness:

This defect can be removed by using convex lens. Light rays before entering the eye converge by convex lens. To observer these rays appear to come from a near point and focused at retina. Thus sharp image is formed.

MAGE FORMATION BY LENSES

In mirrors images are formed through reflection, but lenses form images through refraction. This is explained with the help of ray diagrams as follows:

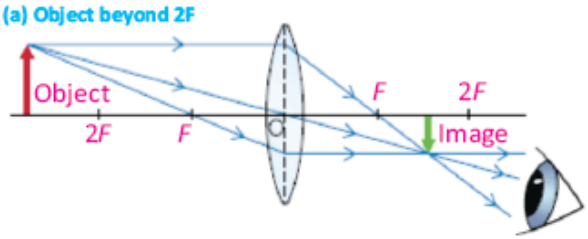
Image formation in convex lens can be explained with the help of three principal rays.

1. The ray parallel to the principal axis passes through the focal point after refraction by the lens.
2. The ray passing through the optical centre passes straight through the lens and remains undeviated.
3. The ray passing through the focal point becomes parallel to the principal axis after refraction by the lens.

(5)Image Formation in Convex Lens

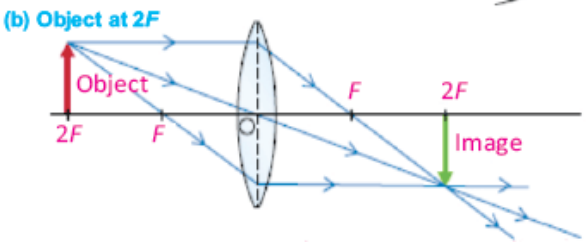
When object beyond 2F:

The image is between F and 2F, real, inverted, smaller than the object.



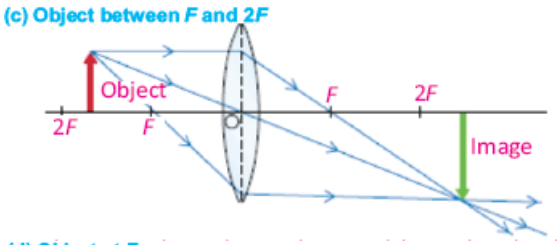
When object at 2F:

The image is at 2F, real, inverted, the same size as the object.



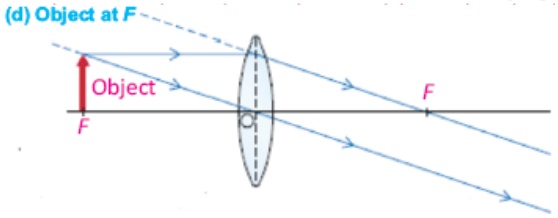
When object between F and 2F:

The image is away from 2F, real, inverted, larger than the object



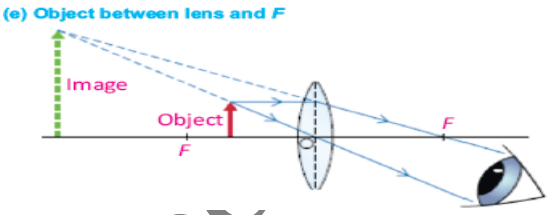
When object is at F:

No image is formed because the refracted rays are parallel and never meet.



When object between lens and F:

The image is behind the object, virtual, erect, and larger than the object



Camera:

It is consist of light proof box with converging lens in front and light sensitive plate at the back. Distance between lens and film is equal to focal length of lens.

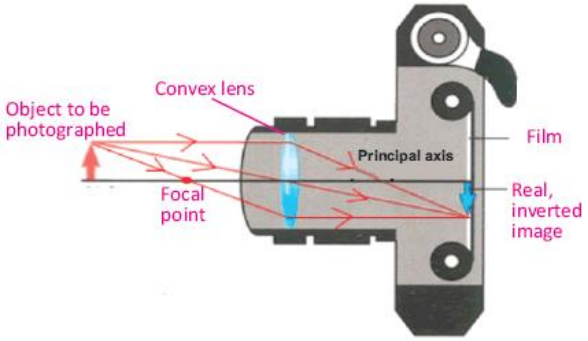
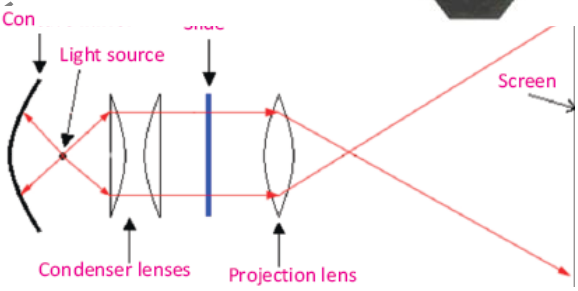


Image Formation.

The object is beyond 2F, real, inverted, smaller than the object.

Slide projector:

It is an instrument used for displaying photographic slides on a screen.



Parts:

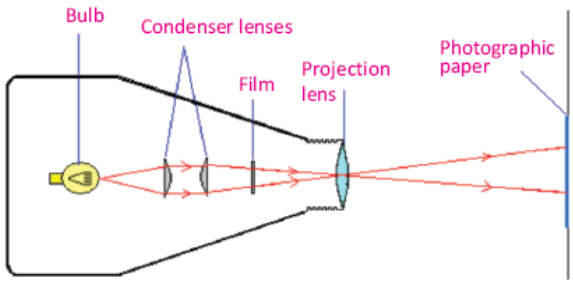
- ⇨ concave lens used to reflect the light
- ⇨ Light source, it paced at the centre of curvature of concave mirror.
- ⇨ condenser lens, it illuminate all the parts of slide with parallel rays
- ⇨ projection lens and screen

How does it work:

Slide is placed between F and 2F of projection lens and it produce the real inverted and large image on the screen.

Photo enlarger:

Its working is similar to the slide projector:



Parts:

- ⇨ Light source
- ⇨ condenser lens, it illuminate all the parts of slide with parallel rays
- ⇨ projection lens and screen

How does it work:

Slide is placed at a distance more than F but less than 2F of projection lens and it produce the real inverted and large image on the screen

Difference b/w real and virtual image:

Real image	Virtual image
1- It can be obtained on screen	1- It can not obtained on the screen.
2- It is represented by continuous line.	2- It is represented by dotted line.
3- It is inverted.	3- It is erected.

NUMERICALS

21.1An object 10.0 cm in front of a convex mirror forms an image 5.0 cm behind the mirror. What is the focal length of the mirror?

Solution:

Given:

$$P = 10 \text{ cm}$$
$$q = -5 \text{ cm}$$
$$f = ?$$

Calculation:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$
$$\frac{1}{f} = \frac{1}{10} + \frac{1}{-5}$$
$$\frac{1}{f} = \frac{1}{10} - \frac{1}{5}$$
$$= \frac{1-2}{10} = -\frac{1}{10}$$
$$f = -10 \text{ cm}$$

12.2An object 30 cm tall is located 10.5 cm from a concave mirror with focal length 16 cm. (a) where is the image located? (b) How high is it?

Solution:

Given:

$$h_o = 30 \text{ cm}$$
$$p = 10.5 \text{ cm}$$
$$f = 16 \text{ cm}$$
$$q = ? \text{ , } h_i = ?$$

Calculation:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$
$$\frac{1}{16} = \frac{1}{10.5} + \frac{1}{q}$$
$$\frac{1}{16} - \frac{1}{10.5} = \frac{1}{q}$$
$$\frac{10.5-16}{16 \times 10.5} =$$
$$\frac{-5.5}{168} =$$
$$-\frac{168}{5.5} =$$
$$30.54 \text{ cm} = q$$

$$\frac{hi}{ho} = \frac{q}{p}$$

$$hi = \frac{q}{p} \times ho = \frac{30.54}{10.5} \times 30$$

hi = 916.2/10.5= 87.25 cm

12.3 An object and its image in a concave mirror are of the same height, yet inverted, when the object is 20 cm from the mirror. What is the focal length of the mirror?

Solution:

Given: hi = ho

p = 20 cm

f =?

Calculation:

$$\frac{hi}{ho} = \frac{q}{p}$$

Since hi = ho so

$$\frac{ho}{ho} = \frac{q}{p}$$

$$1 = \frac{q}{p}$$

p = q = 20

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$\frac{1}{f} = \frac{1}{20} + \frac{1}{20}$$

$$\frac{1}{f} = \frac{1+1}{20} = \frac{2}{20}$$

$$\frac{1}{f} = \frac{1}{10}$$

$$f = 10cm$$

12.4 Fined the focal length of the mirror that form an image 5.66 cm behind the cm behind the mirror of an object placed at 34.4 cm in front of the mirror. Is the mirror concave or convex?

Solution:

Given: p = 34.4 cm

q = - 5.66 cm

f =?

Calculation:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$= \frac{1}{34.5} - \frac{1}{5.66}$$

$$= \frac{5.66 - 34.5}{34.5 \times 5.66} = \frac{-28.84}{195.27}$$

$$= -\frac{195.27}{28.84}$$

f = - 6.77 cm

12.5 An image of a statue appears to be 11.5 cm behind a concave mirror with focal length 13.5 cm. find the distance from the statue to the mirror.

Solution:

Given:

f = -13.5 cm

q = - 11.5 cm

p =?

Calculation:

$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$$

$$-\frac{1}{13.5}=\frac{1}{p}-\frac{1}{11.5}$$

$$-\frac{1}{13.5}+\frac{1}{11.5}=\frac{1}{p}$$

$$\frac{-11.5+13.5}{11.5\times13.5}=$$

$$\frac{2}{155.25}=$$

$$\frac{155.25}{2}=p$$

77.62 cm = p

12.6 An image is produced by a concave mirror of focal length 8.7 cm. The object is 13.2 cm tall and at a distance 19.3 cm from the mirror. (a) Find the location and height of the image. (b) Find the height of the image produced by the mirror if the object is twice as far from the mirror.

Solution:

f = 8.7 cm

ho = 13.2 cm

p = 19.3 cm

q = ? hi =?

P = 2 p

hi =?

Calculation:

$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q}$$

$$\frac{1}{8.7}=\frac{1}{19.3}+\frac{1}{q}$$

$$\frac{1}{8.7}-\frac{1}{19.3}=\frac{1}{q}$$

$$\frac{19.3-8.7}{19.3\times8.7}=\frac{10.6}{167.91}$$

$$\frac{167.91}{10.6}=q$$

15.84 cm = q

$$\frac{hi}{ho}=\frac{q}{p}$$

$$hi=\frac{q}{p}\times ho=\frac{15.84}{19.3}\times13.2$$

$$=\frac{209.8}{19.3}=10.83\text{ cm}$$

(ii)

$$hi=\frac{q}{2p}\times ho=\frac{15.84}{2\times19.3}\times13.2$$

$$= \frac{209.8}{38.6} = 5.42 \text{ cm}$$

12.7. Nabeela uses a concave mirror when applying makeup. The mirror has a radius of curvature of 38 cm. (a) What is the focal length of the mirror? (b) Nabeela is located 50 cm from the mirror. Where will her image appear? (c) Will the image be upright or inverted?
Solution:

$$R = 38 \text{ cm}$$
$$f = ?$$
$$p = 50 \text{ cm}$$
$$q = ?$$

Calculation:

$$f = R/2 = 38/2 = 19 \text{ cm}$$
$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$
$$\frac{1}{19} = \frac{1}{50} + \frac{1}{q}$$
$$\frac{1}{19} - \frac{1}{50} = \frac{1}{q}$$
$$\frac{50-19}{19\times 50} =$$
$$\frac{31}{950} =$$
$$\frac{950}{31} = q$$
$$30.64 \text{ cm} = q$$

12.8 An object 4 cm high is placed at a distance of 12 cm from a convex lens of focal length 8 cm. Calculate the position and size of the image. Also state the nature of the image.
Solution:

$$ho = 4 \text{ cm}$$
$$f = 8 \text{ cm}$$
$$p = 12 \text{ cm}$$
$$q = ? \quad . \qquad hi = ?$$

Calculation:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$
$$\frac{1}{8} = \frac{1}{12} + \frac{1}{q}$$
$$\frac{1}{8} - \frac{1}{12} = \frac{1}{q}$$
$$\frac{3-2}{24} =$$
$$\frac{1}{24} = \frac{1}{q}$$
$$q = 24 \text{ cm}$$
$$m = \frac{q}{p}$$
$$m = \frac{hi}{ho}$$

$$\frac{hi}{ho} = \frac{q}{p}$$

$$hi = \frac{q}{p} \times ho = \frac{24}{12} \times 4$$

hi = 8 cm

12.9. An object 10 cm high is placed at a distance of 20 cm from a concave lens of focal length 15 cm. Calculate the position and size of the image. Also, state the nature of the image.

Solution:

f = 15cm

p = 20 cm

hi =? q =? ,

Calculation:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$-\frac{1}{15} = \frac{1}{20} + \frac{1}{q}$$

$$-\frac{1}{15} - \frac{1}{20} = \frac{1}{q}$$

$$\frac{-4-3}{60} = \frac{}{}$$

$$\frac{-7}{60} = \frac{}{}$$

$$\frac{-60}{7} = q$$

- 8.57 cm = q

Nature: negative sign shows that image is virtual.

$$\frac{hi}{ho} = \frac{q}{p}$$

$$h = \frac{q}{p} \times hi$$

$$= \frac{8.57}{20} \times 10$$

$$= 4.28cm$$

12.10. A convex lens of focal length 6 cm is to be used to form a virtual image three times the size of the object. Where the lens must be placed?

Solution:

f = 6 cm

m = 3

$$m = \frac{q}{p}$$

$$3 = \frac{q}{p}$$

q = -3p (virtual image)

Calculation:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$
$$\frac{1}{6} = \frac{1}{p} - \frac{1}{3p}$$
$$\frac{1}{6} = \frac{3-1}{3p}$$
$$\frac{1}{6} = \frac{2}{3p}$$
$$3p = 12$$
$$p = 4 \text{ cm}$$

12.11A ray of light from air is incident on a liquid surface at an angle of incidence 35°. Calculate the angle of refraction if the refractive index of the liquid is 1.25. Also calculate the critical angle between the liquid air inter-faces.

Solution:

$$\angle i = 35^o$$
$$n = 1.25$$
$$\angle r = ?$$

Calculation:

$$n = \frac{\sin \angle i}{\sin \angle r}$$
$$1.25 = \frac{\sin 35^o}{\sin \angle r}$$
$$\text{Sin } \angle r = \frac{\sin 35^o}{1.25} = \frac{0.573}{1.25}$$
$$\text{Sin } \angle r = 0.4584$$
$$\angle r = \sin^{-1}(0.4584) = 27.31^o$$
$$\angle r = 90^o$$
$$\angle i = \angle C$$
$$n = \frac{\sin \angle r}{\sin \angle i}$$
$$1.25 = \frac{\sin 90^o}{\sin \angle C}$$
$$\text{Sin } \angle C = \frac{1}{1.25} = 0.8$$
$$\angle C = \sin^{-1}(0.8) = 53.13^o$$

12.12. The power of a convex lens is 5 D. At what distance the object should be placed from the lens so that its real and 2 times larger image is formed.

Solution:

$$P = 5 \text{ D}$$
$$P = 1/f \text{ (m)}$$
$$f = 1/p$$
$$= \frac{1}{5} \times 100 \text{ cm} = 20 \text{ cm}$$
$$m = 2$$
$$m = \frac{q}{p}$$

$$2 = \frac{q}{p}$$

$$q = 2p$$

$$p = ?$$

Calculation:

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{q}$$

$$\frac{1}{20} = \frac{1}{p} + \frac{1}{2p} = \frac{2+1}{2p}$$

$$\frac{1}{20} = \frac{3}{2p}$$

$$2p = 60$$

$$P = 30 \text{ cm}$$

Ch. # 13 ELECTROSTATICS

SHORT QUESTIONS

Electrostatics:

The branch of physics which deals with the properties of rest charge is called electrostatics.

What is electric charge?

The property of body by which it attracts or repels the other body is known as electric charge.

Unit: SI unit of charge is coulomb. It is equal to charge of 6.625×10^{18} electrons.

Some other properties of charge:

- ⇨ like charge always repel each other
- ⇨ Unlike charge always attract each other.
- ⇨ Friction can produce two different types of charge on different materials.
- ⇨ Repulsion is sure test of charge on the body.

How does charge produce:

Electric charge can be produce by rubbing a neutral body with another neutral body.

Types of electric charge:

There are two types of charge

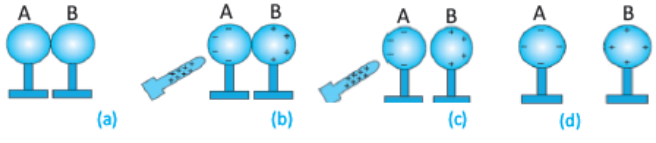
(i) Positive charge (ii) negative charge

Electrostatics induction:

In the presence of charge body, an insulated conductor develops positive charge at one end and negative charge at other end. This process is called electrostatics induction.

H0w we can charge a body by electrostatics induction:

- ⇨ Bring two metal spheres A and B and fix them on insulated stands such that they touch each other.
- ⇨ Bring the positively charged rod near the sphere A.
- ⇨ Negative charge appear on sphere A and positive charge on B.
- ⇨ Now separate the sphere while the rod still nears the sphere.
- ⇨ After removing the rod, charge are uniformly distributed on both spheres.



Electroscope:

A sensitive instrument used to detecting and find nature of charge is called electroscope.

Coulomb's law:

The force of attraction and repulsion between two point charges is directly proportional to product of magnitude of charge and inversely proportional to the square of distance between them.

Mathematical form:

$$F = \frac{1}{4\pi\varepsilon_o} \times \frac{q_1 q_2}{r^2}$$

What is the limitation of coulomb's law?

Coulomb's law is only true for the point charge whose size is very small as compared to the distance between them.

Electric field:

A region or space around the charge in which it exerts an electrostatics force on other charge is called electric field.

Electric field intensity:

The strength of electric field at any point in the space is known as electric field intensity.

OR

Electric field intensity at any point is defined as the force acting on a unit positive charge placed at that point. Its unit is Newton per coulomb (NC^{-1})

Formula:

$$E = \frac{F}{q_o}$$

It is vector quantity. Its direction is in the direction of electrostatics force.

Electric field lines:

The direction of electric field intensity can be represented by lines. These lines are called electric field lines. The concept of electric field lines was given by Michael faraday.

Characteristics of electric field lines:

- ⇨ Field lines always directed from positive to negative charge.
- ⇨ Spacing between the field lines shows the strength of electric field. The lines are closer where the field is strong and farther apart where the field is weak.

Electric potential:

It is equal to the amount of work done in bringing a unit positive charge from infinity to that point. It is scalar quantity.

Formula:

$$V = \frac{W}{q}$$

Unit: The SI unit of electric potential is 1 volt and it is equal to JC^{-1}

Volt:

If a unit positive charge has one joule energy then its electric potential is 1 volt at that point.

Potential difference:

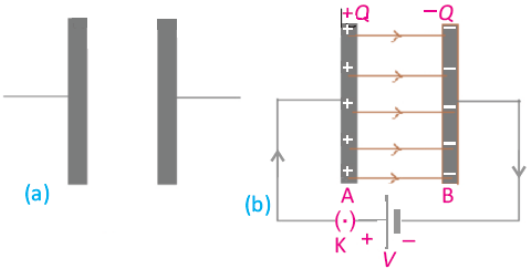
Potential difference between two points is equal to amount of energy with which a unit positive charge moves from these points.

When unit positive charge is moves from lower potential to higher potential, it gains energy.

When unit positive charge is moves from higher potential to lower potential, it loses energy.

Capacitor:

A device which is used to store the charge is called capacitor.



Construction:

It is consist of two parallel metal plates. Air or vacuum is used as insulator between these plates is called dielectric.

Charging of capacitor:

If capacitor is connected to a battery of voltage v, it transfer positive charge + Q charge on plate A. due to electrostatics induction –Q is induced on plate B. Oppositely charge attract each other and remain bound for a long time.

Equation of capacitor:

Charge Q stored on the capacitor is directly proportional to potential difference V across the plates.

$$Q \propto V$$

$$Q = CV$$

Where C is constant of proportionality and is called capacitance of a capacitor.

Capacitance of a capacitor:

The ability of a capacitor to store the charge is called capacitance of a capacitor.

Unit: SI unit of capacitance is Farad.

Farad:

If 1 coulomb charge given to the plate produces one volt potential difference across the plates, then its capacitance is 1 farad.

Sub multiple unit of capacitor:

- ⇨ 1 micro farad = 1×10^{-6} F
- ⇨ 1 nano farad = 1×10^{-9} F
- ⇨ 1 pico farad = 1×10^{-12} F

Factors upon which capacitance depend:

- ⇨ Area of plates
- ⇨ Distance between the plates
- ⇨ Dielectric between the plates.

Capacitor blocks dc but allow ac to pass through the circuit. How does this happen?

Due the presence of insulator between the plates of capacitor dc does not flow continuously. But during AC plates of capacitor are continuously charging and discharging. So it allows passing Ac but blocks dc.

If we double the distance between two charges what will be changed in the force between the charges.

$$F = \frac{1}{4\pi\varepsilon_o} \times \frac{q_1 q_2}{r^2}$$

If r = 2r then

$$F' = \frac{1}{4\pi\varepsilon_o} \times \frac{q_1 q_2}{(2r)^2} = \frac{1}{4\pi\varepsilon_o} \times \frac{q_1 q_2}{4r^2} = \frac{1}{4}\left(\frac{1}{4\pi\varepsilon_o} \times \frac{q_1 q_2}{r^2}\right)$$

$$F' = \frac{1}{4} F$$

Coulomb force will be reduced to 1/4th times of original force.

CONCEPTUAL QUESTIONS

13.1 An electrified rod attracts piece of papers. After a while these pieces fly away! Why?'

Due to induction of opposite charge on its near end first paper get attracted. After remaining in contact with electrified rod it share similar charge with it and fly away.

13.2 How much negative charge has been removed from a positively electroscope, if it has 7.5×10^{-11} C.

Same amount of charge has been removed.

$Q = 7.5 \times 10^{-11}$ C

$e = 1.6 \times 10^{-19}$ C

n =?

$Q = ne$

$$n = \frac{Q}{e} = \frac{7.5 \times 10^{-11}}{1.6 \times 10^{-19}} = 4.8 \times 10^{8}$$

13.3 In what direction will positively charged particle move in an electric field.

Positive charge particle will move form high potential to low potential.

13.4 Does each capacitor carry equal positive charge in series combination? Explain

Charge on each capacitor is same. Battery supply +Q on left plate of each capacitor, Due to induction –Q on right plate on each capacitor.

13.5 Each capacitor in parallel combination has equal potential difference between its plates. Justify the statement.

Potential difference across capacitor is same. Because each capacitor is directly connected to the terminals of battery.

13.6 Perhaps you have seen a gasoline truck trailing chain beneath it. What purpose does the chain serve?

Due to the friction body of truck gets charged. These charges are transferred to the ground through this chain.

13.7 If a high voltage power line fell across your car while you were in the car. Why should you not come out of the car?

Because when you touch the ground, electrons will start to move to ground through your body. This can be Dangerous for you live.

13.8 explain why a glass rod can be charged by rubbing when held by hand but an iron rod can not charged by rubbing, if held by hand.

Because iron is conductor so when we rub it then electron move with in the conductor and did not become static, on other glass rod is an insulator and when we rub it get charge on its surface and acts like a charge body.

Self assessment:

1. **Do you think a mount of positive charge on the glass rod after rubbing it with silk cloth will be equal to the amount of negative charge? Explain.**

Yes, positive charge on glass rod is due the deficiency of electrons those are transferred on the silk cloth. So amount of charge on both objects will be equal.

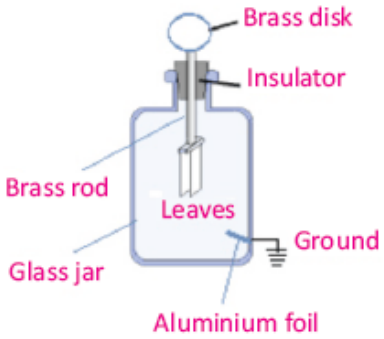
LONG QUESTIONS

Electroscope:

A sensitive instrument used to detecting and nature of charge is called electroscope.

Construction:

It is consists of a brass rod with brass disk at the top and two thin leaves of gold foil hanging at the bottom. The rod is fixed in the jar with an insulator. A thin aluminum foil is attached in side the jar and then grounded with copper wire. This protects the leaves from external electrical disturbance.



Detecting the presence of charge.

In order to detect the charge, any body bring near the uncharged disk.

=> If body is neutral, no deflection in the leaves.

=> If body is charged, leaves of electro scope diverge.

Divergence of leaves proportional to amount of charge.

Detecting the nature of charge:

For detecting the nature of charge first charge the disk of electroscope is positively or negatively.

For positively charge (by electrostatics induction):

In order to charge the disk positively, bring a negative charge body near the disk. Positive charge develops on the disk and negative charge on the leave due to electro static induction. Now disk is connected with aluminum foil with the copper wire. Negative charge will flow the earth and positive charge remains on the disk

By conduction method:

Touch the positively charged rod with the disk. Positive charge is shifted to disk of electroscope.

Detecting the type of charge:

- ⇨ Bring any body near the disk of electroscope. If divergence is increased charge of body is similar to the disk.
- ⇨ On other hand if divergence decreased, the body has negative charge.

Identify the conductors and insulator:

To distinguish the conductor and insulator, touch the body with disk. If leaves collapse from their normal position, body would be a conductor otherwise it is an insulator.

Coulomb's law:

A French scientist Charles Coulomb (1736 – 1806) put forward a law to find the force of attraction or repulsion between two point charges.

The force of attraction or repulsion between two point charges is directly proportional to product of magnitude of charge and inversely proportional to the square of distance between them.

Mathematical form:

$$F = \frac{1}{4\pi\varepsilon_o} \times \frac{q_1 q_2}{r^2}$$

Explanation:

If q_1 and q_2 are two points charge is placed at a distance of 'r' then according to his law

$$F \propto q_1 q_2 \ldots\ldots\ldots\ldots 1$$

$$F \propto \frac{1}{r^2} \ldots\ldots\ldots\ldots\ldots\ldots 2$$

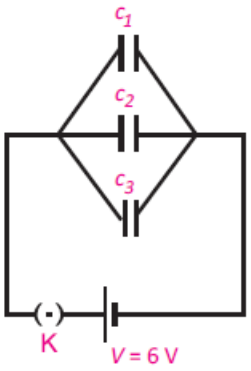
Combing (1) and (2)

$$F \propto \frac{q_1 q_2}{r^2}$$

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

Where k is constant of proportionality, its value depends upon the medium between the charges.

If the medium between two charge is air then value of k in SI system is 9×10^9 Nm^2C^{-2}



Limitation of coulomb's law:

Coulomb's law is only true for the point charge whose size is very small as compared to the distance between them.

Combination of capacitors:

In order to get desired value of capacitance, capacitors are connected in series or parallel combination.

Parallel combination of capacitors:

In this combination, a left plate of each capacitor is connected with the positive terminal of battery and a right plate is connected with the negative terminal of battery.

Characteristics:

1. Potential difference across each capacitor is same.
2. Charge develops across the each capacitor is different due to their capacitance.
3. Total charge Q supplied by the battery is divided among these capacitors.

$$Q = Q_1 + Q_2 + Q_3 \quad \ldots\ldots\ldots\ldots 1$$

Charge on capacitor C_1 is $Q_1 = C_1V$

Charge on capacitor C_1 is $Q_2 = C_2V$

Charge on capacitor C_1 is $Q_3 = C_3V$

So equation (1) becomes

$$Q = C_1V + C_2V + C_3V$$

$$Q = V(C_1 + C_2 + C_3)$$

$$\frac{Q}{V} = C_1 + C_2 + C_3 \quad \ldots\ldots\ldots\ldots\ldots 2$$

4. By replacing this parallel combination of capacitor with one equivalent capacitor having capacitance C_e

$$Q = C_e V$$

$$\frac{Q}{V} = C_e \quad \ldots\ldots\ldots 3$$

Comparing (2) and (3)

$$C_e = C_1 + C_2 + C_3$$

In case of 'n' capacitors are connected in parallel

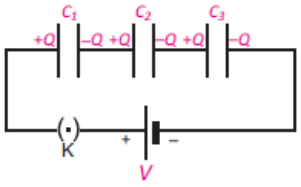
$$C_e = C_1 + C_2 + C_3 + \ldots\ldots\ldots\ldots + C_n$$

5. The equivalent capacitance of parallel combination is greater than any of individual capacitance.

Series combination of capacitor:

In this combination, right plate of one capacitor is connected left plate of other capacitor and so on.

Characteristics:



1. Charge on each capacitor is same. Battery supply +Q on left plate of each capacitor, Due to induction –Q on right plate on each capacitor.
2. Potential difference across each capacitor is different.
3. Voltage of battery 'V' has been divided among these capacitors. Hence

$$V = V_1 + V_2 + V_3 \quad \ldots\ldots\ldots (1)$$

Where $Q = C_1V_1$ $\Rightarrow V_1 = \frac{Q}{C_1}$

$Q = C_2V_2$ $\Rightarrow V_2 = \frac{Q}{C_2}$

$Q = C_3V_3$ $\Rightarrow V_3 = \frac{Q}{C_3}$

$$V = \frac{Q}{C_1} + \frac{Q}{C_2} + \frac{Q}{C_3}$$

$$= Q\left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}\right)$$

$$\frac{V}{Q} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \quad \text{..... 2}$$

4. By replacing this parallel combination of capacitor with one equivalent capacitor having capacitance C_e

$$Q = C_e V$$

$$\frac{Q}{V} = C_e \quad \Rightarrow \quad \frac{V}{Q} = \frac{1}{Ce} \quad \text{..... 3}$$

Comparing (2) and (3)

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

In case of 'n' capacitors are connected in series

$$\frac{1}{Ce} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \text{.....} + \frac{1}{Cn}$$

5. The equivalent capacitance of series combination is less than any of individual capacitance.

Different types of capacitor:

Parallel plate capacitor:

It is made of flexible materials that can be rolled in to shape of cylinder. Some insulator materials are used as dielectric between its plates.

Types of capacitor depend upon the construction and nature of dielectric.

There are two main types of capacitors.

- ⇨ Fixed capacitor
- ⇨ Variable capacitor

Fixed capacitor:

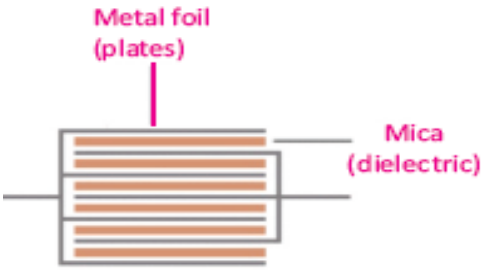
Such capacitor whose capacitance can not be changed is called fixed capacitor.

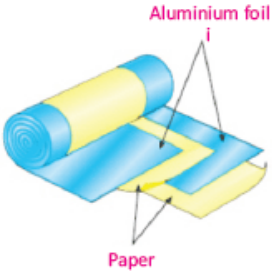
Types of fixed capacitors

- ⇨ Papers capacitors
- ⇨ Mica capacitors

Papers capacitor:

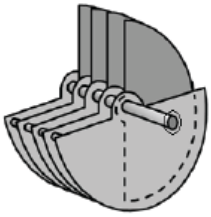
It has cylindrical shape. Oiled, greased or thin sheet of plastic is used as dielectric. For safety it is enclosed in to plastic case.





Mica capacitor:

Mica is used as dielectric between two metal plates. For safety it is enclosed in to plastic case. Wires attached to plates is project out of case for connection



How capacitance of capacitor can be increased?

To increase the capacitance, large no. of plates combines each other which are alternatively connected.

Variable capacitor:

Such capacitor whose capacitance can be changed is called variable capacitor

Construction:

It is consists of two sets of plates. One set remains fixed while other can rotate so that distance between the plates fixed and can not touch each other. Air or oil is used as dielectric. The common area of plates which face each other determines the value of capacitance.

Used: it is used for tuning the radio.

Electrolytic capacitor:

It consists of metal foil in contact with electrolytes. When voltage is applied, a thin layer of metal oxides formed on the foil. This layer acts as the dielectric. High capacitance is obtained because dielectric layer is very thin.

Advantage:

A large amount of charge is obtained at a very voltage.

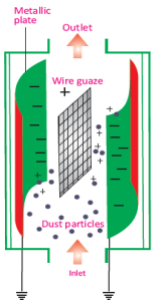
Uses of capacitors:

- ⇨ It is widely used in electrical and electronic circuit.
- ⇨ They are used in tuning transmitter, receiver and transistor radio.
- ⇨ They are also used for table fan, ceiling fans, exhaust fans, air conditioners, cooler and motor for their smooth running.
- ⇨ It is used in electronics circuit of computer.
- ⇨ It is used to differentiate between high and low frequency signal.
- ⇨ It is used in resonant circuit to tune the radio at particular frequency. Such circuit is called filter circuit.
- ⇨ Ceramic capacitors are superior to other so they are wildly used for different purpose.

Application of electrostatics:

Static electricity is widely used in photocopying machines inject printer, car painting and extracting dust particles from chimneys.

Electrostatic air cleaner:



An electrostatic air cleaner is used in homes to relieve the discomfort of allergy sufferers.

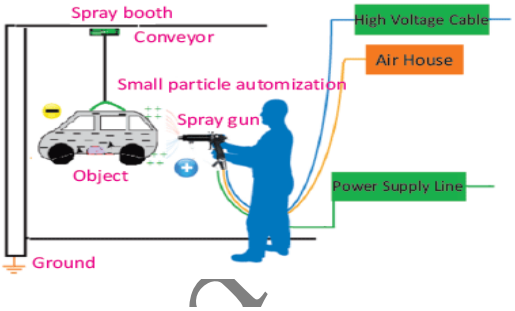
It is consists of metal plates in which a wire gauze is fixed. Positive charge is given to the wire gauze. Air mixed with dust and pollen

enters the device across a positively charged, get positive charge. By electrostatics induction negative charge induce on the metal plates. Due to opposite charge these dust particles stick to metal plates where they are removed.

Advantage:

Through this process we can remove a very high percentage of contaminants from the air stream.

Electrostatic Powder Painting



Automobile manufacturers use static electricity to paint new cars. The body of a car is charged. The particles of paints get opposite charge by coming out from nozzle. The charged paint particles are attracted to the car and stick to the body. Once the paint dries, it sticks much better to the car and is smoother, because it is uniformly distributed.

Advantage:

This is a very effective, efficient and economical way of painting automobiles on large scale.

SOME HARZARDS OF STATIC ELECTRICITY:

Lighting:

The thunderclouds are charged by the friction between water molecules in the clouds and air molecules. When this charge is sufficient high, it produces opposite charge on the objects on the ground. This creates a strong electric field between clouds and ground. Suddenly charges jump to the ground with violent spark and explosion.

Precautions:

To save from damaging the tall building, light conductor is used. It provide steady discharge path for large amount of negative charge from the top of building to earth.

Fire or explosions:

A fire or explosion may occur due to excessive amount of charges produce by friction.

Example:

- ⇨ It produces when we get out from the car or remove an article of clothing.
- ⇨ It can be generated by the friction of the gasoline being pumped in to a container.

Hazards:

If static charges are allowed to discharge through an area where there are petrol vapors, a fire can occur.

NUMERICALS

13.1. The charge of how many negatively charged particles would be equal to 100 μC. Assume charge on one negative particle is1.6 × 10-19 C ?

Solution:

$$Q = 100\mu C = 100\times10^{6}C$$
$$e = 1.6 \times 10^{-19}\ C$$
$$n = ?$$

Calculation:

$$Q = ne$$
$$100\times10^{6} = n \times 1.6 \times 10^{-19}$$
$$n\frac{100\times10^{6}}{1.6\times10^{-19}} =$$
$$62.5 \times 10^{-6+19} =$$
$$62.5 \times 10^{13} =$$
$$6.25\times10^{14} = n$$

13.2. Two point charges q_1= 10 μC and q_2= 5 μC are placed at a distance of 150 cm. What will be the Coulomb's force between them? Also find the direction of the force.

Solution:

$$q_1 = 10\mu C = 10 \times 10^{-6}C$$
$$q_2 = 5\mu C = 5 \times 10^{-6}C$$
$$r = 150 \text{ cm} = 1.5 \text{ m}$$
$$F = ?$$

Calculation:

$$F = k\ \frac{q_1 q_2}{r^2}$$
$$= 9 \times 10^{9} \times \frac{10\times10^{-6} \times 5\times10^{-6}}{1.5^2}$$
$$= \frac{450\times10^{-3}}{2.25} = 200\times 10^{-3}$$
$$= 0.2 \text{ N}$$

13.3. The force of repulsion between two identical positive charges is 0.8 N, when the charges are 0.1 m apart. Find the value of each charge.

Solution:

$$q_1 = q_2 = q = ?$$
$$r = 0.1\text{m}, F = 0.8 \text{ N}$$

Calculation:

$$F = k\ \frac{q_1 q_2}{r^2}$$
$$0.8 = 9 \times 10^{9} \times \frac{q \times q}{(0.1)^2}$$
$$\frac{0.8\times(0.1)^2}{9\times10^{9}} = q^2$$
$$\frac{0.8\times1\times10^{-2}}{9\times10^{9}} =$$
$$\frac{8\times10^{-12}}{9} =$$
$$0.888\times10^{-12} =$$
$$88.8\times10^{-14} = q^2$$
$$\sqrt{88.8\times10^{-14}} = q$$
$$9.4 \times 10^{-7} \text{ C} = q$$

13.4. Two charges repel each other with a force of 0.1 N when they are 5 cm apart. Find the forces between the same charges when they are 2 cm apart.

Solution:

$$F1 = 0.1N$$
$$r_1 = 5cm$$
$$r_2 = 2cm$$
$$F_2 = ?$$

Calculation:

$$F_1 = k\ \frac{q_1 q_2}{r^2} \text{ .....1}$$

$$F_2 = k\ \frac{q_1 q_2}{r^2} \text{ ..... 2}$$

$$\frac{F_2}{F_1} = \frac{kq_1q_2 / r_1^{\ 2}}{kq_1q_2 / r_2^{\ 2}}$$

$$\frac{F_2}{F_1} = \frac{r_2^{\ 2}}{r_1^{\ 2}}$$

$$\frac{F_2}{0.1} = \frac{5^2}{2^2}$$

$$F_2 = \frac{25 \times 0.1}{4} = 0.62 \text{ N}$$

13.5. The electric potential at a point in an electric field is 104 V. If a charge of +100 μC is brought from infinity to this point. What would be the amount of work done on it?

Solution:

$$V = 10^4 \text{ V}$$
$$Q = +100\mu C = 100 \times 10^{-6} C$$
$$W = ?$$

Calculation:

$$W = Q\ V = 10^4 \times 100 \times 10^{-6}$$
$$= 10^{+6} \times 10^{-6}$$
$$= 10^{+6-6}$$
$$= 10^0 = 1 \text{ J}$$

13.6. A point charge of +2C is transferred from a point at potential 100V to a point at potential 50V. What would be the energy supplied by the charge?

Solution:

$$q = +2 \text{ C}$$
$$V_1 = 100 \text{ V}$$
$$V_2 = 50 \text{ V}$$
$$W = ?$$

Calculation:

$$W = q\ (V_1 - V_2) = 2\ (100 - 50)$$
$$= 2\ (50) = 100 \text{ J}$$

13.7. A capacitor holds 0.06 coulombs of charge when fully charged by a 9 volt battery. Calculate capacitance of the capacitor.

Solution:

$$Q = 0.06 \text{ C}$$
$$V = 9 \text{ V}$$
$$C = ?$$

Calculation:

$$Q = CV$$

$$C = \frac{Q}{V} = \frac{0.06}{9}$$
$$= 0.00666 \text{ F}$$
$$= 6.67 \times 10^{-3} \text{ F}$$

13.8. A capacitor holds 0.03 coulombs of charge when fully charged by a 6 volt battery. How much voltage would be required for it to hold 2 coulombs of charge?

Solution:

$Q_1 = 0.03$ C
$Q_2 = 2$C
$V_1 = 6$V
$V_2 = ?$

Calculation:

$$\frac{Q_1}{V_1} = \frac{Q_2}{V_2}$$
$$\frac{0.03}{6} = \frac{2}{V_2}$$
$$V_2 = \frac{2 \times 6}{0.03} = \frac{12}{0.03}$$
$$= 400\text{V}$$

13.9 Two capacitors of capacitances 6 μF and 12 μF are connected in series with 12 V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor.

Solution:

$C_1 = 12$ μF
$C_2 = 6$μ F
V= 12 V
Ce=? Q = ? V_1=? V_2=?

Calculation:

$$\frac{1}{Ce} = \frac{1}{C_1} + \frac{1}{C_2}$$
$$\frac{1}{Ce} = \frac{C_1 + C_2}{C_1 C_2}$$
$$\text{Ce} = \frac{C_1 C_2}{C_1 + C_2} = \frac{6 \times 12}{6 + 12}$$
$$= \frac{72}{18} = 4 \text{ μF}$$
$$Q = CeV = 4 \text{ μ} \times 12$$
$$= 48 \text{ μC}$$
$$Q = C_1 V_1$$
$$48 \text{ μ} = 6 \text{ μ } V_1$$
$$8 \text{ V} = V_1$$
$$Q = C_2 V_2$$
$$48 \text{ μ} = 12 \text{ } V_2$$
$$4 \text{ V} = V_2$$

13.10. Two capacitors of capacitances 6 μF and 12 μF are connected in parallel with 12V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor.

Solution:

$$C_1 = 6\mu F$$
$$C_2 = 12\ \mu F$$
$$V = 12V$$
$$Ce = ?\ ,\ Q_1 = ?\ ,\ Q_2 = ?\ V = ?$$

Calculation:

$$Ce = C_1 + C_2$$
$$= 6\mu F + 12\ \mu F$$
$$= 18\ \mu F$$
$$Q_1 = C_1\ V$$
$$= 6\ \mu \times 12$$
$$Q_2 = C_2\ V$$
$$= 12\ \mu \times 12$$
$$= 144\ \mu\ C$$
$$V = 12\ V$$

CH. # 14 CURRENT ELECTRICITY

SHORT QUESTION

CURRENTY ELECTRICITY:

The branch of physics which deals with the properties of charge when it is in motion.

Electric current:

The rate of flow of electric charge through any cross-sectional area is called current.

Mathematical form:

If the charge Q is passing through any area in time t, then current I flowing through it will be given by

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

SI unit of current is ampere (A).

Ampere:

If a charge of one coulomb passes through a cross sectional area in one second, this amount of current is one ampere.

Sub- multiple unit of current:

$1\ mA = 10^{-3}\ A$

$1\ \mu A = 10^{-6}\ A$

What is the source of current?

Battery is the one of the source of current. For continuous flow of current, potential difference is necessary across the two ends of conductor. Inside the battery, chemical reaction separates the positive and negative charges causes the potential difference between terminals of battery. When a conductor is connected to a battery, charges moves through the circuit. The energy of charge is converted in to other form of energy heat, light and sounds etc.

Other sources of current:

- ⇨ AC generator
- ⇨ Solar cell

⇨ Thermocouple

Conventional current:

Current flowing from positive to negative terminal of a battery due to the flow of positive charges is called conventional current.

It has the same effect as the current flowing from negative terminal to the positive terminal due to the flow of negative charges.

The Measurement of Current:

Galvanometer and ammeter is used to measure the current in the circuit.

Galvanometer:

It is very sensitive instrument to measure and detect the current in the circuit. It measures the current in milli – ampere or micro -ampere.

Ammeter:

It is modified form of galvanometer which measures the current in ampere.

How galvanometers can convert in to ammeter:

To convert the galvanometer in to ammeter, a small value of resistance called shunt is connected parallel to the galvanometer.

How an ammeter is connected in a circuit:

⇨ It is connected in series.

⇨ Positive terminal of battery is connected to positive mark of ammeter.

What is an ideal galvanometer?

An ideal galvanometer should have a very small resistance so that maximum current pass through it.

Potential difference:

Potential difference across the two ends of a conductor causes the dissipation of electrical energy into other forms of energy as charges flow through the circuit.

SI unit of potential difference is volt.

Electromotive force

It is the energy supplied by a battery to a unit positive charge when it flows through the closed circuit.

OR

The energy converted from non-electrical forms to electrical form when one coulomb of positive charge passes through the battery.

Thus

$$e.m.f = Energy/Charge$$

$$E = W/Q$$

The unit for e.m.f. is JC^{-1} which is equal to volt (V) in SI system

If emf of the battery is 2 volt. What its mean?

Its mean total energy supplied by the battery is 2 joules if one coulomb charge flow through the close circuit.

The Measurement of Potential Difference:

A device that is used to measure the potential difference is called voltmeter.

How voltmeter is connected in a circuit:

⇨ It is connected in parallel with the device across which potential difference is to be measured.

⇨ Positive terminal of battery is connected to positive terminal of volt meter.

What is an ideal volt meter?

An ideal voltmeter is one whose resistance is very high so that no current passes through it.

The measurement of e.m.f:

In order to measure the e.m.f of battery, voltmeter is connected directly with the terminal of battery.

Ohm's law:

According to ohm

The amount of current passing through a conductor is directly proportional to the potential difference applied across its ends, provided the temperature and the physical state of the conductor does not change

$$I \propto V \text{ or } V \propto I$$

$$V = IR$$

Where R is the constant of proportionality, and it is the resistance of the conductors. Its SI unit is ohm, denoted by a symbol Ω.

Resistance:

The opposition offered by a conductor to the flow of current is called resistance.

Unit: the SI unit of resistance is ohm.

Ohm:

When a potential difference of one volt is applied across the ends of a conductor and one ampere of current passes through it, then its resistance will be one ohm.

Limitation of ohm's law;

Ohm's law is only applicable on metallic conductor.

Why resistances of conductor increase with the increase in temperature?

With the increases of temperature, thermal vibration of atoms increases. So the chance of collisions of free electron with atoms increases. Hence resistance of conductor is increased.

V-I CHARACTERISTICS OF OHMIC AND NON OHMIC CONDUCTORS:

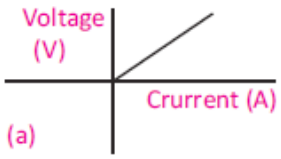
Ohmic conductor:

A conductor that obeys the ohm's law is called ohmic conductor. For examples metals etc.

V-I CHARACTERISTICS:

=> Ohmic conductor has a linear V-I graph.

=> Straight line shows the constant ratio between voltage and current.



Non ohmic conductor:

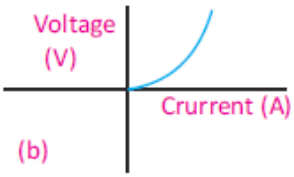
A conductor that does not obey the ohm's law is called non ohmic conductor.

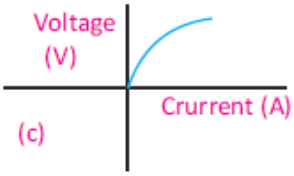
V-I CHARACTERISTICS:

=> Non -ohmic conductor has a non linear V-I graph.

=> Curve line shows the ratio between voltage and current is not constant.

=> For example filament lamp and thermister. Resistance of filament increases as it gets hotter. While resistance of thremister decrease as it get hotter.





What are the factors affecting the resistance?

Resistance of conductor depends upon the fallowing factors

- ⇨ temperature
- ⇨ length of conductor
- ⇨ cross sectional area of conductor

Resistivity or specific resistance:

The resistance of cube meter conductor is called resistivity. Its unit is ohm-meter.

Conductor:

The substance in which current can flow easily is called conductor. They have excess of free electrons. **For example** silver and copper

Non- conductor or insulator:

The substance in which current can not flow easily is called non conductor. There are no free electrons. **For example** plastic, wood glass etc.

What is series combination of resistors?

In series combination, resistors are connected end to end. Current through each resistor is same.

Formula for equivalent resistances for n no. of resistors are connected is series:

If resistances R_1, R_2, R_3 ,…….. R_n are connected in series then equivalent resistances of this combination is

$$R_e = R_1 + R_2 + R_3 + \ldots\ldots\ldots\ldots + R_n$$

Formula for equivalent resistance for n no. of resistors is connected in parallel:

If resistances R_1, R_2, R_3 ,…….. R_n are connected in parallel then equivalent resistances of this combination is

$$1/R_e = 1/R_1 + 1/R_2 + 1/R_3 + \ldots\ldots\ldots\ldots + 1/R_n$$

What is parallel combination of resistors?

In parallel combination, one end of each resistor is connected with positive terminal of battery while the other end of each resistor is connected with the negative terminal of battery.

What is mean by circuit diagram?

A circuit diagram is symbolic method of describing a real circuit. The electric symbols used in circuit diagram are standard.

Joule's law:

The amount of heat generated in a resistance due to flow of charges is equal to the product of square of current I, resistance R and the time duration t.

Mathematical form:

$$W = I^2Rt = V^2t / R$$

Electric power:

The amount of energy supplied by current in unit time is known as electric power.

Electric power P = electrical energy/time = W/t

$$P = QV/t = IV = I^2 R$$

The unit of electric power is watt which is equal to one joule per second. It is represented by the symbol W.

Kilowatt- Hour:

The amount of energy delivered by a power of one kilowatt in one hour is called kilowatt-hour. It is equal to 3.6 MJ

Relation b/w kilowatt hour and joule:

One kilowatt-hour=1kWh= 1000 W ×1 hour

$=1000\ W \times (3600\ s)$

$= 36 \times 10^5\ J = 3.6\ M\ J$

Formula for calculating the energy in kWh:

The amount of energy in kilowatt-hour = watt x time of use in hours/1000

To find the cost of electricity:

Cost of electricity = no. of unit consumed × cost of one unit

= watt x time of use in hours/1000 × cost of one unit

Direct current:

Current derived from cell or battery is called direct current.

- ⇨ It is unidirectional.
- ⇨ Level of dc source remains constant with time.
- ⇨ Its transmission is difficult from one place to other place.

Alternating current:

Such current that change current direction after equal interval of time is called alternating current. Level of Ac continuously varying. Its transmission is very easy from one place to other place.

Time period of AC current:

The time interval after the ac voltage or current repeat its value is known as its time period.

Frequency of AC used in Pakistan:

In Pakistan alternating current oscillates 50 times every second. So its frequency is 50 HZ.

Advantage of AC over DC:

Transmission of AC is very easy than DC. So almost all over the world power station produce AC.

Earth wire or ground wire:

This carries no electricity. The earth wire is connected to large metal plates buried deep in the ground.

Neutral wire:

This wire is maintained zero potential by connected it to the earth at power station.

Live wire:

This wire is connected at a high potential. The potential difference between neutral and live wire is 220V.

What is mean by damped condition?

The resistance of human skin reduced to few ohms from 100000 ohms under wet condition. This is called damped condition.

Fuse:

A safety device that is connected in series with the live wire. It protects the appliances when excess current flows.

Circuit breaker:

It is also a safety device acts in the same way as fuse. It breaks the circuit when excess current flows through it. It works on the principle of electromagnetism.

Earth wire:

The earth wire is a crucial part of the home electrical system and is designed to protect against electric shock. If faults occur in the electrical system, the electricity will flow to earth by the shortest and easiest path.

What is mean by short circuit?

When live wire and neutral wires come in direct contact, short circuit is occurred.

Dangers limit of current for human live:

Voltage of 50V and current of 50 mA can be fatal.

Advantage of parallel circuit:

1. Each device in the circuit receives the full battery voltage.
2. Each device in the circuit may be turned off independently.

CONCEPTUAL QUESTIONS

14.1 Why in conductors charge is transferred by free electrons rather than by positive charges?

Because electrons are free in conductor and by applying potential difference, they move from lower potential to higher potential. On the other side, positive charges are present in the nucleus of the atom and they are not free to move that's why electric current is caused by free electrons.

14.2 What is the difference between a cell and a battery?

The difference between a cell and a battery is that a cell is a single unit that converts chemical energy into electrical energy, and a battery is a collection of cells

14.3 Can current flow in a circuit without potential difference?

No, for continuous flow of current, potential difference is necessary across the two ends of conductor.

14.4 Two points on an object are at different electric potentials. Does charge necessarily flow between them?

Electric current flow due to the potential difference. If the object is conductor then electric current will flow. But if the object is insulator then no current will flow.

14.5 In order to measure current in a circuit why ammeter is always connected in series?

In series there is only one path to the flow of current. So ammeter is connected in series so that all the current passes through the ammeter which is to be measured.

14.6 In order to measure voltage in a circuit voltmeter is always connected in parallel. Discuss.

in order to measure voltages accurately, it to connect in parallel to the circuit because of the fact the voltage is same in parallel and divides in series so if connected in parallel it will show the exact volt as in circuit but if connected in series the voltages is the sum of the drops in circuit and in voltmeter

14.7 How many watt-hours are there in 1000 joules?

$$1\ W\ h = 1\ w \times 3600\ s = 1\ J/s \times 3600\ s = 3600\ J$$

$$1\ W\ h = 3600\ J$$

$$1 / 3600\ Wh = 1J$$

$$1000\ J = 1000 \times 1 / 3600\ Wh = 0.28\ W\ h$$

14.8 From your experience in watching cars on the roads at night, are automobile headlamps connected in series or in parallel?

The head light of cars are connecting in parallel because their brightness are approximately same. If they are connected in series then first light will be brighter than the second light. While in parallel potential will remain same and they will have same brightness.

OR

Head lamps of automobiles are generally wired in parallel. This way, if one headlight is to burn out the others remain switched ON.

14.9 A certain flash-light can use a 10 ohm bulb or a 5 ohm bulb. Which bulb should be used to get the brighter light? Which bulb will discharge the battery first?

If the bulbs are connected in parallel then they will have same brightness because the brightness depends upon the voltage. If the bulbs are connected in series then first bulb will be brighter than the second because in series the voltage drop is different in two bulbs. The bulb which has more resistance will discharge the battery soon

14.10 It is impracticable to connect an electric bulb and an electric heater in series. Why?

In series connection current remains same. Heater required very large amount of current than bulb. So this large value of current fuses the bulb.

14.11 Does a fuse in a circuit control the potential difference or the current?

Fuse in a circuit controls the excess amount of current.

LONG QUESTIONS

Q. No.1

Specific resistance or resistivity:

The resistance of cube meter conductor is called resistivity. Its unit is ohm-meter.

Explanation:

Resistance of conductor depends upon the fallowing factors

- ⇨ temperature
- ⇨ length of conductor
- ⇨ cross sectional area of conductor

It is experimentally observed that resistance of conductor is directly proportional to the length of conductor and inversely proportional to the cross section area of conductor.

$R \alpha L$ …….. 1

$R \alpha 1/A$ ……..2

Combing 1 and 2

$R \alpha L/A$

$R = \text{constant } L/A$

$R = \rho L/A$

Where ρ is proportionality constant and is called specific resistance. Its value depends upon the nature of conductor. Its unit is ohm meter ($\Omega - m$)

Q.No.2

Combination of resistors:

(i) Series combination (ii) parallel combination

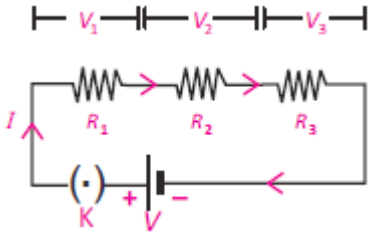
(i) Series combination:

In this combination, resistors are connected end to end and there is only a single path to the flow of current.

Characteristics:

1. Current flow through all the circuit is same.
2. Sum of the Voltage drops across each resistor is equal the total voltage of battery.

$V = V_1 + V_2 + V_3$ ……1



Voltage drops across R_1 $V_1 = IR_1$

Voltage drops across R_2 $V_2 = IR_2$

Voltage drops across R_3 $V_3 = IR_3$

Equation 1 becomes

$V = IR_1 + IR_2 + IR_3$

$= I(R_1 + R_2 + R_3)$

3. By replacing this series combination of resistors with one equivalent resistor having resistance R_e $V = IR_e$ …….. 2

Comparing 1 and 2

$R_e = R_1 + R_2 + R_3$

4. **Equivalent resistance:**

It is equal to sum of all individual resistance connected in series.

5. If resistances $R_1, R_2, R_3, \ldots\ldots R_n$ are connected in series then equivalent resistances of this combination

$R_e = R_1 + R_2 + R_3 + \ldots\ldots\ldots\ldots\ldots + R_n$

Q.No.3

Parallel combination:

In parallel combination, one end of each resistor is connected with positive terminal of battery while the other end of each resistor is connected with the negative terminal of battery.

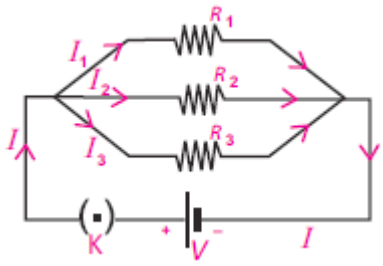
Characteristics:

1. Voltage across each resistance is same.
2. Total current is equal to the sum of the current passing in each resistor.

$I = I_1 + I_2 + I_3$ …… 1

By ohm's law, current flow in the resistors is

$I_1 = \frac{V}{R_1}$, $I_2 = \frac{V}{R_2}$ $I_3 = \frac{V}{R_3}$



$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$

$= V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$

3. By replacing this parallel combination of resistors with one equivalent resistor having resistance R_e $I = V(1/R_e)$

Comparing 1 and 2

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

4. If resistances $R_1, R_2, R_3, \ldots\ldots\ldots\ldots R_n$ are connected in parallel then equivalent resistances of this combination

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots\ldots\ldots + \frac{1}{R_n}$$

Advantage of parallel circuit:

1. Each device in the circuit receives the full battery voltage.
2. Each device in the circuit may be turned off independently.

Q.No.4

Electrical energy and joule's law:

The amount of heat generated in a resistance due to flow of charges is equal to the product of square of current I, resistance R and the time duration t.

Mathematical form:

$$W = I^2Rt = V^2t / R$$

Explanation:

Consider two points with a potential difference V volt. If Q coulomb of charge flows between these points. Then energy supplied by the battery is

$$W = QV \text{ ……..} \quad 1$$

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

$$I \times t = Q$$

Equation 1 becomes

$$W = I \times t \times V$$

From ohm's law $V = IR$

$$W = I \times t \times IR$$

$$= I^2Rt = V^2t/R$$

This electrical energy can be converted in to heat or other form of energy. For example bulb converts this in to light and fans in to mechanical energy.

Q.No.5

Hazards of electricity:

Insulation damage:

All electrical wires are well insulated with some plastic cover for safety. However if current exceeds from its limit, or short circuit is occurred due to any reason it damage the insulation.

Reason of short circuit:

(1) If the resistance of circuit becomes very small, then short circuit is occurred. A large value of current will flow through the circuit. On other hand different appliances are connected in parallel so equivalent resistance reduces of very small value. This additional current produces the enough heat energy which melts the wire.

(2) When live wire and neutral wires come in direct contact, short circuit is occurred.

Precaution:

In order to avoid such situations, current carrying wire should never be naked. They should be covered with good insulator. Such an insulation covered wired is called cable.

Q.No.6

Safety devices:

Fuse:

A safety device that is connected in series with the live wire. It protects the appliances when excess current flows. It is thin piece of metal that melts when large current flow it.

Points to keep in mind to use the fuse.

- ⇨ Fuse rating should be slightly large the amount of current that flow through the circuit.
- ⇨ It should be connected in series with live wire.
- ⇨ Switch off the main before changing any fuse.

Circuit Breaker:

It is also a safety device acts in the same way as fuse. It breaks the circuit when excess current flows through it. It works on the principle of electromagnetism.

Working:

When normal current passes through the live wire, electromagnetic is not enough to separate the contact point. When some thing is wrong or current exceed to it limit, electromagnetic is so strong it separate the connect points and break the circuit.

After repairing the fault, a button is pressed on the outside of circuit breaker.

Earth wire:

The earth wire is a crucial part of the home electrical system and is designed to protect against electric shock. If faults occur in the electrical system, the electricity will flow to earth by the shortest and easiest path.

Explanation:

Many electrical appliances have metal case such as cookers, washing machine. Earth wire provides the safe rout to the flow of current. If the live wire inside appliance loose or touches the metal casing. Current goes through the earth instead of our body. Due to low resistance, large value of current breaks the circuit or melt the fuse.

Q. Which metal is used as the filament of electric bulb? Explain with reason.

High resistance metals such as tungsten is used as the filament of electric bulb.

Reason: They offer more resistance against flow of charge. More energy is dissipated and appears in the form of light.

NUMERICALS

14.1 A current of 3mA is flowing through a wire for 1 minute. What is the charge flowing through the wire?

Solution:

$= 3mA = 3\times10^{-3}A$

$t = 1min = 60s$

$Q = ?$

Calculation:

$$I = Q/t$$
$$1\times t = Q$$
$$3\times10^{-3}\times60 =$$
$$180\times10^{-3}\ C = Q$$

14.2 At 100,000 Ω, how much current flows through your body if you touch the terminals of a 12 V battery? If your skin is wet, so that your resistance is only 1000 Ω, how much current would you receive from the same battery?

Solution:

$R_1 = 100000\ \Omega$

$V = 12\ V$

$I_1 = ?$

Calculation:

$$V = I_1 R_1$$
$$12 = I_1\times100000$$
$$12 = I_1\times10^5$$
$$\frac{12}{10^5} = I_1$$
$$12\times10^{-5} = I_1$$
$$1.2\times10^{-4}\ A = I_1$$

$R_2 = 1000\ \Omega$

$I_2 = ?$

$V = I_2 R_2$

$$12 = I_2 \times 1000$$
$$12 = I_2 \times 10^3$$
$$\frac{12}{10^3} = I_2$$
$$12 \times 10^{-3} = I_2$$
$$1.2 \times 10^{-2}\ A = I_2$$

14.3 The resistance of a conductor wire is 10 MΩ. If a potential difference of 100 volt is applied across its ends, then find the value of current passing through it in mA.

Solution:

$$R = 10\ M\ \Omega = 10 \times 10^6\ \Omega$$
$$V = 100\ V$$
$$I\ (mA) = ?$$

Calculation:

$$V = IR$$
$$100 = I \times 10 \times 10^6$$
$$\frac{100}{10 \times 10^6} = I$$
$$\frac{100}{10 \times 10^3 \times 10^3} = I$$
$$\frac{100}{10000} \times 10^{-3} = I$$
$$0.01mA = I$$

14.4 By applying a potential difference of 10 V across a conductor a current of1.5A passes through it. How much energy would be obtained from the current in 2 minutes?

Solution:

$$V = 10V$$
$$I = 1.5\ A$$
$$t = 2\ min = 2 \times 60 = 120\ s$$
$$W = ?$$

Calculation:

$$W = qV = It \times V$$
$$= 1.5 \times 120 \times 10$$
$$= 1800\ J$$

14.5 Two resistances of 2 kΩ and 8 kΩ are joined in series, if a 10 V battery is connected across the ends of this combination, find the following quantities: (a) **The equivalent resistance of the series combination.**

(b) Current passing through each of the resistances.

(c) The potential difference across each resistance.

Solution:

$$R_1 = 2k\ \Omega$$
$$R_2 = 8\ k\ \Omega$$
$$V = 10V$$
$$Re = ?\ ,\ I = ?\ ,\ V_1 = ?\ ,\ V_2 = ?$$

Calculation:

$$Re = R_1+R_2$$
$$= 2k\ \Omega+8\ k\ \Omega = 10\ k\ \Omega$$
$$V = I\ Re$$
$$10 = I \times 10\ k$$
$$10 = I \times 10 \times 10^3$$
$$\frac{10}{10\times10^3} = I$$
$$1\times10^{-3}\ A = I$$
$$V_1 = IR_1$$
$$= 1\times10^{-3}\times 2\times10^3 = 2\ V$$
$$V_2 = IR_2$$
$$= 1\times10^{-3}\times 8\times10^3 = 8\ V$$

14.6 Two resistances of 6KΩ and 12kΩ are connected in parallel. A 6V battery is connected across its ends, find the values of the following quantities:

(a) Equivalent resistance of the parallel combination.

(b) Current passing through each of the resistances.

(c) Potential difference across each of the resistance.

Solution:

$$R_1 = 6k\ \Omega$$
$$R_2 = 12\ k\ \Omega$$
$$V = 6V$$
$$Re = ?\ ,\ I_1 = ?\ ,\ I_2 = ?\ ,\ V = ?$$

Calculation:

$$\frac{1}{Re} = \frac{1}{R_1} + \frac{1}{R_2}$$
$$= \frac{R_1 + R_2}{R_1 \times R_2}$$
$$Re = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{6k \times 12k}{6k + 12k}$$
$$Re = \frac{72k^2}{18k} = 4k\ \Omega$$
$$V = I_1R_1$$
$$6 = I_1\times6k$$
$$\frac{6}{6\times10^3} = = I_1$$
$$1\times10^{-3} = I_1$$
$$1mA = I_1$$
$$V = I_2R_2$$
$$6 = I_2\times12k$$
$$\frac{6}{12\times10^3} = = I_2$$
$$0.5\times10^{-3} = I_2$$
$$0.5\ mA = I_2$$

14.7 An electric bulb is marked with 220V, 100W. Find the resistance of the filament of the bulb. If the bulb is used 5 hours daily, find the energy in kilowatt-hour consumed by the bulb in one month (30 days).

Solution:

V = 220V

P = 100 W

t = 5 hour

Duration = 30 days

i) R=? ii) Energy in kilo watt hour

Calculation:

$$P = \frac{V^2}{R}$$

$$R = \frac{V^2}{p} = \frac{220 \times 220}{100}$$

$$= \frac{48400}{100} = 484\Omega$$

$$\text{Energy in kilo watt hour} = 30 \times \frac{watt \times time(hour)}{1000}$$

$$= 30 \times \frac{100 \times 5}{1000} = 15 \text{ kWh}$$

14.8 An incandescent light bulb with an operating resistance of 95 Ω is labelled "150 W." Is this bulb designed for use in a 120V circuit or a 220V circuit?

Solution:

R = 95 Ω

P= 150 W

Is this bulb designed for 120V or 220V?

Calculation:

$$P = \frac{V^2}{R}$$

$$150 = \frac{V^2}{95}$$

$$150 \times 95 = V^2$$

$$14250 = V^2$$

$$119.37 = V$$

Hence it is design for 120V.

14.9 A house is installed with

(a) 10 bulbs of 60 W each of which are used 5 hours daily.

(b) 4 fans of 75 W each of which run 10 hours daily.

(c) One T.V. of 100 W which is used for 5 hours daily.

(d) One electric iron of 1000 W which is used for 2 hours daily.

If the cost of one unit of electricity is Rs.4. find the monthly expenditure of electricity (one month =30 days).

Solution:

Energy consumed by 10 bulbs

$$= \frac{watt \times time(hours)}{1000} = 10 \times \frac{60 \times 5}{1000} = 3\text{kWh}$$

Energy consumed by 4 fans

$$= \frac{watt \times time(hours)}{1000} = 4 \times \frac{75 \times 10}{1000} = 3\text{kWh}$$

Energy consumed by 1 t.v

$$= \frac{watt \times time(hours)}{1000} = \frac{100 \times 5}{1000} = 0.5\text{kWh}$$

Energy consumed by 1 eletric iron

$$= \frac{watt \times time(hours)}{1000} = \frac{1000 \times 2}{1000} = 2\text{kWh}$$

Total energy consumed in 1 day

$= 3+3+0.5+2 = 8.5$ kWh

Energy consumed in 30 days $= 8.5 \times 30 = 255$ kWh

Price of 1 unit = 4 Rs.

Price of 255 units $= 255 \times 4 = 1020$ Rs.

14.10 A 100 W lamp bulb and a 4 kW water heater are connected to a 250 V supply. Calculate (a) the current which flows in each appliance

(b) The resistance of each appliance when in use.

Solution:

$= P_1 = 100\text{W}$

Power of heater $= P_2 = 4\text{kW} = 4000$ W

$V = 250$ V

$I_1 = ?$, $I_2 = ?$, $R_1 = ?$ $R_2 = ?$

Calculation:

$$P_1 = \frac{V^2}{R_1}$$

$$R_1 = \frac{V^2}{P_1} = \frac{(250)^2}{100} = 625\Omega$$

$$P_2 = \frac{V^2}{R_2}$$

$$R_2 = \frac{V^2}{P_2} = \frac{(250)^2}{4000} = 15.62\Omega$$

$$V = I_1R_1$$

$$250 = I_1 \times 625$$

$$\frac{250}{625} = I_1$$

$0.4\text{A} =$

$$V = I_2R_2$$

$$250 = I_2 \times 15.62$$

$$\frac{250}{15.62} =$$

$16\text{A} = I_2$

14.11 A resistor of resistance 5.6 Ω is connected across a battery of 3.0 V by means of wire of negligible resistance. A current of 0.5 A passes through the resistor. Calculate (a) power dissipated in the resistor (b) total power produced by the battery.

Solution:

$R = 5.6\Omega$

$V = 3.0$ V , $I = 0.5$ A

Power of battery =?

Dissipated power of resistor =?

Calculation:

$P = VI$

$= 3 \times 0.5 = 1.5$ W

$P = I^2R$

$= 0.5 \times 0.5 \times 5.6 = 1.4$ W

Some power is dissipated due to the internal resistance of battery

CH. # 15 ELETROMAGNETISM

SHORT QUESTIONS

Electromagnetism:

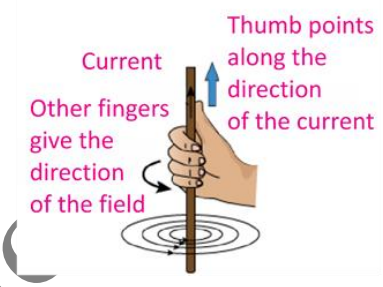
The branch of physics which deals magnetic effects of electric current is called electromagnetism.

Magnetic effect of current in straight wire:

Ampere observed that when a current passes through a conductor, it produce magnetic field around it. The lines of force of magnetic field are in the form of concentric circle.

Direction:

The direction of magnetic field depends upon the direction of current and can be determined by **right hand grip rule.**



Hold the wire in right hand such that the erect thumb in the direction of current. Then curling finger of hand will circle in the direction of magnetic field.

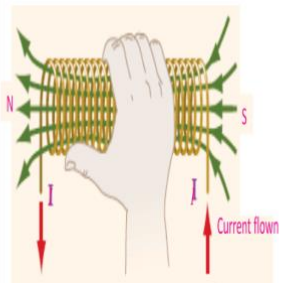
- ⇨ If current flows from top to bottom, magnetic lines of force are clockwise.
- ⇨ If current flows from bottom to top, magnetic lines of force are anticlockwise

Magnetic field of solenoid:

A coil of wire consisting of many loops is called a solenoid.

Characteristics of magnetic field of solenoid:

- ⇨ Magnetic field of solenoid is similar to bar magnetic.
- ⇨ Along the axis of solenoid, magnetic lines of force are parallel and straight.
- ⇨ In side the solenoid, magnetic field will be strong.



Direction:

If we grip the coil with our right hand by curling our fingers in the direction of the conventional current, our thumb will indicate the north pole of the coil.

Electromagnetic:

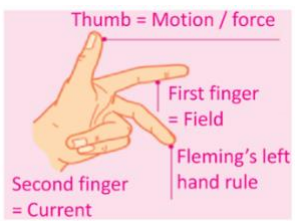
The type of temporary magnet, which is created when current flows through a coil, is called an electromagnet.

Why force acts on current carrying conductor placed in a magnetic field:

When current carrying conductor is placed in a magnetic field, this magnetic field interacts with the magnetic field of current. As result, at one side magnetic fields become strong and other side is weak. Then force acts on conductor from strong to weak side.

Dependence of force:

- ⇨ The current of wire is increased
- ⇨ The strength of magnetic field is increased.
- ⇨ The length of wire in side the magnetic field.



Fleming left hand rule:

Stretch the thumb, forefinger and the middle finger of the left hand mutually perpendicular to each other. If the forefinger points in the direction of the magnetic field, the middle finger in the direction of the current, then the thumb would indicate the direction of the force acting on the conductor.

D.C motor:

A device that converts electrical energy in to mechanical energy is called d.c motor.

Principle of d.c motor:

When a current carrying coil is placed in a magnetic field, It experience a torque which rotates it. This is the principle of d.c motor.

Commutator:

Split ring that connected to the ends of coil with the help of carbon brushes used to change the direction of current is called Commutator.

Armature:

A number of coils are wound around an iron cylinder, which is rotated in the magnetic field is called an armature.

Field coil:

Magnetic field is produced either by permanent magnetic or electromagnetic, called a field coil.

How force acts on the armature can be increased.

- ⇨ Increasing the number of turns of coil.
- ⇨ Increasing the current of the coil.
- ⇨ Increasing the strength of magnetic field
- ⇨ Increasing the area of the coil.

Magnetic flux OR strength of magnetic field:

The number of magnetic lines of force passing through any surface is called magnetic flux of that surface or strength of magnetic field.

Maximum strength of magnetic field:

No. of magnetic lines of force is maximum when the surface is held perpendicular to the magnetic lines of force.

Minimum strength of magnetic field:

No. of magnetic lines of force is minimum when the surface is held parallel to the magnetic lines of force.

Electromagnetic induction:

Due to the change in number of magnetic lines of force in the coil, e.m.f. induces in it. This phenomenon is called electromagnetic induction.

Induced emf and induced current:

Due to the change in number of magnetic lines of force in the coil, emf induces in it which causes the induce current. This emf is called induced emf and induced current.

Faraday's law of electromagnetic induction:

The value of induce emf in a circuit is directly proportional to the rate of change of number of magnetic lines of force through it.

Factors Affecting Induced e.m.f

The magnitude of induced e.m.f. in a circuit depends on the following factors:

1. Speed of relative motion of the coil and the magnet
2. Number of turns of the coil
3. Amount of current passing through the coil.

Lenz's law:

The direction of an induced current in a circuit is always such that it opposes the cause that produces it.

A.C generator:

A device that converts mechanical energy in to electrical energy is called A.C generator.

Principle of A.C generator:

When coil is rotated in the magnetic field, Due to the change in number of magnetic lines of force in the coil, e.m.f. induces in it. This is the principle of A.C generator.

Mutual induction:

Due to the change in current in one coil, current is induced in second coil. This phenomenon is called mutual induction.

Transformer:

A device that changes the value of A.C voltage is called transformer. It works on the principle of mutual induction.

Step up transformer:

A transformer that increases the value of AC voltage is called step up transformer. In such a transfer, no. of turns of secondary coils is greater than no. of turns of primary coils $N_s > N_p$.

Step down transformer:

A transformer that decreases the value of AC voltage is called step down transformer. In such a transfer, no. of turns of secondary coils is less than no. of turns of primary coils $N_s < N_p$.

What is an ideal transformer?

An ideal transformer is one which dissipates no power itself and for such a transformer, we can write

$$P_p = P_s$$
$$V_p I_p = V_s I_s$$

Relay:

The relay is used to control large current with the help of a small current.

If the current passing through a wire in same direction, Would the wire attract or repel each other?

They attract each other.

Reason:

Magnetic field of lines due to the current in side the wire is opposite so cancel each other. Magnetic fields of out side push the wire inward.

What is advantage of high voltage transmission?

The power is transmitted over long distance at high voltage to minimize the loss of energy in the form of heat during the transition. At high voltage current is reduced and hence power loss is reduced.

CONCEPTUAL QUESTIONS

15 .1 Suppose someone handed you three similar iron bars and told you one was not magnet but the other two were. How would you find the iron bar that was not magnet?

With the help of bar magnetic, we will place compass needle near these three iron bars. Compass needle for which iron bar, did not change its needle then this means that this iron bar is not a magnet.

15 .2 Suppose you have a coil of wire and a bar magnet. Describe how you could use them to generate an electric current.

We will move the bar magnet into and out of the coil and this changing magnetic field will induce emf and electric current.

15 .3 which device is used for converting electrical energy into mechanical energy?

D.C Motor

15 .4 Suppose we hang a loop of wire so that it can swing easily. If we now put a magnet into the coil, the coil will start swinging. Which way will it swing relative to the magnet and why?

According to Lenz's law, the direction of the induced e.m.f is always such that it opposes the change producing it. When magnetic moves forward, loop repels and when it moves backward, loop attracts. So loop will start swing.

15 .5 A conductor wire generates a voltage while moving through a magnetic field. In what direction should the wire be moved, relative to the field to generate the maximum voltage?

To generate the maximum voltage (emf) in the conductor we must move the wire in such a way that angle between velocity or wire and magnetic field must be 90^0.

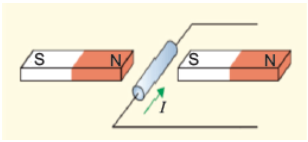
15 .6 what is the difference between a generator and a motor?

A.C generator Converts mechanical energy in to electrical energy while d.c motor converts electrical energy in to mechanical energy.

15 .7 what reverses the direction of electric current in the armature coil of D.C. motor?

Split ring that connected to the ends of coil with the help of carbon brushes used to change the direction of current. It is also called Commutator.

15 .8 A wire lying perpendicular to an external magnetic field carries a current in the direction shown in the diagram below. In what direction will the wire move due to the resulting magnetic force?



Wire will move in the downward direction.

Reason: Resulting magnetic field lower side of the wire is weaker than upper side.

15.9 Can a transformer operate on direct current?

No, direct current can not produce the varying magnetic filed.

LONG QUESTIONS

Q. NO.1 DC MOTOR:

D.C motor:

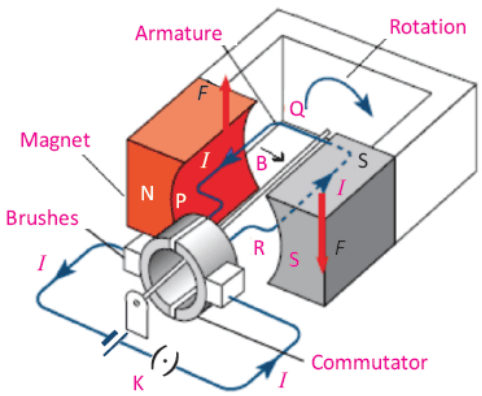
A device that converts electrical energy in to mechanical energy is called d.c motor.

Principle of d.c motor:

When a current carrying coil is placed in a magnetic field, it experiences a torque which rotates it. This is the principle of d.c motor.

CONSTUCTION:

It is consist of a rectangular coil PQRS placed in poles of magnetic. The ends of coil are attached with the split ring. Two carbon brushes remain pressed against split rings. These are connected to a D.C. source.



WORKING:

When motor is on, forces push the PQ side of the coil up and RS side dawn until the coil reaches the vertical position. In this situation net force act on the coil is zero. But due to its momentum

it turns on. To rotate the coil continuously, split ring changes the direction of current and is called commutator. This reversal of current will allow the coil to rotate continuously. At each half turn, Split ring changes the direction of current and causes the coil to rotate continuously in magnetic field. In this way, electrical energy converts in to mechanical energy.

Armature:

A number of coils are wound around an iron cylinder, which is rotated in the magnetic field is called an armature.

Field coil:

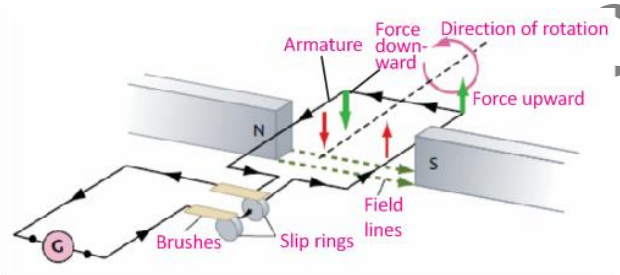
Magnetic field is produced either by permanent magnetic or electromagnetic, called a field coil.

How force acts on the armature can be increased.

- ⇨ Increasing the number of turns of coil.
- ⇨ Increasing the current of the coil.
- ⇨ Increasing the strength of magnetic field
- ⇨ Increasing the area of the coil.

Q. NO.2 AC generator

A device that converts mechanical energy in to electrical energy is called A.C generator.



Principle of A.C generator:

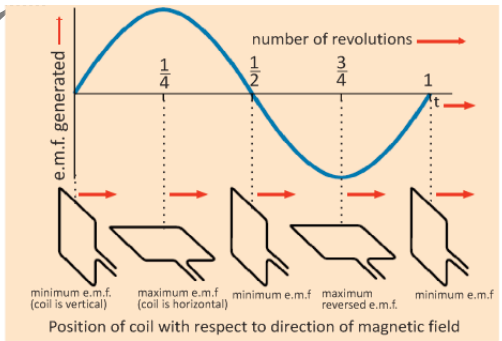
When coil is rotated in the magnetic field, Due to the change in number of magnetic lines of force in the coil, e.m.f. induces in it. This is the principle of A.C generator.

Factor depends upon the emf produced by AC generator.

- ⇨ Length of wire is rotating in the magnetic field.
- ⇨ No. of loops in the armature.

Current from a generator:

When a generator is connected in a close circuit, the Induce emf generates the electric current.



Minimum current:

Initial, coil is in vertical position i.e. plane of coil is perpendicular to field lines. Flux is maximum but rate of change of magnetic lines of force is minimum current is zero.

Maximum current:

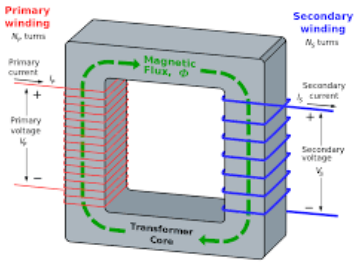
As the coil rotate from the vertical position to horizontal position, it cut the large no. of magnetic lines of force per second so emf and hence current increase. When the coil is in horizontal position. Current reaches its maximum value.

As the coil continue to turn, segment that is moving up is begins to move down and current change the direction. This change of current takes places at each half turn (180^o). Such a current is known as alternating current.

Transformer:

A device that changes the value of A.C voltage is called transformer. It works on the principle of mutual induction.

Construction:



It is consists of a rectangular iron core. Two coils are wounds around the core. One coil is called primary and other is called secondary.

Working:

When ac mains is connected to primary coil, it produce varying magnetic field. The iron core enhances the field to such large value that all magnetic lines of force passing through the secondary coil. This changing field induces emf.

Equation of transformer:

If voltage of primary coil = V_p

Voltage of secondary coil = V_s

No. of turns of primary coil= N_p

No. of turns of secondary coil = N_s

Then $$\frac{Vs}{V_p} = \frac{N_s}{N_p}$$

Step up transformer:

A transformer that increases the value of AC voltage is called step up transformer. In such a transfer, no. of turns of secondary coils is greater than no. of turns of primary coils $N_s > N_p$.

Step down transformer:

A transformer that decreases the value of AC voltage is called step down transformer. In such a transfer, no. of turns of secondary coils is less than no. of turns of primary coils $N_s < N_p$.

What is an ideal transformer?

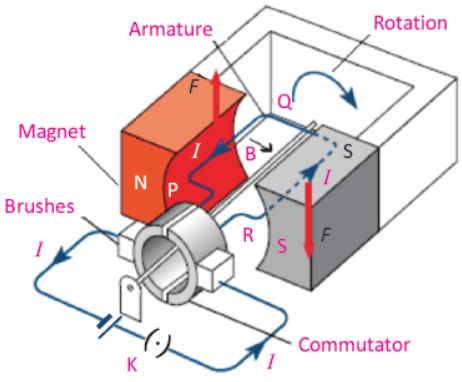
An ideal transformer is one which dissipates no power itself and for such a transformer, we can write

$P_p = P_s$

$V_pI_p = V_sI_s$

Q.No. 4 Turning effect on a current carrying coil in the magnetic field

Instead of straight wire, if a current carrying coil is placed in magnetic field, coil will rotate due to the torque acting on it.



Consider a rectangular coil is placed in side the magnetic field. If the ends of coil are connected with the terminals of a battery, Current would start flowing through the coil. By applying the left hand rule on each sides of coil, Force on the PQ is upwards and on the side RS is downward. These two forces are equal but in opposite direction, so they form a couple and coil rotates in clockwise direction.

Dependence of torque acts on a coil

- ⇨ magnitude of current
- ⇨ No. of turns of coils

NUMERICALS

15 .1 A transformer is needed to convert a mains 240 V supply into a 12 V supply. If there are 2000 turns on the primary coil, then find the number of turns on the secondary coil.

Solution:

$$Vp = 240A$$
$$Vs = 12\ V$$
$$Np = 2000$$
$$Ns = ?$$

Calculation:

$$\frac{Vs}{Vp} = \frac{Ns}{Np}$$
$$Np \times Vs = Ns \times Vp$$
$$2000 \times 12 = Ns \times 240$$
$$24000 = Ns \times 240$$
$$\frac{24000}{240} = Ns$$
$$100 = Ns$$

15 .2 A step-up transformer has a turn ratios of 1 : 100. An alternating supply of 20 V is connected across the primary coil. What is the secondary voltage?

Solution:

$$Ns:Np = 100:1$$
$$\frac{Ns}{Np} = \frac{100}{1}$$
$$Vp = 20\ V$$
$$Vs = ?$$

Calculation:

$$\frac{Vs}{Vp} = \frac{Ns}{Np}$$
$$\frac{Vs}{20} = \frac{100}{1}$$
$$Vs = 20 \times 100 = 2000V$$

15 .3 A step-down transformer has a turns ratio of 100 : 1. An ac voltage of amplitude 170 V is applied to the primary. If the current in the primary is 1.0 mA, what is the current in the secondary?

Solution:

$$Ns: Np = 1:100$$
$$\frac{Ns}{Np} = \frac{1}{100}$$
$$Vp = 170\ V$$
$$Ip = 1.0\ mA$$
$$Is = ?$$

Calculation:

$$\frac{Vs}{Vp} = \frac{Ns}{Np}$$

$$\frac{Vs}{170} = \frac{1}{100}$$

$$Vs = \frac{170}{100} = 1.7 \text{ V}$$

In put power = out put power

$$VpIp = VsIs$$

$$170 \times 1\times10^{-3} = 1.7 \times Is$$

$$\frac{170\times1}{1000\times1.7} = Is$$

$$0.1A = Is$$

15 .4 A transformer, designed to convert the voltage from 240 V a.c. mains to 12 V, has 4000 turns on the primary coil. How many turns should be on the secondary coil? If the transformer were 100% efficient, what current would flow through the primary coil when the current in the secondary coil was 0.4 A?

Solution:

$$Vp = 240V$$

$$Vs = 12V$$

$$Np = 4000$$

$$\text{Efficiency} = 100\%$$

$$Is = 0.4 \text{ A}$$

$$Ip = ?$$

Calculation:

$$\frac{Vs}{Vp} = \frac{Ns}{Np}$$

$$\frac{12}{240} = \frac{Ns}{4000}$$

$$\frac{12\times4000}{240} = Ns$$

$$200 = Ns$$

In put power = out put power

$$VpIp = VsIs$$

$$240\times Ip = 12\times0.4$$

$$Ip = \frac{12\times0.4}{240} = 0.02 \text{ A}$$

15 .5 A power station generates 500 MW of electrical power which is fed to a transmission line. What current would flow in the transmission line if the input voltage is 250 kV?

Solution:

$$= 500 \text{ MW} = 500 \times10^{6} \text{ W}$$

$$Vp = 250KV = 250 \times 10^{3}V$$

$$I = ?$$

Calculation:

$$P = IV$$

$$500 \times10^{6} = I \times 250 \times 10^{3}$$

$$\frac{500\times10^{6}}{250\times10^{3}} = I$$

$$2 \times 10^{3} \text{ A} =$$

CH. # 16 BASIC ELECTRONICS

SHORT QUESTIONS

ELECTRONICS:

The branch of physics which deals with the control of motion of electrons using different devices.

Cathode rays:

By passing current through the discharge tube, rays that are emitted form the cathode named as cathode rays.

Why cathode rays called electrons?

Cathode rays also called electrons due to

- ⇨ In electric field they deflect towards positively charged plate.
- ⇨ Their e/m is equal to e/m of electron.

Thermionic emission:

The process of emission of electrons from the hot metal surfaces is called thermionic emission.

Reason:

The attractive force is present between the valence electrons and nucleus. At room electrons can not escape. By heating the metal some of these electrons gains sufficient energy and escape from the metal surface.

How thermionic emission is produced electrically:

Electrically thermionic emission can be produced by tungsten filament. Typically value of voltage and current are used 6 V and 0.3 A respectively.

Analogue quantities:

The quantities whose value vary continuously or remain are constant are known as analogue quantities. For example pressure, temperature and distance.

Analogue electronics:

The part of electronics which consists of such circuits that implement the analogue quantities is called analogue electronics.

A public address system is an example of analogue electronics.

Digital quantities.

The quantities whose value vary non-continuous manner are called digital quantities. Digital quantities are expressed in the form of digits or numbers.

Digital electronics:

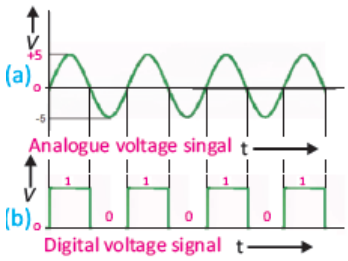
The part of electronics which implement the data in the digits form is called digital electronics.

Analogue signal:

A continuously varying signal is called an analogue signal. For example alternating voltage is an analogue signal

Digital signal:

A signal that has only two discrete values is called a digital signal. For example voltage with square waveform is a digital signal.



Applications of digital technology:

In computer system, Modern telephone system, devices to control the operation of industrials machines, military navigation and medical equipment are using technology.

Analogue to digital converter (ADC):

Such a circuit which converts the analogue signal in to digital signal is called analogue to digital converter.

Digital to analogue converter (DAC):

Such a circuit which converts the digital signal in to analogue signal is called digital to analogue converter.

What are logic gates:

Such circuits which implement different logic operations are called logic gates.

Logic states or logic variable:

States 1 and 0 is also called Logic states or logic variable.

What is Boolean algebra?

The branch of mathematics which deals with the relationship of logic variables. It is invented by George Boole.

Truth table:

Set of inputs and out puts in binary form is called truth table.

Complementation:

NOT gate perform the basic logical function called inversion or complementation.

Logic operation:

Digital circuit performs binary arithmetic operations with binary digits with 1 or 0. These operations are called logic function or logic operation.

Basic logic operation:

There are three basic logic operations.

1. AND operation 2. OR operation 3.NOT operation

1. AND operation:

An operation whose output is high when its both inputs is high. Such circuit which implement AND operation is called AND gate.

Mathematical form:

X = A.B and reads as X equals A AND B

Symbol:

Truth table:

A	B	X = A.B
0	0	0
0	1	0
1	0	0
1	1	1

2. OR operation:

An operation whose output is low when its both inputs is low. Such circuit which implement OR operation is called OR gate.

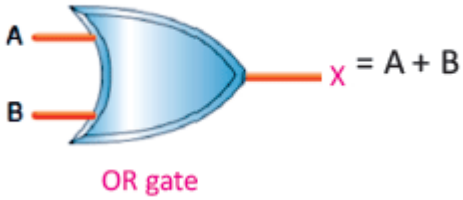
Mathematical form:

X = A+B and reads as X equals A OR B

Symbol:

Truth table:

A	B	X = A+B
0	0	0
0	1	1
1	0	1
1	1	1



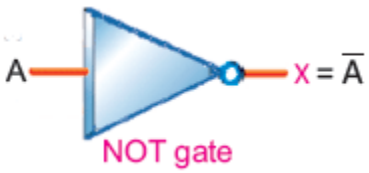
3. NOT operation

Such operation whose out put is high when its input is low and output is low when input is high. Such circuit which implements NOT operation is called NOT gate. NOT gate is also called inverter.

Mathematical form:

X = $\overline{A}$ and reads as X equals A NOT

Symbol:



Truth table:

A	X = $\overline{A}$
0	1
1	0

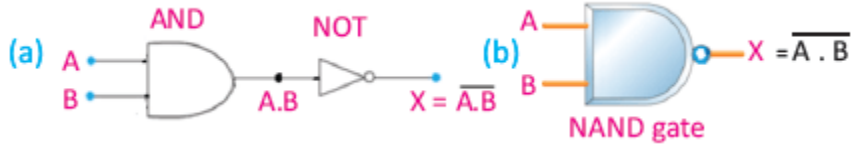
4. NAND operation:

An operation whose output is low when its both inputs is high. Such circuit which implements NAND operation is called NAND gate.

Mathematical form:

X = $\overline{A.B}$ and reads as X equals A AND B NOT

Symbol:



Truth table:

A	B	$\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0

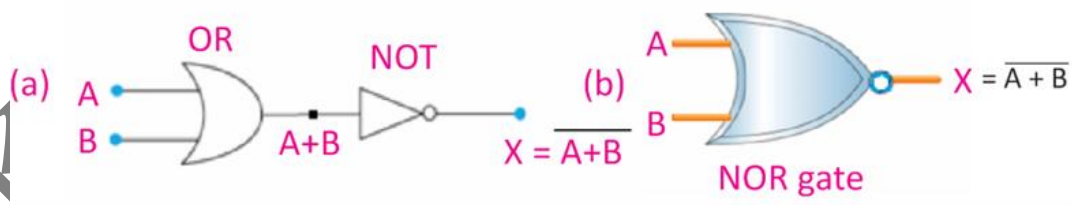
4. NOR operation:

An operation whose output is high when its both inputs is low. Such a circuit which implements NOR operation is called NOR gate.

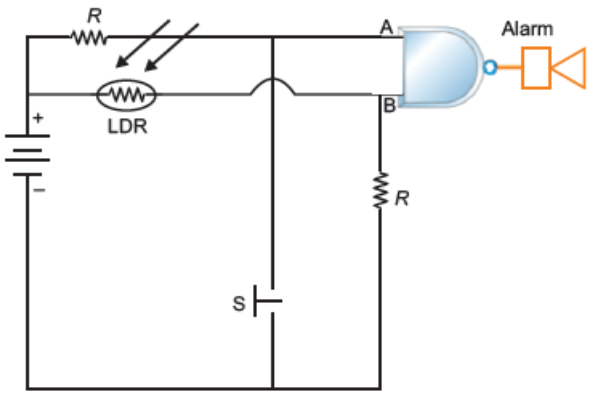
Mathematical form:

X = $\overline{A+B}$ and reads as X equals A OR B NOT

Symbol:



Truth table:



A	B	$\overline{A+B}$

0	0	1
0	1	0
1	0	0
1	1	0

Digitization:

It is the process of transforming information in to 1's and 0's.

What is LDR?

LDR means light dependent resistor. Its resistance is varying with the intensity of light. It can acts as a switch that is close in the presence of light and open in dark.

House Safety Alarm:

To make a burglar alarm, a single NAND gate is used.

Components:

1. NAND gate 2. LDR 3. Push- buttons switch 4. An alarm

Circuit diagram is shown in figure.

Operation:

In normal, presence of light input A at high and input B is also at high so out put is low and burglar alarm is not sounded.

When burglar steps on switch, in put A at low but input B is also high then out put becomes high and burglar alarm will be sounded.

If he interrupt the light, then in put A at low but input B is at low then out put again high and burglar alarm will be again sounded.

CONCEPTUAL QUESTIONSP

16.1 Name two factors which can enhance thermionic emission.

1) Temperature
2) Intensity of light

16.2 Give three reasons to support the evidence that cathode rays are negatively charged electrons.

1) Their e/m is equal to e/m of electron. .
2) In electric field, they are attracts by positively charged plate.
3**)** By applying the magnetic field these rays starts moving in a circle. By applying Right Hand Rule we concluded that they have negative charge.

16.3 When electrons pass through two parallel plates having opposite charges they are deflected towards the positively charged plate. What important characteristic of the electron can be inferred from this?

The shows that electrons have negative charge

16.4 When a moving electron enters the magnetic field, it is deflected from its straight path. Name two factors which can enhance electron deflection.

The force acts the electron in magnetic field is $F = q\ v\ B \sin\theta$

Strong magnetic field and angle between v and B is 90^o.are required to produce high deflection,

16.5 How can you compare the logic operation X=A.B with usual operation of multiplication.

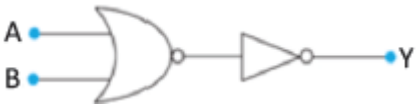
It gives the similar result. If we multiply 1 and 0 or 0 and 1 0r 0 and 0 or 1and 1 in common way, its result similar with and operation.

16.6 NAND gate is the reciprocal of AND gate. Discuss

The output of NAND is high only when its both inputs low. In AND gate output is high only when its both inputs high. So they are reciprocal to each other.

16.7 Show that the circuit given below acts as OR gate.

Here we use double NOT gate. So $\overline{\overline{A+B}}$ = A+B. so it act as OR gate.



A	B	$\overline{A+B}$	$\overline{\overline{A+B}}$
0	0	1	0
0	1	0	1
1	0	0	1
1	1	0	1

16.8 Show that the circuit given below acts as AND gate.

Here we use double NOT gate. $\overline{\overline{A.B}}$ = A.B so it act as AND gate.

A	B	$\overline{A}.\overline{B}$	$\overline{\overline{A}.\overline{B}}$
0	0	1	0
0	1	1	0
1	0	1	0
1	1	0	1

LONG QUESTIONS

Q.No.1

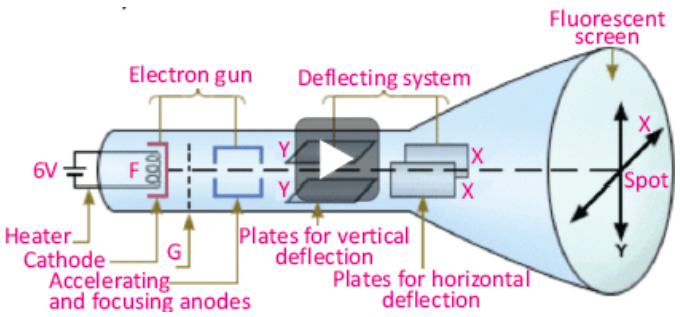
CATHODE RAYS OSCILOSCOPE:

It is an instrument which is used to display the magnitude of changing electric current or potentials.

Parts:

The cathode ray oscilloscope consists of fallowing components.

- ⇨ 1grid.
- ⇨ The deflecting plates
- ⇨ A fluorescent screen



The electron gun:

It is consists of filament, cathode, grid and anodes.

Cathode:

It is source of electrons emitted by heating indirectly.

Grid:

It is connected by negative potential. Negative potential of grid can be used as a brightness control. The more negative potential, repel more electrons hence a few electrons will reach the anodes.

Anodes:

It is connected with positive potential, used to accelerate and focusing the electron beams.

The deflecting plates:

There are two sets of deflecting plates. Horizontal set of plates deflect the beam of electron vertically and vertical sets of plates deflects the beam horizontally.

The fluorescent screen:

It a thin layer of phosphor emitted visible light when electrons fall on it.

Uses:

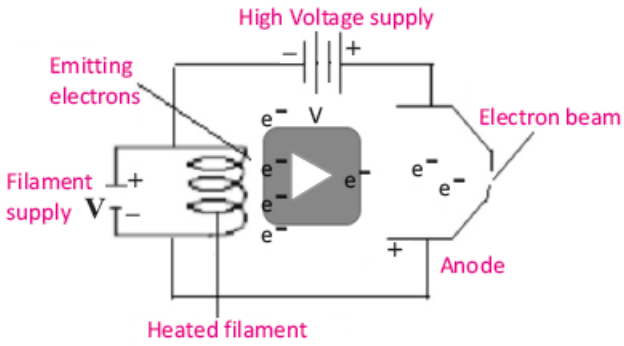
CRO is used to

- ⇨ To display the waves form.
- ⇨ To display the heart beats.
- ⇨ To measure the peak value of voltage
- ⇨ To measure frequency and time period
- ⇨ In range finding and echo- sounding.

Q.No.2

Investigating the properties of electrons:

Electron gun is used to investigate the properties of electron beam. These electrons are emitted from cathode by heating tungsten filament. For this 6v are required. A high positive potential is applied to anode. These electrons are accelerated to a very high speed passing through the hole of anode in the form of beam. The whole set is fitted in an evacuated glass tube.



Deflection of electrons by electric field:

When electric field is applied across the electron beams, electrons are deflected towards the positive plate. And repelled by negative plates with force F = qe. The degree of deflection is proportional to the strength of electric field.

Deflection of electrons by magnetic field:

If the magnetic field is applied at right angle to the electron beams by using horse shoe magnetic. Now beam of electrons deflect from its original path.

Ch. # 17 INFORMATION AND COMMNICATION TECHNOLOGY

Information and Communication Technology (ICT):

Information and Communication Technology (ICT) is defined as the scientific methods and means to store, process and transmit vast amounts of information in seconds with the help of electronic equipments.

Information technology:

The scientific method used to store information, to arrange it for proper use and to communicate it to others is called information technology.

Telecommunication:

The method that is used to communicate information to far off places instantly is called telecommunication.

Components of computer based information system:

Computer based information system consists of five parts.

1. **hardware:**

   The parts of computer which can be touch are called hardware. The central processing unit (CPU), input and out put devices and storage devise are including in it.

2. **software:**

   The term software refers to computer program and manuals that supports them. Computer program are machine- readable instructions that direct the circuits with in the hardware parts of CBIS to produce useful information from data.

3. **data:**

   Data are facts and figure that are used by programs to produce useful information. It may be in the form of text, graphic and figures that can be recorded and have specific meaning.

4. **producers:**

   These are set of instruction and rules to designs and use information system. These are written in manuals and documents for use. These rules or methods may change for time to time.

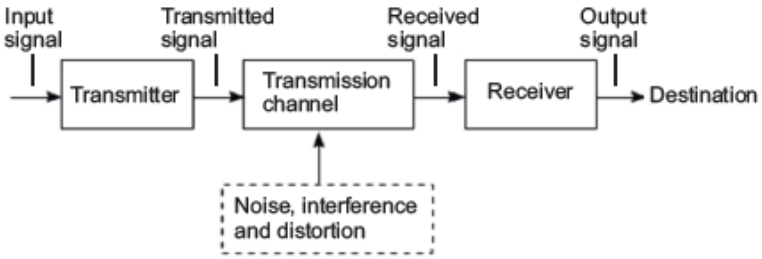
5. **people:**

   Every CIBS needs people if it is to be useful, who influence the success or failure of information systems. People design and operate the software for the smooth running of any CBIS. People write procedures and ultimately people who determine the success or failure of a CBIS

Flow of information:

The transfer of information from one place to other place through different electronics and optical devices is known as flow of information.

Elements of communication:



1. Transmitter 2. Transmission channel 3. Receiver

1. Transmitter:

It processes the input signal.

2. Transmission channel:

It sends the signal from source to destination. It may be in the from of wires, radio waves or optical fiber,

3. Receiver:

Receiver takes the signal from transmission channel and sent to transducer after processing it.

Transmission of electrical signal through wire:

Alexander graham bell is the first person who sends the sound signal in the form of electrical signal in 1876. He made a simple telephone which consists of two parts.

1. **Mouth piece 2. Ear piece**

1. Mouth piece:

The mouthpiece and receiver contain carbon granules and a thin metal diaphragm. When we speak into the mouthpiece, the sound vibrations also vibrate the diaphragm. A slight vibration of the diaphragm compresses the carbon and thus an electrical current can flow through the wire.

2. Ear piece:

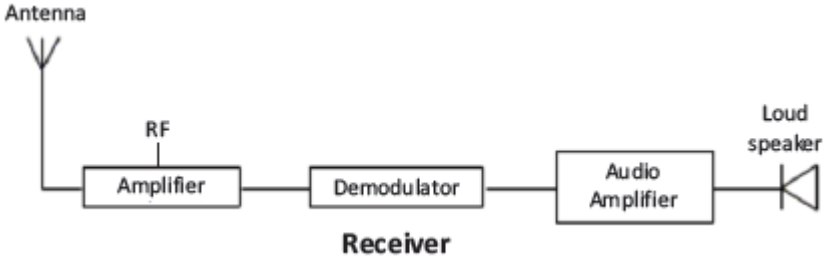
The electrical current flowing through an electromagnet in the receiver produces a varying magnetic field. This magnetic field attracts the thin metal diaphragm in the receiver, causing it to vibrate. This vibration of the diaphragm produces sound waves.

Transmission of radio waves through space:

Audio signal, video signal or computer signal in the form of electrical signal travels through the wire or radio waves. But for a long distance it is better to superimpose it on the electromagnetic waves.

Transmission antenna:

Microphone converts the sound signal in to electrical signal. This electrical signal is fed in to the transmission antenna, which oscillate the charges and radiate the electromagnetic waves.



Receiving antenna:

At the end, receiving antenna selects the particular signal and amplifies it. In demodulator process, information extracts from electromagnetic waves and sends to receptor. It changes in to sound signal again.

Fax machine:

In fax machine, text or figures are scanned then converts in to electrical signal. Telephones lines are used as a transmission channel. At the end electrical signal is changed again in to original form. A printer is used to print this copy.

Cell phone OR Mobile phone:

Cell phone is a two way communication and radio technology used in it. It contains both radio transmitter and receiver, so it sends and receives the signal in the form of radio wave.

Parts of cell phone:

1. Cells 2. Base stations (BSc)
3. Mobile switching centres

A base station is a wireless communications station set up at a particular geographical location. The geographical area covered by a single base station is known as a cell. The group of cells forms a cluster. All BSs within a cluster are connected to a MSC using land lines. The MSC stores information about the subscribers located within the cluster and is responsible for directing calls to them.

How cell phone does work?

When a caller calls another cell phone, sound waves of the caller are converted into radio waves signal. This radio signal of particular frequency is sent to the local base station of the caller where the signal is assigned a specific radio frequency. This signal is then sent to the base station of the receiver through MSC. Then the call is transferred to the cell phone of the receiver. Mobile receiver again changes the radio waves into sound.

Photo phone:

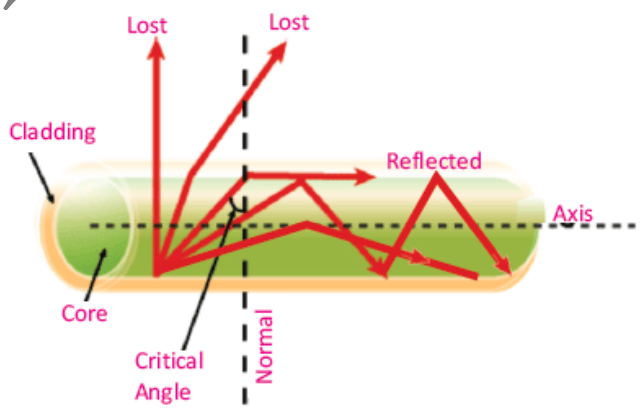
Its working principle is same as common phone. The main advantage of the phone over common phone is that we can communicate with our friends and relatives with the physical appearance of each other.

Transmission of light signal through optical fibres:

An optical fibre is a bundle of glass with the thickness of human hairs.

Transmission of light signal:

Optical fibre consists of two layers. Inner layer is called core and outer layer is cladding. Refractive index of core is relatively large than cladding when light is enter in optical fibre in such a that angle of incidence is greater than critical angle, it totally reflected back in optical fibre and travel in straight line until it reaches other end.



Advantage:

- ⇨ Speed of visible light is large than radio waves, so rate of transmission is fast.
- ⇨ Its quality is batter than electrical signal because the signal lost with increasing data rate.

Multi-mode cable and mono – mode cable:

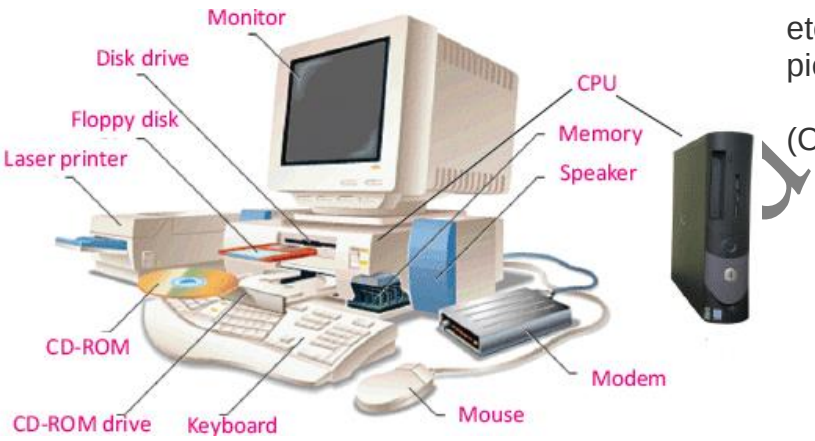
In multi mode cable, each optical fibre is 10 times thicker than in mono mode cable and travel in different paths. So it can be used for a short range such as used to link computer networks together. In mono mode, light travels in single path.

Computer:

Computer is an electronic computing machine used for adding, subtracting or multiplying.

Hard ware:

Computers work through an interaction of hardware and software. Hardware refers to the parts of a computer that you can see and touch. These include CPU, monitor, keyboard, mouse, monitor, printer etc. The most important piece of hardware is the central processing unit (CPU) that contains a tiny rectangular chip called microprocessor. It is the "brain" of computer—the part that translates instructions and performs calculations.



Software:

Software refers to the instructions, or programs, that tell the hardware what to do. A word processing program that you can use to write letters on your computer is a type of software. The operating system (OS) is software that manages your computer and the devices connected to it. Two well known operating systems are Windows and Linux operating system.

Importance:

Computer plays an important role in our daily life.

=>In offices, computers are used for preparing letters, documents and reports.

=> In hotels, computers are used for advance booking of rooms, preparing bills and providing enquiry services.

=> In railways, computers are used for rail reservation, printing of tickets and preparation of reservation charts.

=> In medical, Doctors use computers for diagnosing illness and treatment of diseases.

=>Architects use them for building designing and city planning. In meteorology department, computers are used for weather forecasting.

Now usual desktop computers have been replaced by laptops to a great extent. Laptops are more compact and hence are portable.

Information storage device:

Storage devices are used to store the information in computer. These devices work on the principle of electronics, magnetism and laser technology.

Primary memory:

It is based on electronics and consists of integrated circuits (ICs). It consists of two parts; Read only memory (ROM), which starts the computer and Random access memory (RAM), which is used by computer as temporary memory. RAM vanishes when the computer is switched off.

Secondary memory:

It is used to store the data permanently in the computer. When we open a program, data is moved from the secondary storage into the primary storage. The secondary storage devices are audio-video cassettes and hard disk etc.

Audio and video cassettes:

These devices are based on magnetism. Audio cassettes consist of a tape of magnetic material on which sound is recorded in a particular pattern of a magnetic field

Recording head:

For this purpose, microphone changes sound waves into electric pulses, which are amplified by an amplifier. Magnetic tape is moved across the head of audio cassette recorder which is in fact an electromagnet

Thus magnetic tape is magnetized in a particular pattern according to rise and fall of current. In this way, sound is stored in a specific magnetic pattern on this tape.

Play head:

To produce the sound again, the tape is moved past the play back head. Changes in the magnetic field on the tape induce alternating current signals in the coil wound on the head. These signals are amplified and sent to the loudspeakers which reproduce the recorded sound. In video tape/cassettes, pictures are recorded along with sound.

Magnetic disks:

There are different types of magnetic disks coated with a layer of some magnetic material. The read/write head of disks are similar to the record replay head on a tape recorder. It magnetizes parts of the surface to record information. The difference is that a disk is a digital medium– binary numbers are written and read. A floppy disc is a small magnetically sensitive, flexible plastic wafer housed in a plastic case. It is coated with a magnetic oxide.

Advantage and disadvantage:

Floppies are inexpensive, convenient, and reliable, but they lack the storage capacity for many large jobs. They are reliable only for short-term storage, as the magnetic fields weaken the data will also be lost.

Hard disk:

Most users rely on hard disks as their primary storage devices. A hard disk is a rigid, magnetically sensitive disk that spins rapidly and continuously inside the computer chassis or in a separate box connected to the computer housing .This type of hard disk is never removed by the user. A typical hard disk consists of several platters, each accessed via a read/write head on a moveable arm.

Compact disk:

This is based on laser technology. It is a molded plastic disc on which digital data is stored in the form of microscopic reflecting and non reflecting spots which are called “pits” and “lands” respectively. Pits are the spiral tracks encoded on the top surface of CD and lands are the areas between pits

To read data:

A fine laser beam is used to read the data. Pits and lands reflect different amount of the laser light falling on the surface of CD. This pattern of different amount of the light

reflected by the pits and the lands is converted into binary data. The presence of pit indicates '1' and absence of pit indicates '0'.

Storage capacity:

A CD can store over 680 megabyte of computer data. A DVD, the same size as traditional CD, is able to store up to 17 gigabytes of data.

FLASH DRIVE

It is also an electronic based device and consists of data storage ICs. A flash drive is a small storage device that can be used to transport files from one computer to another.

A flash drive is easy to use. Once we have created a paper or other work, we can simply plug our flash drive into a USB port. We must make a backup of our created paper or project on our flash drive and save it. If printer is not available at home then we can print at our school with the help of flash drive.

Word processing:

Word processing is such a use of computer through which we can write a letter, prepare reports and books. By means of this we can develop any documents and see it on the screen after typing it.

In modern word processing we can write in different style and different colours.

Data managing:

To collect information for a special purpose and to store it in a computer in file form, which may help at times when needed is called data managing.

- ⇨ The educational institution, libraries, hospitals and industries store the concerned information by data managing.
- ⇨ In big departmental stores and super market, optical scanners are used to read, with the help of laser beam, in this way details about price is obtained.

INTERNET:

INTERNET is a network of large no. of computers which is major sources of information and word communication.

Internet is basically a large computer network whichp extends all across the word. In internet, million of computers remain connected together through telecommunication system. Thus like a telephone connection, any computer of any city can establish a connection with any other computer of any other city and exchange data or messages with it.

Internet services:

- ⇨ Web browsing- this function allows the viewers to view web page.
- ⇨ E- mail – allows people to send and receive text message.

Browsers:

All browsers are designed to display the page of information located at wed sites around the world. The most popular browsers are, internet explore Google chrome, opera, safari, mozilla fire fox etc.

Electronic mail:

E - Mail provides very fast delivery of message to any enabled site on the internet. Communication through e- mail is more quick and reliable.

Advantage:

Fast Communication–We can send messages anywhere in the world instantly.

Cost Free Service– If we have an internet access, and then we can avail the e-mail service free of cost.

Simple to Use- After initial set up of e-mail account, it is easy to use.

More Efficient– We can send our message to many friends or people only in one action.

Versatile - Pictures or other files can also be sent through e-mail.

Internet has proved to be very beneficial to us. Here is the list of use of internet.

i. Faster Communication **ii. Big Source of Information**

iii. Source of Entertainment **IV. Access to Social Media**

v. Access to Online Services **VI. E-commerce**

vii. E-Learning

Word theft:

It is most common form of crime. Computers are used to steal money, goods, and information and computer resources.

Piracy:

It is the illegal duplication of copy right materials like books papers and software etc.

Hacking:

It is the illegal activity. It is an authorized access to computer systems of other persons.

E – Commerce:

E-commerce is the way of doing business on the web. We can order our favorite book or any other items on line.

Differentiate CD and Floppy:

If the CD is made of metal or glass, it is called hard disk and if it is made of soft elastic material then it is called floppy.

CONCEPTUAL QUESTIONS

17.1. Why optical fiber is more useful tool for the communication process?

- ⇨ Speed of visible light is large than radio waves, so rate of transmission is fast.
- ⇨ Its quality is batter than electrical signal because in electrical signal data loses with increasing data rate.

17.2. Which is more reliable floppy disk or a hard disk?

Hard disk is more reliable than floppy disk. Now a days we required a large space to store data and floppy can store only some MB. While now a days we have Hard Disk can store data several GB.

17.3. What is the difference between RAM and ROM memories?

Read only memory (ROM), which starts the computer and Random access memory (RAM), which is used by computer as temporary memory. RAM vanishes when the computer is switched off.

Super computer:

The most powerful computer which can send the information in one thousand billion part of a second is called super computer. It contains many processors.

CH. # 18 ATOMIC AND NUCLEAR PHYSICS

SHORT QUESTIONS

Nuclear Physics:

The branch of physics which deal with the central part of atom is called nuclear physics.

Nucleus: The central part of atom is called nucleus.

Nucleons:

The particles of nucleus (proton and neutron) are called nucleons.

Which one is simplest atom?

Hydrogen is the simplest atom which contains only single proton.

Some important points about atom.

- ⇨ Word atom derived from Greek letter atoms which means indivisible.
- ⇨ Electron, proton and neutron are fundamental particles of atom.
- ⇨ Electron is negatively charge particle. Charge on electron is -1.6×10^{-19} C and mass of electron is 9.1×10^{-31}kg.
- ⇨ Proton is positively charge particle. Charge on proton is $+1.6 \times 10^{-19}$ C and mass of proton is 1.67×10^{-27}kg. It is 1836 times heavier than electron.
- ⇨ Neutron is neutral particles. Its mass nearly equal to mass of proton.
- ⇨ Size of atom is 10^{-10} m , size of nucleus is 10^{-14},size of proton and neutron is 10^{-15} m and electron < 10^{-18} m

Atomic number:

Number of protons in the nucleus is called atomic number or charge number. It is denoted by Z.

Atomic mass number:

Total number of protons and neutrons in the nucleus is called atomic mass number. It is denoted by A.

Representation of an atom:

Atom is represented by symbol ${}^{A}_{Z}X$, so carbon atom can be written as ${}^{12}_{6}C$.

Isotopes:

Atoms of an element which have same atomic number but different mass number are called isotopes. Hydrogen has three isotopes. Protium, deuterium and tritium.

- ⇨ Protium contains one proton and one electron.
- ⇨ Deuterium contains one proton, one neutron and one electron.
- ⇨ Tritium contains one proton, two neutrons and one electron.

Natural radioactivity:

The spontaneous emission of radiation by unstable nuclei is called natural radioactivity. And the elements which emit such radiation are called radioactive elements.

Natural radioactivity was discovered by Henry Becquerel in 1896.

First radioactive element was discovered was uranium. Later on Marie Curie and Pierre discovered two new elements polonium and radium.

Unit:

The SI unit of radioactivity is the Becquerel,

1 Bq = 1 disintegration per second

Multiple units of radioactivity are kilobecquerel and megabecquerel.

Large unit of radioactivity is curie.

1 curie = 3.7×10^{10} disintegration per second

Nature of radioactive rays:

Rutherford and his colleagues discovered that radioactive rays are of three types. They are; alpha particles, beta particles and gamma rays.

Background radiations:

Radiations present in atmosphere due to different radioactive substance are called back ground radiations.

Cause:

Everywhere in rock, soil, water and air of our planet are traces of radioactive elements. They emit radiation and cause the back ground radiation.

Cosmic radiation:

The earth and all living things on it also receive radiation from outer space. This radiation is called cosmic radiation.

Primary cosmic radiation:

These consist of protons, electrons, alpha particles and large nuclei.

Secondary cosmic radiation:

The cosmic radiation interacts with atoms in the atmosphere to create a shower of secondary radiation, including X-rays, muons, protons, alpha particles, electrons, and neutrons.

Nuclear transmutation:

The spontaneous process in which a parent unstable nuclide change into a more stable daughter nuclide with the emissions of radiation is called nuclear transmutation.

Alpha decay:

The emission of alpha particles is called alpha decay.

In alpha decay, the atomic number Z of the parent nuclide reduces by 2 and its mass number A decreases by 4.

General Equation:

$$^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He + \text{Energy}$$

parent nuclide — daughter nuclide — α-particle

Example:

$$^{226}_{88}Ra \longrightarrow {}^{222}_{86}Rn + {}^{4}_{2}He + \text{Energy}$$

radium — radon — α-particle

Beta (B)-decay:

In beta (B -decay, the parent nuclide has its proton number Z increased by 1 but its mass number A remains unchanged.

General Equation:

$$^{A}_{Z}Z \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + \text{Energy}$$

parent nuclide — daughter nuclide — β-particle

Example:

$$^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e + \text{energy}$$

3. Gamma (γ)-decay:

The emission of gamma radiation from radioactive element is called gamma decay. In gamma decay, there is no change in the nucleus.

$$^{A}_{Z}X^{\star} \longrightarrow {}^{Z}_{6}X + \gamma$$

parent nuclide — daughter nuclide — gamma rays

$$^{60}_{27}Co^{\star} \longrightarrow {}^{60}_{27}Co + {}^{0}_{0}\gamma + \text{Energy}$$

cobalt cobalt γ-rays

Gamma rays are usually emitted along with either an alpha or a beta particle.

Ionization:

The process of formation of ions is called ionization. In this process matter is change in to positive and negative ions.

- ⇨ All three kinds of radiations, alpha , beta and gamma can ionize the matter
- ⇨ Ionization power of alpha particles is greater than beta and gamma particles due their large charge and mass.

Penetrating power:

The ability of radiations to penetrate a certain material is called penetrating power.

- ⇨ Penetrating power of gamma radiation is more than alpha and beta radiation due their large speed and neutral nature.

Range of radiations:

The radiations cover some distance in a medium before coming to rest. This distance is called range of particles.

- ⇨ Alpha particle has the shortest range because of its greatest ionizing power. It has range of a few centimeters in air.
- ⇨ Beta radiations have also short range as compared to gamma rays.
- ⇨ Gamma rays have a range of several meters in air.

.**Half life:**

The time during which half of the unstable radioactive nuclei disintegrate is called half life of that element.

Stable nuclei:

Nuclei which do not emit radiation naturally are called stable nuclei. The elements with atomic number 1 to 82 are stable nuclei.

Unstable nuclei:

The elements whose atomic number is greater than 82 are naturally unstable. They emit radiations.

Artificial radioactivity:

Stable and non radioactive elements can also be change in to radioactive elements by bombarding with protons, neutrons or alpha particles. This process is called artificial radioactivity.

Radioactive or radioisotopes:

Artificially produced radioactive elements are called radioactive or radioisotopes

What is radioactive tracer?

They are chemical compounds containing some quantity of radioisotopes. They can be used to explore the metabolism of chemical reaction inside the human body, animals and plants.

Fission reaction:

A process in which heavy nuclei split in to smaller nuclei by absorbing slow moving neutron is called fission process.

Equation of fission process;

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

Chain reaction:

When one nucleus of uranium breaks 3 neutrons are produced. These three neutrons causes to break three more nucleus and 9 neutrons are produced and so an. This is called chain reaction.

Controlled chain reaction:

Neutrons produced in the fission reaction can be absorbed by some element such as boron or cadmium and allowed to one neutron to take part in further fission. In this fixed amount of energy is produced. This is called controlled chain reaction.

Nuclear fusion:

When two light nuclei combine to from a heavier nucleus, this process is called nuclear fusion.

Example:

If an atom of deuterium is fused with tritium atom, then alpha particle is formed with release of energy.

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

Problem in fusion reaction:

In fusion, charge on both nuclei is same, so force of repulsion are exist between them. To overcome this difficulty, 10 million Kelvin temperatures are required.
This is achieving only by fission reaction.

Energy of sun:

The energy of sun is the result of fusion reaction. Temperature of sun is 20 million which make the fusion favorable according to this reaction, four hydrogen nuclei fuse together to form a helium nucleus along with 25.7 Mev of energy.

Chernobyl accident:

In Russia. At Chernobyl, due leakage of nuclear radiation causes a massive destruction of local community and also contaminated vegetation and live stock in the large surrounding areas.

Hazards of radiation:

1. Radiation burns, mainly due to beta and gamma radiations, which may cause redness and sores on the skin.
2. Sterility (i.e. inability to produce children)
3. Genetic mutations in both human and plants. Some children are born with serious deformities.
4. Leukemia (cancer of the blood cells).
5. Blindness or formation of cataract in the eye.

Precautions:

Because we cannot detect radiations directly, we should strictly follow safety precautions, even when the radioactive sources are very weak.

1. The sources should only be handled with tongs and forceps.
2. The user should use rubber gloves and hands should be washed carefully after the experiment.
3. All radioactive sources should be stored in thick lead containers.
4. Never point a radioactive source towards a person.
5. Frequent visits to the radiation sensitive areas should be avoided.

What is carbon dating?

The process of estimating of age of fossils like dead plants and animals and stones etc. by measuring the activity of carbon-14 is known as carbon dating.

Characteristics of radiation:

Alpha (α) Particles:

- ⇨ It is positively charge particles ejected with high speed.
- ⇨ They can stop by ordinary sheet or thin aluminum foil.
- ⇨ They can ionize the gas when passing through it.

Beta (B) Particles:

- ⇨ It is high-energy electron ejected at various speed nearly equal to speed of light
- ⇨ Beta particles may be able to penetrate several millimeters of aluminum.

Gamma (y) Rays:

=> Gamma photons have no mass and no electrical charge.
=> Electromagnetic radiation of very short wavelength.
=>Their wavelengths and energies can vary.
=> High-energy gamma rays can penetrate at least 30 cm of lead or 2 km of air.

Under what conditions alpha and gamma rays are emitted.

When number of neutrons and protons is too much high, alpha particles are emitted and when no. of neutrons is greater than no. of protons in a radioactive element, beta particles are emitted.

Why penetrating power of alpha particles is less than beta and gamma rays.

Because it's most energy is used in the process of ionization.

CONCEPTUAL QUESTIONS

18.1. Is it possible for an element to have different types of atoms? Explain.

Yes, it is possible and it is called Isotopes. In Isotopes the number of neutrons is different but number of protons and electrons remain same of a particular atom. Like Hydrogen have 3 Isotopes.

18.2. What nuclear reaction would release more energy, the fission reaction or the fusion reaction? Explain.

In fission reaction of U-235, energy released per nucleon is .85 Mev. The energy released when 4 Hydrogen nuclei fuse 6.2MeV for fusion so it is obvious that fusion is the more effective than nuclear reaction.

18.3. Which has more penetrating power, alpha particle or gamma rays photon?

Gamma rays has more penetrating power than alpha rays and beta rays due to fallowing reason

=> High speed and neutral in nature.
=> Less ionizing power

18.4. What is the difference between natural and artificial radioactivity?

In natural radio activity, emissions of radiations are spontaneously and naturally. While in artificial radioactivity, emissions of radiations are due the bombardment of neutron with stable elements.

18.5. How long would you likely have to wait to watch any sample of radioactive atoms completely decay?

Theoretically it will take an infinite time to decay completely.

18.6. Which type of natural radioactivity leaves the number of protons and the number of neutrons in the nucleus unchanged?

During the emission of gamma particles, there is no change in the nucleus. **Reason:** Because gamma rays are mass less and charge less.

18.7. How much of a 1g sample of pure radioactive matter would be left undecayed after four half-lives?

$$N = No\frac{1}{2^t}$$

$$= 1 \times 1/ 2^4 = 1\ (1/16)$$

After four half lives sample of radio active matter reduces to $\frac{1}{16}$ times of 1 g.

18.8. Tritium $^{3}_{1}H$ is radioactive isotope of hydrogen. It decays by emitting an electron. What is the daughter nucleus?

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

$$^{3}_{1}H \rightarrow {}^{3}_{1+1}H + {}^{0}_{-1}e + Energy$$

$$^{3}_{1}H \rightarrow {}^{3}_{2}H + {}^{0}_{-1}e + Energy$$

Hence a daughter nucleus is isotopes of helium.

18.9. What information about the structure of the nitrogen atom can be obtained from its nuclide $^{14}_{7}N$ in what way atom in $^{14}_{7}N$ is different from the atom in $^{16}_{7}N$.

$_{7}{}^{14}N$ (Nitrogen): -

Number of electrons = 7
Number of protons = 7
Number of neutrons = mass no - atomic no
Number of neutrons = 14 -7 = 7

$_{7}{}^{16}N$ (Nitrogen Isotope)

Number of electrons = 7
Number of protons = 7
Number of neutrons = mass no – atomic no
Number of neutrons = 16 – 7 = 9

The positively charged protons in a nucleus have a huge force of repulsion. Why do not they fly apart?

Because there ere strong nuclear forces which binding the particles in a nucleus. This force acts over a very short range.

LONG QUESTIONS

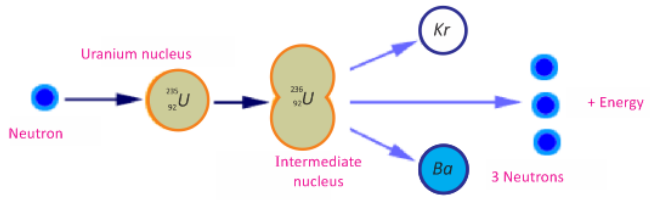
Q .No.1

Fission reaction:

The fission process was first observed in 1939 by Otto Hahn and Fritz Strassman.

A process in which heavy nuclei split in to smaller nuclei by absorbing slow moving neutron is called fission process.

Equation of fission process;



$$^{1}_{0}n + {}^{235}_{92}U^{*} \longrightarrow {}^{236}_{92}U \longrightarrow X + Y + \text{neutron}$$

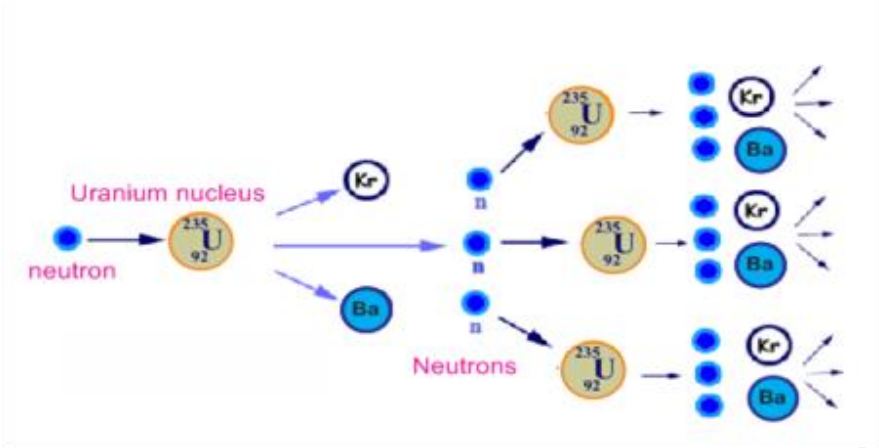
Where X and Y are called fission fragments.

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

Total mass of Ba and Kr is less than the mass of uranium nucleus. This loss in mass is converted in to energy according to $E = mc^2$ relation.

Chain reaction:

When one nucleus of uranium breaks, 3 neutrons are produced. These three neutrons causes to break three more nucleus and 9 neutrons are produced and so an. This is called chain reaction.



Controlled chain reaction:

Neutrons produced in the fission reaction can be absorbed by some element such as boron or cadmium and allowed to one neutron to take part in further fission. In this way, fixed amount of energy is produced. This is called controlled chain reaction.

Advantage:

Burning of One tonne coal produce 3.6×10^{10} J energy while during the fission of 1 kg of uranium, 6.7×10^{11} J energy is released. So in fission reaction, large amount of energy is obtained.

Q.NO.2

What is radioisotopes and write its uses.

Radioactive or radioisotopes:

Artificially produced radioactive elements are called radioactive or radioisotopes

Examples:

1. ${}_{0}^{1}n + {}_{11}^{23}Na \longrightarrow {}_{11}^{24}Na$ + gamma rays
2. ${}_{2}^{4}He + {}_{13}^{27}Al \longrightarrow {}_{15}^{30}P + {}_{0}^{1}n$

Radio isotopes are frequently used in medicine, industry and agriculture for useful purpose.

1. Tracer:

They are chemical compounds containing some quantity of radioisotopes. They can be used to explore the metabolism of chemical reaction inside the human body, animals and plants. The malignant part of the body absorbed more quantity of isotopes and this help in tracing the effected part of body.

For example:

- ⇨ Iodine 131 accumulates in thyroid gland and can be used for the monitoring of thyroid functioning.
- ⇨ For diagnose the brain tumor phosphorus-32 is used.
- ⇨ In industry, it is used to locate the wear and tear of the moving parts of machinery
- ⇨ They can be used for the location of leaks in underground pipes.
- ⇨ In agriculture, phosphorse-32 is used to check the action of fertilizer.
- ⇨ Co- 60 is used for curing and diagnoses the cancer.

Carbon dating:

The process of estimating of age of fossils like dead plants and animals and stones etc. by measuring the activity of carbon-14 is known as carbon dating.

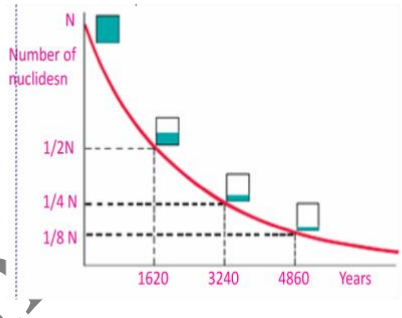
1. Radio active carbon is present in small amount of atmosphere. Plants used carbon dioxides and three becomes slightly radioactive.
When tree dies, carbon -14 in side the plants starts decaying. Comparing the activity of C-14 in live and dead tree, scientists can estimate the its age.
2. Other element is used for estimate the age is K-40. In decay process it changes in to Ar-40 with half life 2.4×10^8 years. The age of rock sample can be estimated by comparing the concentration of k–40 and Ar– 40.

Q. No.3

Half life:

The time during which half of the unstable radioactive disintegrate is called half life of that element.

Every element has its own characteristics half life. For example the half life of radium is 1620 years. Its means after 1620 years, the half of a radium sample is converted in to other element.



Explanation:

If the half life of radio active element is $T_{1/2}$,

The end of this time number of atom in this sample = ½.

After the time 2 $T_{1/2}$, number of remaining atoms = ½. ½ = $1/2^2$ = ¼

After the time 3 $T_{1/2}$, number of remaining atoms = ½. ½ .1/2 = $1/2^3$ = 1/8

At the end of the't' half life, number of remaining atoms= $1/2^t$

If No is the original atom in the sample of radio active element, then after 't' half lives, the remaining no of atoms can be determined by the relation

$$N = No \times 1/2^t$$

The process of radioactivity does not depend upon the chemical reaction. It is also not effected by any change in physical condition like pressure, temperature and electric or magnetic field.

NUMERICALS

18.1. The half-life of 716N is 7.3 s. A sample of this nuclide of nitrogen is observed for 29.2s. Calculate the fraction of the original radioactive isotope remaining after this time.

Solution:

Half-life of $^{14}_{7}N = 7.3\text{s}$

Duration $= 29.2\text{s}$

N =?

Calculation:

$$\text{No. of half life} = \frac{29.2}{7.3} = 4$$

$$N = No \times \frac{1}{2^t}$$

$$N = No \times \frac{1}{2^4} = \frac{No}{16}$$

Remaining amount is $1/16^{th}$ of original amount.

18.2. Cobalt-60 is a radioactive element with half-life of 5.25 years. What fraction of the original sample will be left after 26 years?

Solution:

$$\text{Half life of } Co-60 = 5.5 \text{ years}$$
$$\text{Duration} = 26 \text{ years}$$
$$N = ?$$

Calculation:

$$\text{No. of half life} = \frac{26}{5.5} = 5$$
$$N = No \times \frac{1}{2^t}$$
$$= No \times \frac{1}{2^5} = \frac{No}{32}$$

Remaining amount is $1/32^{th}$ of original amount.

18.3. Carbon-14 has a half-life of 5730 years. How long will it take for the quantity of carbon-14 in a sample to drop to one-eighth of the initial quantity?

Solution:

$$\text{Half life of C-14} = 5730 \text{ years}$$
$$N = No/8$$
$$\text{Duration} = ?$$

Calculation:

$$N = No \times \frac{1}{2^t}$$
$$No/8 = No \times \frac{1}{2^t}$$
$$1/8 = \frac{1}{2^t}$$
$$8 = 2^t$$
$$2^3 = 2^t$$
$$t = 3$$
$$\text{Duration} = 3 \times 5730$$
$$= 17190 \text{ years}$$
$$= 1.72 \times 10^4 \text{ years}$$

18.4. Technetium-99m is a radioactive element and is used to diagnose brain, thyroid, liver and kidney diseases. This element has half-life of 6 hours. If there is 200 mg of this technetium present, how much will be left in 36 hours.

Solution:

$$\text{Half life} = 6 \text{ hours}$$
$$\text{Duration} = 36 \text{ hour}$$
$$\text{no. Of half life} = \frac{36}{6} = 6$$
$$\text{Original quantity} = No = 200 \text{ mg}$$
$$\text{Remaining quantity} = ?$$

Calculation:

$$N = No \times \frac{1}{2^t}$$
$$= 200 \times \frac{1}{2^6} = \frac{200}{64} = 3.125 \text{ mg}$$

18.5. Half-life of a radioactive element is 10 minutes. If the initial count rate is 368 counts per minute, find the time for which count rate reaches 23 counts per minute.

Solution:

Count rate = 380 count/min

Half life =10 min

Final count rate = 23 count/min

Duration =?

Calculation:

$$368 \xrightarrow{10\,\text{min}} 184 \xrightarrow{10\,\text{min}} 92 \xrightarrow{10\,\text{min}} 46 \xrightarrow{10\,\text{min}} 23$$

Hence no. of half lives = 4

Duration = 4× 10 min = 40 min

18.9. Ashes from a campfire deep in a cave show carbon-14 activity of only one-eighth the activity of fresh wood. How long ago was that campfire made?

Solution:

Half life of C-14 = 5730 years

Duration =?

Calculation:

$$N = No/8$$

$$N = No \times \frac{1}{2^t}$$

$$No/8 = No \times \frac{1}{2^t}$$

$$1/8 = \frac{1}{2^t}$$

$$8 = 2^t$$

$$2^3 = 2^t$$

$$t = 3$$

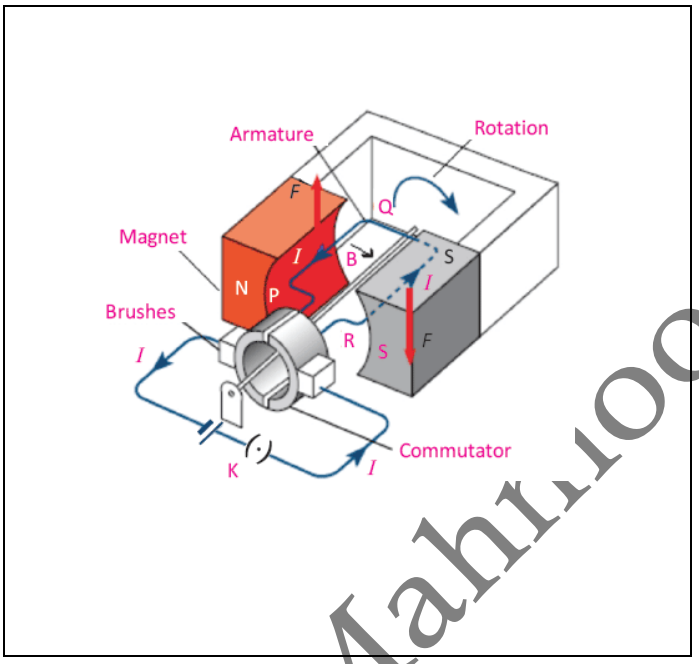
Duration = 3 × 5730

= 17190 years

THE END

EASY NOTES (PART -1)

PHYSICS 10



Written by:
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MPHIL(PHYSICS)

NAME:…… CLASS……**10th S-2**

INSITUTION:…… **GHS YAZMAN** ……

MCQ (10-18)

CH.# 10

I	II	III	IV	V	VI	VII	VIII	IX
A	B	C	A	D	A	B	C	B

CH.# 11

I	II	III	IV	V	VI	VII		
A	A	B	C	D	B	C		

CH.# 12

I	II	III	IV	V	VI	VII	VIII	IX	X
C	C	B	C	B	A	B	A	B	B

CH.# 13

I	II	III	IV	V	VI	VII	VIII	IX
B	A	C	A	B	C	D	A	D
X	XI							
B	B							

CH.# 14

I	II	III	IV	V	VI	VII	VIII	IX
D	C	B	C	A	D		C	A

CH.# 15

I	II	III	IV	V	VI	VII	VIII	IX
D	D	D	A	C	B	D	B	C

CH.# 16

I	II	III	IV	V	VI	VII	VI	IX
D	D	C		C	A	B		

CH.# 17

I	II	III	IV	V	VI	VII	VIII	IX
C	A	D	C	D	D	B		

CH.# 18

I	II	III	IV	V	VI	VII	VIII	IX
A	B	B	C	B	C	B	A	B